SPECIAL COMMUNICATION

Maximum yields might improve public health—if filter vents were banned: a lesson from the history of vented filters

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Filter ventilation is the dominant design feature of the modern cigarette that determines yields of tar, nicotine, and carbon monoxide on smoking machine tests. The commercial use of filter ventilation was precipitated by the 1964 United States Surgeon-General's report, further advanced by the adoption of an official Federal Trade Commission test in 1967, and still further advanced by the inclusion of a gas phase (carbon monoxide) measure in 1979. The first vented-filter brand on the market in the United States (Carlton) in 1964 and the second major vented-filter brand (True) in 1966 illustrate this. Ultimately, filter ventilation became a virtually required way to make very low tar cigarettes (less than 10 mg or, even more so, less than 5 mg tar). The key to the lower tar cigarette was not, in effect, the advanced selective filtration design characteristics or sophisticated tobacco selection or processing as envisioned by experts (although these techniques were and are used); the key to the very much lower tar cigarette was simply punching holes in the filter. We propose that the banning of filter vents, coupled with low maximum standard tar, nicotine, and carbon monoxide yields, would contribute to making cigarettes much less palatable and foster smoking cessation or the use of clearly less hazardous nicotine delivery systems. It may be necessary to link low maximum yields with the banning of filter ventilation to achieve public health benefit from such maxima.

The establishment of standard tar tests in the United States in the mid 1960s led to the recognition by the industry that filter ventilation was necessary to produce lower tar yield cigarettes (about 10 mg tar or less) that could sell well. Without filter vents, the very low tar filter cigarette would have required strenuous puffing and yielded mainly dissatisfaction and low sales. The pressure toward more consumer acceptable lower tar and presumably safer cigarettes, caused the birth of the first commercial vented-filter cigarette, Carlton (American Tobacco Company (ATC)), which was rushed to market to capitalise on the crescendo of fear attending the 1964 Surgeon-General's Report.[1] Further, the imminent adoption of the Federal Trade Commission (FTC) standard tar test in 1966 to 1997 was associated with the introduction of the second major vented-filter brand and the first very successful lower tar cigarette of the period—True (Lorillard Tobacco Company).

In this paper we discuss how banning filter vents might influence smoking behaviour and cigarette harm. In particular, if vents were removed from cigarettes and coupled with International Organization for Standardization (ISO)/FTC cigarette yield maximums (for example, the European Union's 10 mg tar, 1.0 mg nicotine, and 10 mg carbon monoxide), then this might change people's smoking habits and help reduce exposure to smoke constituents.[1] The creation of a cigarette market of more truly lower-yielding cigarettes would likely be more frustrating to smoke, and this might motivate smokers to quit, which would truly be harm reducing even if smoke constituents remained highly toxic.

PUNCHING HOLES IN CIGARETTES: ''FILTER AMPLIFICATION''

A lower tar cigarette as measured by standard tests must either reduce the number of available puffs, reduce the concentration of tar in each puff, or both.[2] The use of ventilation in one form or another to reduce yields was relatively common knowledge in the mid 1950s—the first US patent was issued in 1890.[3] An article in the widely-read *Reader's Digest*[4] in 1959 described ventilation of the paper as a ''trick'' the industry was using to go beyond basic filtration effects. This article also cited a letter by Smyth in the *British Medical Journal* in February 1959 that recommended punching vent holes in cigarettes.[5] Philip Morris (PM) had earlier marketed Spud cigarette—a mentholated cigarette with ventilating slits in the paper—in 1958, and ATC in 1959 had marketed Rivera, also mentholated, with vent holes on the paper just in front of the filter.[6 7] PM had conducted very extensive research on filter ventilation as well as paper ventilation from the mid-1950s to 1960 on prototypes (some using Marlboro and Alpine), including studies on smoker ''satisfaction'' and ''frustration'' as a function of filter ventilation; but PM appears not to have marketed ventilated-filter cigarettes until after Carlton and True were introduced.[3 8]

Increased paper porosity was widely used commercially to reduce yields before the move to filter ventilation. It was understood that there were limits to what changes to the paper could accomplish. If the paper was too porous, the structural integrity could be compromised; also vent holes along the length of a cigarette contributed to making the already weakest first puffs taste weaker because the maximum ventilation was with the unburned cigarette and the dilution effect decreased as the cigarette burned down.

The cellulose acetate filter used on today's cigarette works mainly by having the tar particles impact and collect on the filter fibres as the smoke passes through the filter. In the case of filters that included activated charcoal portions, chemical processes are also at work, mainly removing gas phase smoke constituents. Effective filters essentially ''trap'' more smoke particles by having more fibres per millimetre of filter or more millimetres of filter.[9 10] The removal of tar, however, reduces the taste from the cigarette, so filters are designed to be less than 100% effective from the beginning. Thus, according to the cigarette industry, to produce a satisfactory taste a successful filter traps some but not all of the smoke particles.[9] As tar trapping ability rises, it takes much more forceful puffs

Abbreviations: ATC, American Tobacco Company; EU, European Union; FTC, Federal Trade Commission; ISO, International Organization for Standardization; PM, Philip Morris

to get satisfying levels of particulates (that is, ''tar'' as well as nicotine). At the same time such a filter had relatively little effect on the gas phase (for example, carbon monoxide, hydrogen cyanide, etc) and some industry experts were concerned for taste reasons about a dramatic change in the balance of gas phase and particulate phase as a result of filtration.[11]

PM scientists spoke of ventilation as ''filter amplification'' rather than as a genuine filtration process. The ''filter amplification'' effect was thought to enhance the effectiveness of filters by: (1) a straightforward air dilution effect (substituting a percentage of smoke with ambient air); (2) a slowing down of smoke passing through the filter (making the filter more effective); and (3) reducing the temperature of the burning cone that produced smoke.[3]

AN EXUBERANT ''MODERN SCIENCE'' FAILED TO MAKE CIGARETTES SAFER

The Surgeon General's Report, released on 11 January 1964, said very little about filters (except an indirect encouragement of charcoal filters for potential benefits on lung ciliary action). On 14 January, Surgeon General Luther Terry clarified that, '' . . . the committee felt that the development of better filters or more selective filters is a promising avenue for further development'' (p 22).[12] On 24 January 1964, in *Life Magazine* (a best-seller), Dr Ernst Wynder of the prestigious Sloan-Kettering Institute, reported that some companies were making positive advances with their filters.[13] In April, a very popular weekly magazine published ''New hope for cigarette smokers: Crash effort for a safer cigarette''.[12] Ernst Wynder was quoted at length: ''…we must come up with a safer cigarette, which I am convinced we can do. The less harmful cigarette will be designed with a multiple approach. We can use strains of tobacco that have less hazardous substances in them, we can use less hazardous methods of curing tobacco, we can use finer cuts of tobacco for more complete combustion, we can find better mechanical filters to remove particles, and we can add as many filters as necessary for selective removal of gases and other dangerous materials.'' Note the scientific optimism of these statements, and that Wynder's vision of selectively bred, selectively made, and selectively filtered cigarettes omits mention of the fundamentally crude and non-selective ''filtration'' design feature which would in the end be largely responsible for the modern lower-tar cigarette: filter ventilation.

CARLTON, VENTED-FILTERS NUMBER 1 AND THE 1964 SURGEON-GENERAL'S REPORT

Before the 1964 Surgeon General's Report, the tobacco industry had been working to construct a satisfying lower-tar cigarette.[4 14] In 1955, the FTC ostensibly had ended the industry's ''tar derby'' and direct tar and nicotine based advertising, but in 1957 respected magazines (*Reader's Digest* and *Consumer Reports*) published detailed assessments of cigarette safety issues and reports of standard laboratory analyses of tar and nicotine yields.[15–17] In April 1963, an ATC executive wrote a confidential memorandum to the president of ATC on ''Filtration Trends'', concluding that, despite the earlier FTC intervention to stop the ''Tar Derby'', tar yields had gone as low as they could go and that Lorillard's Kent (one of the current lowest yield cigarettes) could not go much lower without ''emasculating what taste it has''.[18]

Fears of smoking fostered sales of filter cigarettes. In anticipation of the release of the Surgeon General's Report that would help scientifically certify the cancer risks of smoking, the ATC, an industry leader at the time, rushed to bring to market a new, historically low-tar cigarette.[19 20]

On 4 January 1964, ATC announced the release of Carlton: the first brand with tar and nicotine results on the package (2.5 mg tar, 0.4 mg nicotine) and the brand with the lowest tar on the market.[21] The brand was also described as having ''special precision vents and high-porosity paper''.[22] Five days later, on 11 January 1964 (a Saturday, to protect the value of tobacco stocks), the Surgeon General's Report was released. The following Tuesday, Carlton was being advertised widely in newspapers.[23] In the rush to market, the first version of Carlton had air vents placed on the cigarette paper just beyond the filter. Shortly after release it was decided it would be better to move the vents to the filter, but it took until late April 1964 to make the production change.[24–26] With the introduction of filter vents, the reported tar level changed to 2.7 mg and the reported nicotine concentration dropped to 0.3 mg.[27]

Carlton thus became the first ventilated filter cigarette in commercial release. The advertising then described the ''air vents in the filter'' and showed a diagram of them (fig 1).[23] Note that this reporting of tar and nicotine yields took place three years before the advent of the official FTC test. The tar and nicotine tests used for the advertising were done by Foster D Snell Consulting Chemists—the same firm that had tested for *Reader's Digest*.[28] The test had been published in 1936 and also formed the basis of a test in the process of being adopted by the Association of Official Agricultural Chemists, in cooperation with tobacco industry chemists.[29 30] Because the ATC was arguably violating the 1955 FTC ruling eliminating advertising of tar and nicotine yields, they felt they needed a cigarette that was much lower in tar than the rest of the market.

This is Carlton, the unusual new cigarette from The American Tobacco Company. Everything about Carlton is selected and crafted to produce this one result: (A cigarette that is low in "tar" and nicotine—yet high in smoking pleasure.) Carlton is so low in "tar" and nicotine we print test results on all packs, on all cartons. Give Carlton the time it takes you to smoke a carton. See for yourself.

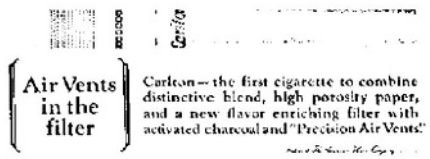

Figure 1 Carlton cigarette magazine advertising first used on 5 June 1964, in *Life Magazine*, indicating ''Air vents in the filter''.[24] The text at the bottom reads: ''[Air Vents in the Filter] Carlton—the first cigarette to combine distinctive blend, high porosity paper, and a new flavor enriching filter with activated charcoal and 'Precision Air Vents'''.

TRUE: MAJOR VENTED-FILTER CIGARETTE NUMBER 2

Although Montclair—a mentholated sister brand of Carlton—was marketed as a vented-filter cigarette in 1964, the second *major* vented-filter cigarette to appear to capture a significant market share was True (0.8 mg nicotine, 12.9 mg tar) announced by Lorillard in April 1966.[29 31] True emitted nearly half the tar and nicotine of the best-selling filter cigarette, Winston.[32] True was a very successful cigarette. Carlton, in its first year, had sold 0.31% of the market; in its third quarter of its first year (1966), True sold 0.48% share of the market.[33] By 1968, True had a very successful 1.72% of the market. It caught the interest of the competing companies who appreciated that filter ventilation was needed to achieve very low standard yields. In 1966, experts at PM were indicating that True-type filter ventilation gave them "the means of marketing a low-TPM [total particulate matter] delivery (8 mg)".[34] The success of True appears to have been critical to the popularisation of filter ventilation (fig 2).[35 36] PM experts noted that to make a less than 12 TPM cigarette (about 10 mg FTC tar), filter ventilation was "required".[37] Three (Doral, Multifilter, Marlboro Light) of the next four super "high-filtration" products were vented filter cigarettes, introduced from 1969 to 1971.[33] Vantage was the exception, although it later became ventilated.[38]

Some have argued that the availability and success of True facilitated the establishment of the FTC test in the USA.[39 40] It was felt that an official test was needed to support tar and nicotine advertising which would lead continuing smokers to such a consumer-acceptable and less dangerous cigarette. Note the illogical lawyerism used in allowing "lower tar claims" but not allowing "reduced risk claims," even though the obvious expectation was that everyone would interpret lower tar as lower risk.[41 42]

WITH THE ADDITION OF CARBON MONOXIDE TESTING OF CIGARETTES, FILTER VENTS BECAME VIRTUALLY A REQUIRED DESIGN FEATURE FOR LOWER-TAR CIGARETTES

Ironically, the addition of a gas phase toxin to the standard measurements in 1979 was intended to reduce the risks of smoking, but, instead, it probably contributed to filter ventilation being a key design feature, because it was the dominant way to reduce carbon monoxide yields.[10 43–45] A highly effective cellulose acetate filter, while blocking tar and nicotine, will essentially let carbon monoxide pass through.

WHAT IS THE PROBLEM WITH FILTER VENTS?

We have reviewed the problem with vents in detail previously.[2] In brief, vents facilitate the taking of larger puffs, are subject to being blocked with fingers or lips, and contribute the illusion of lower yields. This historical analysis indicates that filter vents were seen as the best way to produce lower yields cigarettes that would be acceptable to consumers, a finding consistent with the historical work of King and Borland on Australian cigarettes.[46] Although King and Borland were unable to fix the date of introduction of filter ventilation commercially in Australia (see p 87), their earliest dates for the idea of punching holes was 1965—after, for example, the *British Medical Journal* letter in 1959[5] and the advertising of filter vents in 1964 (fig 1).

IF FILTER VENTS ARE CRUCIAL TO MEETING YIELD MAXIMUMS, THEN BANNING VENTS COULD INCREASE THE PUBLIC HEALTH VALUE OF YIELD MAXIMUMS

Previously, we and others have argued for the banning of filter vents.[47 48] However, for more lightly ventilated cigarettes, this would likely mean little change beyond slight changes in sensory effects.[49] We propose that a ban on filter vents be linked with a very low maximum yield regulation (say 5 mg tar, 0.5 mg nicotine, 5 mg carbon monoxide (CO)), to have maximum benefit for public health. Even if ISO tests are not revised to better model compensatory smoking, our arguments lead to emphasising the establishment of low maximum yields, as a key deficiency of the ISO standard may lie in not accounting for ventilation.[50]

In our study of filter ventilation in samples of cigarettes in Canada, the USA and the United Kingdom, we found filter vents on *all* brands at or below the 10 mg tar, 1.0 mg nicotine, and 10 mg CO.[51] In a recent analysis of changes in cigarettes in the UK with the introduction of the lower European Union (EU) maximum, vents were also found to be a key way the industry dealt with the regulation.[52] A recent analysis of popular UK cigarette brands found that the machine generated tar yield with vents fully blocked (50 ml puffs, every 30s), was 30 mg, three times higher than the maximum tar yield permitted under the current EU 10-1-10 standard (Clifford Watson, personal communication 2006).

If companies were forced to meet yields without reliance on filter ventilation, it is likely that they would need to use less tobacco per cigarette as well as improved filtration and would need to emphasise decreased burn-time.[53] It is unclear how easily smokers would be able to adjust to these redesigned cigarettes. Many smokers would likely find them difficult and unpleasant to smoke which might facilitate them cutting back or quitting smoking. These cigarettes could be viewed as truly safer by virtue of increasing quitting. Even though some smokers may be tempted to remove effective filters, they would likely be no worse off doing this than smoking their currently vented high tar yielding cigarette; also, it would be an obvious act of subversion rather than the insidious acts of unwittingly taking bigger puffs or blocking vents with lips or fingers on vented-filter cigarettes.

Of course, there is the concern that cigarette companies will have other weapons to use to make low-tar, low-nicotine, low CO cigarettes that are highly compensatable.[54] This may be true, but it is unlikely that other design changes would be as effective as filter ventilation. Early research showed that paper porosity coupled with larger puffs increases ventilation rather than decreases it.[55] Also,

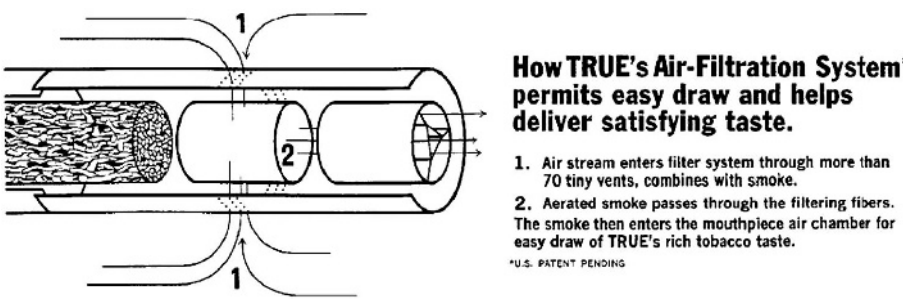

Figure 2 This represents text and a figure taken from a portion of a full page advertisement in the *New York Times* on 29 April 1966. The filter ventilation system is featured.[36] The actual image is taken from a later announcement, with the same copy and diagram, but is used because of the much higher quality of the image.[37]

What this paper adds

Filter vents are the dominant design feature of the modern cigarette determining machine-measured tar, nicotine, and carbon monoxide yields. Some researchers have argued that vents ought to be banned as deceptive to consumers. Current tar, nicotine, and carbon monoxide standard yield maximums do not promote the marketing of less hazardous cigarettes.

The commercial use of filter ventilation was precipitated by the 1964 United States Surgeon-General's report and further advanced by the creation of an official Federal Trade Commission test, and still further advanced by the inclusion of carbon monoxide measurement in the standard test. Ultimately, filter ventilation became necessary to construct nominally very low tar cigarettes. Banning filter ventilation as a design feature could make cigarettes less palatable, when combined with a low maximum yield standard, and perhaps foster smoking cessation or the use of clearly less hazardous nicotine delivery systems.

governments might require cigarette makers to inform them about other design changes, or perhaps even prohibit design alternations without permission so that the intended benefit of lower tar yields could be realised.

It is our opinion that real public health benefit might be gained by setting a significantly lower maximum, say, 5 mg tar, 0.5 mg nicotine, and 5 mg CO per cigarette without vented filters. In 1999, UK Action on Smoking and Health (ASH) and *The Observer*[56] commissioned tests that looked at the effects of blocking all the vents on two brands on ISO tar and nicotine yields. Unblocked the ISO yields for Silk Cut Ultra were 0.16 mg. nicotine and 1.4 mg tar; fully blocked, the nicotine was 1.21 mg nicotine and 12.3 mg tar. This Silk Cut Ultra was about 84% filter vented.[51] Marlboro Lights started out at 0.54 mg nicotine and 6.3 mg tar; fully blocked, the nicotine rose to 0.77 mg and the tar to 10.5 mg. Marlboro Lights were at that time about 45% filter vented. These results indicate that banning vents would likely decrease the range of standard yield differences among cigarettes. Note that the lowest tar and nicotine cigarette on the UK market would fail to meet the EU requirements if vents were blocked.

The dream of a consumer *acceptable* cigarette that would be much lower in risk has not and probably will never become a reality. History has taught us that a safer cigarette is not one that involves the relatively low-technology solution of holes punched in filters (notwithstanding that high-speed, precision filter ventilation is not easy to accomplish). Filter vents should be banned and then, at the same time, maximum tar, nicotine, and CO yields reduced. Reduced desirability cigarettes may also be a key aspect of their reduced risk.[57]

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ITCPE online supplement

The ITCPE online supplement from the Framework Convention on Tobacco Control (Tobacco Control 2006 Jun; 15 Suppl 3) titled: Evaluation of the FCTC: results from the International Tobacco Control Policy Evaluation Project (ITC Project) is now available online at: http://tc.bmjjournals.com/supplements.shtml