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Scope for regulation of cigarette smoke toxicity: the case for including charcoal filters

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Abstract

Aim To compare the emissions toxicity of two manufactured cigarette brands, one with and one without a charcoal filter, in the light of manufacturers' laboratory research findings on the properties of charcoal filters.

Method Emissions of Mild Seven charcoal filter brands, regular (labelled '12 mg tar') and Light (labelled '9 mg tar') purchased in 2004, were compared with those of Holiday Extra-mild brand (9 mg tar, acetate filter), purchased in 2002. All emissions were tested under intensive machine smoking conditions by Labstat International Inc., Kitchener, Ontario.

Results The Mild Seven brands contained a small amount of charcoal, its black granules visible against the white acetate filter. The charcoal filter in the brands tested did not reduce toxicity to the extent expected, though they gave significantly lower emissions for the respiratory- toxicants acrolein (14%–17% lower, $p \leq 0.01$) and formaldehyde (26–37% lower, $p \leq 0.01$). Reductions were not significant for acetaldehyde, and actually higher for hydrogen cyanide. Overall, estimated cardiovascular-respiratory toxicity was not reduced, whether based on toxicant emissions or the toxicant to nicotine ratios.

Of the packet labels, neither tar yield (mg) nor the descriptors 'mild, 'light', or 'extra-mild', or 'charcoal filter' for these three brands was associated with any reduction of the combined respiratory—and cardiovascular toxicity of mainstream smoke, as measured by leading toxicants tested by the intensive method.

Previously secret documents from cigarette companies, including British American Tobacco, reported reductions of 75%–80% in hydrogen cyanide, acetaldehyde, acrolein, and formaldehyde in mainstream smoke from addition of charcoal to the filter. We estimated that an effective charcoal filter could reduce a brand's overall relative toxicity score for identifiable toxicant by over 40%.

Conclusion Since 1965, major cigarette firms have known from their chemists that many smoke toxicants, including hydrogen cyanide and acrolein, were removable by manufacturing the cigarette with a charcoal filter. To this day, few brands have charcoal filters. The best known, Mild Seven, contained a token charcoal filter only. In neither Japan nor New Zealand did this brand lower cardiovascular toxicant emissions in smoke. In the Smoke-free Environments Act, Government has the power to lower smoke emissions by regulation, but no regulations are in place. The Act does not give power to add filters to cigarettes, but does give power to lower smoke emissions to the level attainable by using a charcoal filter, which could reduce smoke emission toxicity to a large extent. Regulation to require effective charcoal filters is now long overdue.

A committed but concerned smoker might ask—'Which cigarette brand has the least toxic emissions in its smoke?' If a certain brand had significantly lower emissions, we reasoned that smokers should be informed of the fact. If there was such a brand, no cigarette manufacturer was making any such claim. In 2003, the Ministry of Health had tested only two brands for emission toxicity. By 2004, the Ministry was reviewing the Smoke-free Environments regulations, including the possibility of regulating toxicity.

We looked first at Japan, where two-thirds of cigarettes sold in the preceding 20 years had charcoal filter tips, thought to possibly explain the lower rate of lung cancer in male smokers in Japan versus the United States.[1] The most popular Japanese brand, Mild Seven, probably the world's most popular charcoal brand, was sold in small quantities in New Zealand. Data from the Ministry of Health in Tokyo,[2] however, showed that the Mild Seven charcoal filter cigarette, and other regular cigarettes with charcoal filters did not lower emissions below the Canadian regular brands average as published by the Government of British Columbia.[3] As charcoal is widely used in gas masks and in chemical laboratories to adsorb gases, the reason for these findings was unclear.

Method

Toxicant selection—Toxicants for comparing brands were selected by toxicological risk assessment.[4]

Cigarette manufacturers' reports and charcoal filter references—Document collections at www.tobaccodocuments.org (previously secret internal industry documents accessed by legal discovery) and www.pubmed.org (US Institutes of Medicine) were searched on acrolein, cyanide, and charcoal. In addition, Swedish Match supplied a short summary of past experiments with charcoal filters. (Wahlberg I. personal communication, 2004).

Smoke tests—Emissions from two charcoal filter brands, Mild Seven regular, labelled 13 mg tar, and Mild Seven Lights, labelled 8 mg tar, were compared with Holiday Extra Mild (9 mg tar), an acetate filter brand. (The labels for tar were based on the ISO method—puff volume 35 ml, puff interval 60 seconds, puff duration 2 seconds, no holes covered).

The Mild Seven charcoal filter brands were purchased in Newmarket, Auckland in 2004, and analysed by Labstat International Inc, Kitchener, Ontario, Canada, using the Health Canada intensive machine smoking method (55-ml puff volume, puff duration of 2 seconds, 30 seconds between puffs, and all ventilation holes covered). For comparison, we used data from Holiday Extra-mild cigarettes, purchased in Wellington in 2002, and also tested at that time by Labstat by the same intensive machine smoking method.[4] For both studies, we tested a short list of toxicants known from industry documents to be reduced by charcoal filters. Brands were tested for tar and nicotine; for the respiratory toxicants acrolein, acetaldehyde, formaldehyde; and for the cardiovascular toxicants carbon monoxide and hydrogen cyanide.

Spreadsheet scenarios—We created emissions spreadsheets containing the observed emissions for each brand. Then we changed certain emissions to simulate the effects of regulation for charcoal filters and/or switching to brands with lower emission toxicity.[5] We ran separate estimations of each brand's observed toxicity (with an acetate filter), then with a combined acetate-charcoal filter, assuming the acetate functioned as before, and the charcoal removed 75% of acetaldehyde, acrolein, benzene, hydrogen cyanide, and formaldehyde, as found on emission testing of mainstream smoke from that brand of (acetate filter) cigarette.

Results

Cigarette company documents—In 1964-5, RJ Reynolds, and British American Tobacco (BAT) scientists showed that charcoal filters lowered hydrogen cyanide in smoke by 74% to 78%,[6,7] and aldehydes by 75% to 95%.[7] In the 1990s, Swedish Tobacco, before it sold its cigarette business and became Swedish Match, compared

two 80% ventilated cigarette brands, one with a charcoal filter, the other with a cellulose acetate filter. Charcoal reduced the gas phase components by 80% compared with the acetate filter cigarette. The greatest reductions were found for aromatic hydrocarbons, nitriles, and ketones. (Wahlberg I. personal communication, 2004).

Observed effects in smoke test results—Labstat Inc reported that in both variants of Mild Seven charcoal filter cigarettes, the charcoal granules were mixed and inseparable from the cellulose acetate portion of the 'dual filter', so that the charcoal could not be weighed. From our own visual examination, it appeared that the charcoal was a very minor component of the filter.

Table 1 shows that on testing by intensive machine smoking, emissions for tar, nicotine, and carbon monoxide for all three brands were much higher than the levels given on the packet label (which were based on the less intense ISO method).

Table 1. Per cigarette emissions in mainstream smoke of three brands sold in New Zealand, with and without charcoal filters, tested by intensive smoking machine method at Labstat Inc Canada

Mean (standard deviation)	Mild Seven Regular	Mild Seven Lights	Holiday Extra Mild
Year purchased	2004 NZ	2004 NZ	2002 NZ
Packet label#	12 mg tar	8 mg tar	9 mg tar
Filter	Charcoal, acetate	Charcoal, acetate	Acetate
Tobacco weight mg	1004 (10)	972 (12)	888 (na)
"Tar" mg	29.4 (1.6)	28.4 (0.9)	32.6 (1.6)
Nicotine mg	1.91 (0.06)	1.71 (0.04)	1.82 (0.08)
Carbon monoxide mg	25.1 (0.7)	25.7 (1.5)	26.4 (1.0)
Formaldehyde mcg	111** (12)	94.8** (6.4)	150 (12)
Acetaldehyde mcg	1152 (47)	1172 (55)	1198 (61)
Acrolein mcg	123** (8)	128** (6)	148 (6)
Hydrogen cyanide mcg	310 (11)	339* (27)	282 (18)

#Value on packet label was determined by ISO method; na = not available; *$p \leq 0.05$ and, **$p \leq 0.01$, with respect to the value for Holiday Extra Mild.

Compared with Holiday Extra-Mild, the Mild Seven charcoal filter brands (both regular and lights) gave significantly lower emissions for the respiratory toxicants acrolein ($p<0.01$), and formaldehyde ($p<0.01$). For acetaldehyde, a respiratory toxicant, and carcinogen, levels were not significantly different in the charcoal brands. Emissions of hydrogen cyanide, a cardiovascular toxicant, tended to be higher in the smoke of the Mild Seven brands, than for Holiday Extra-Mild. On spreadsheet simulation, assuming untested analytes were the same in all three brands, overall relative brand toxicity for Holiday Extra Mild was intermediate between the two Mild Seven brand variants.

Estimated effects on overall identifiable toxicity—Estimating from the emissions spreadsheet, we scored the relative toxicity of the average of British Columbian regular brands under intensive conditions as the standard, as 1.00. Adding a charcoal filter reduced overall estimated identifiable toxicity by 43% to 0.57. The estimated overall relative emission toxicity of Holiday Extra Mild under intensive smoking conditions with an estimated score of 1.39, was higher than for Canadian brands.

Adding a charcoal filter similarly reduced HEM's overall identifiable toxicity by 44% to 0.78. The emission toxicity of 'Export A full flavor' was among the lowest of Canadian brands at 0.85: but was estimated to be lower still at 0.49 with an efficient charcoal filter—a 42% reduction.

Non-cancer risk—Substituting in the emissions spreadsheet, for Canadian regular brands on average, a charcoal filter (see Method) reduced the estimated cardiovascular and respiratory identifiable toxicity by 72% and 74% respectively. For Holiday Extra-mild, the reduction was 72% and 75% respectively. No method was available for assessing what fraction of these reductions might be applicable to total non-cancer smoking risk. Thus no non-cancer mortality reduction estimate can be made.

Cancer risk—The Canadian regular brands (overall total relative toxicity score 1.00) provided the standard score for cancer toxicity of 0.39, based on an estimated 39% of cigarette-attributed deaths in New Zealand in 2000 being due to cancers.[8] With a charcoal filter, cancer toxicity reduced 13%, from 0.39 to 0.34, as we assumed no reduction of 1,3-butadiene, the main carcinogen. As identifiable cancer risk represented 35% of total cancer risk,[5] total cancer risk from smoking reduced by (0.35*13) = 4.6%. This is a smaller but more firmly based estimate than is available for cardiorespiratory risk, where the main benefits of charcoal filters can be achieved.

If regulation utilised both brand and filter differences in emission toxicity, (HEM without a charcoal filter, compared with 'Export A full flavor' fitted with a charcoal filter), the difference was from 1.39 to 0.49, a 65% reduction in identifiable toxicity exposure overall, and a 47% reduction in identifiable cancer toxicity exposure. These relative toxicities are based on toxicant to nicotine ratios. If identifiable cancer risk reduced 47%, from 0.55 to 0.29, then total cancer risk from smoking can be lowered 47%* 0.35,[5] that is, by 16.5% if charcoal filters and other differences in brand toxicity are utilised. Were Holiday Extra-mild's emissions found to be typical of New Zealand cigarettes (it is the only brand fully tested so far), then in 2000, cigarette cancer deaths[8] could have been 280 fewer.

Discussion

This study shows that:

- The intensive smoking machine method gave emission toxicity levels approximately double that from the ISO method.
- Low tar ratings, 'mild', 'light', or 'extra-mild' labels on cigarette packets do not equate with reduced toxicant emissions.
- The ineffectiveness of the charcoal filter in Mild Seven cigarettes noted in analyses by the Ministry of Health in Tokyo is confirmed for the same brand sold in New Zealand.[2]
- Charcoal filters are unlikely to explain differences in lung cancer rates between Japan and the United States.[1]
- Since 1965, major cigarette companies have knowingly exposed smokers to high levels of these major smoke toxicants, which, their chemists had reported, could be greatly reduced by using charcoal filters.

Descriptors on cigarette packets—In view of current interest in banning of misleading descriptors as a possible outcome of the Ministry of Health's current review of packet labelling, we note that of the three brands studied, whether considering the tar ratings on the side of the packet, the descriptors 'light', 'extra-mild,' or the filter description 'charcoal filter', none was matched by reduced toxicant emissions. Our findings illustrate the need for Government to revise its regulations and ban misleading labels on cigarette packets unless the claims can be substantiated.

Limitations of the study—Findings are limited to the brands we studied, and to the time of purchase. Manufacturers may have since changed a brand's design or tobacco blend and consequent emissions, as most emissions are not monitored by the Ministry of Health. In the current state of science we are unable to quantitatively describe the relationship between non-cancer toxicants in smoke and future disease risk.

Other smoke hazards including reactive oxygen species remain unmeasured. Some toxicants are known to interact. Also smoking machines measure the toxicant exposure of the machine, whereas smokers may inhale more intensively, and also exhale some of the gases, thus retaining and absorbing some gases more than others. Further, actual toxicant exposure implies measurement of the inhaled smoke. Combining effects from charcoal filters and other brand differences[5] assumes independent effects, which in practice may not be fully realisable, as some interaction may be difficult to avoid.

The charcoal filter—The light dusting of charcoal found in Mild Seven filters may satisfy consumer taste and conform nominally to its label. It does not exploit charcoal's toxicant-reducing potential. Smokers may take time to become accustomed to the taste of charcoal filter cigarettes, but if these filters are mandated across all brands, smokers would buy and smoke them. Besides Mild Seven, BAT's Kent brand had a charcoal filter, but it also appeared to contain little charcoal. Charcoal filter cigarettes need to contain active charcoal (with greater surface areas and pores, up to 180 mg per cigarette) if they are to maximally reduce toxicant gases. Regulations will need to tilt manufacture towards maximally effective filters, against the manufacturer's wish not to upset the smoker.

This reports of cigarette chemists over the past 40 years are in line with the large apparent reductions in emissions recently reported by manufacturers; in 2004 for the Advance brand's trionic (charcoal, cellulose acetate, resin) filter[9], and in 2005 for Philip Morris' carbon filters technology.[10] These charcoal filter cigarettes are currently being test-marketed in the United States, but there is no sign of them being launched in New Zealand as yet.

Regulation for effective filters should extend to filters sold loose, as in New Zealand loose cigarette tobacco accounts for one-quarter of all tobacco sold for smoking, and for over half of tobacco smoked by Maori.

As the excess cumulative premature death risk of continuing to smoke is 50%, it is obvious that even if regulation reduces cigarette smoke toxicity substantially, smoking will remain a highly dangerous activity. Quitting is still the best advice.

The introduction of acetate filters in cigarettes in the 1960s led to soaring sales, encouraged by tobacco advertising. A new filter could not easily repeat this now, in the face of advertising and smoking bans, anti-smoking media campaigns, and

tobacco taxation policies. As cigarette toxicity is regulated, however, these support measures should be increased.

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What this paper adds

This is the first published report comparing what charcoal filters can do in a cigarette company laboratory with what they do in a commercial cigarette.

Over the last 40 years cigarette company scientists have reported that charcoal can reduce aldehydes and hydrogen cyanide emissions in cigarette smoke by 75%-80%. In two Mild Seven charcoal filter brand variants sold in New Zealand containing minimal charcoal, no such reduction in these emissions was seen.

Emission reductions seen with the charcoal filters as reported 40 years ago, could today lower a brand's overall identifiable toxicity by over 40%, mainly by reducing gases toxic to lungs, heart and blood vessels. Whether overall total brand toxicity would be reduced by this much is uncertain, as currently unidentified toxicants may not be susceptible to removal by charcoal filters. With more certainty, effective filters could reduce total cigarette cancer risk by at least 5%, or 80 deaths a year.

References

1. Stellman SD, Takezaki T, Wang L. et al. Smoking and lung cancer risk in American and Japanese men: an international case-control study. Cancer Epidemiology and Prevention. 2001;10:1193–9.
2. Constituent analysis of tobacco smoke in seven brands sold in Japan. Ministry of Health, Tokyo. Available online. URL: http://www.mhlw.go.jp/topics/tobacco/houkoku/seibun.html (in Japanese). Accessed April 2005.
3. What is in cigarettes? Smoke constituents. Ministry of Health Planning, Government of British Columbia. Available online. URL: http://www.healthservices.gov.bc.ca/ttdr/ Accessed April 2005.
4. Laugesen M, Fowles J. Scope for regulation of cigarette smoke toxicity according to brand differences in published toxicant emissions. N Z Med J. 2005;118(1213). URL: http://www.nzma.org.nz/journal/118-1213/1401
5. Fowles J. Chemical composition of tobacco and cigarette smoke in two brands of New Zealand cigarettes. Prepared as part of a New Zealand Ministry of Health contract. Porirua: ESR, final report revised 25 August 2003. Available online. URL: http://www.ndp.govt.nz/tobacco/ChemicalCompositionCigarettes.pdf Accessed April 2005.
6. Cundiff RH. The spectrophotometric determination of hydrogen cyanide in cigarette smoke. 8 June 1964. RJ Reynolds collection. Bates nos. 50094 596, 51480 1751. http://tobaccodocuments.org

7. British American Tobacco Company. 54 page document, circa 1965. Guildford miscellaneous collection. Available online. URL: http://tobaccodocuments.org/guildford_misc/402368992-9045.html Accessed April 2005.
8. Peto R. Lopez AD, Boreham J, et al. Mortality from smoking in developed countries 1950-2000. Oxford: OUP, 1994. Data updated 23 August 2004. Available online. URL: http://www.ctsu.ox.ac.uk/~tobacco/ Accessed April 2005.
9. Steinik M, Smith M. The path to a safer cigarette. Advance Lights. Trionic filter. Global Equity Research, JP Morgan, 28 July 2004. Packet onsert at p. 28.
10. Gaworski CL. SCoR Program. Carbon filter technology. Philip Morris USA. Powerpoint Meeting presentation at Massachusetts Department of Health, February 7, 2004.