

RESEARCH PAPER

A tobacco industry study of airline cabin air quality: dropping inconvenient findings

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Objective: To examine an industry funded and controlled study of in flight air quality (IFAQ).

Methods: Systematic search of internal tobacco industry documents available on the internet and at the British American Tobacco Guildford Depository.

Results: Individuals from several tobacco industry companies, led by Philip Morris, designed, funded, conducted, and controlled the presentation of results of a study of IFAQ for the Scandinavian airline SAS in 1988 while attempting to minimise the appearance of industry control. Industry lawyers and scientists deleted results unfavourable to the industry's position from the study before delivering it to the airline. The published version of the study further downplayed the results, particularly with regard to respirable suspended particulates. The study ignored the health implications of the results and instead promoted the industry position that ventilation could solve problems posed by secondhand smoke.

Conclusions: Sponsoring IFAQ studies was one of several tactics the tobacco industry employed in attempts to reverse or delay implementation of in-flight smoking restrictions. As a result, airline patrons and employees, particularly flight attendants, continued to be exposed to pollution from secondhand smoke, especially particulates, which the industry's own consultants had noted exceeded international standards. This case adds to the growing body of evidence that scientific studies associated with the tobacco industry cannot be taken at face value.

The first calls for restricting smoking on commercial aircraft came in December 1969, when consumer advocates Ralph Nader and John Banzhaf filed separate petitions with the US Federal Aviation Administration (FAA), which was responsible for aircraft safety. Nader requested ending onboard smoking entirely, characterising smoke as an annoyance and a health hazard.^{1,2} Banzhaf asked for separate sections for smokers on the grounds that passive smoking was hazardous.³ The FAA studied the issue, finding eventually that exposure to tobacco smoke was unlikely to be "injurious to the health of nonsmokers", and declined to take action. The reformers then took their case to the Civil Aeronautics Board (CAB), which regulated economic issues related to airlines; the CAB proved more receptive.¹ These events marked the beginning of a 25 year fight for smoke-free flights worldwide.

By 1972, several US carriers had voluntarily created limited non-smoking sections aboard some or all of their airplanes.^{4,5} Throughout the 1970s and early 1980s, due largely to the efforts of anti-smoking advocates and airline employees, the CAB codified that separation by publishing a series of regulations restricting onboard smoking, mandating separate seating of smokers and non-smokers (1973), segregation of cigar and pipe smokers (1979), and provision of a non-smoking seat to any passenger who requested one (1981).¹ Tobacco industry response to CAB actions took many forms, including letter writing campaigns, petition drives, and surveys aimed at persuading the CAB that the flying public did not support attempts to regulate smoking or that existing restrictions were adequate.⁶⁻¹⁰ During this period, industry opposition to potential restrictions on smoking centred on ideas of unfair or unequal treatment of smokers.¹¹

Knowledge of the health dangers of secondhand smoke accumulated rapidly in the 1980s after the first studies linking passive smoking with lung cancer appeared in 1981.¹²⁻¹⁵ Three important scientific consensus documents were published in 1986. The US Surgeon General issued an

entire report about secondhand smoke, *The health consequences of involuntary smoking*, concluding that secondhand smoke caused lung cancer in non-smokers and that "simple separation of smokers and nonsmokers within the same airspace may reduce but cannot eliminate nonsmoker exposure to environmental tobacco smoke [ETS]".¹⁴ The National Research Council published *Environmental tobacco smoke: measuring exposures and assessing health effects*, which concluded: "Considering the evidence as a whole, ETS increases the incidence of lung cancer in non-smokers."¹⁵ Finally, the National Academy of Sciences (NAS) published *The airliner cabin environment*, which highlighted the problem of secondhand smoke and closed by "unanimously and forcefully proposing that smoking be banned on all commercial flights within the United States".¹⁶ (The Department of Transportation later rejected the NAS proposal on grounds that further study was needed.¹⁷)

The tobacco industry understood the important symbolic value of restricting smoking on airplanes; a 1988 a Philip Morris (PM) report "Action plan for ETS in Europe" recognised that "In-flight restrictions receive broad publicity and encourage the adoption of other prohibitions elsewhere".¹⁸ Faced with a direct assault on in-flight smoking coupled with increasing publicity about the dangers of secondhand smoke, the industry adopted the same strategy it had started using in the mid 1980s in efforts to resist demands for smoke-free workplaces and public places¹⁹⁻²⁴:

Abbreviations: CAB, Civil Aeronautics Board; CIAR, Center for Indoor Air Research; ETS, environmental tobacco smoke; FAA, Federal Aviation Administration; IAQ, indoor air quality; IFAA, International Flight Attendants Association; IFAQ, in flight air quality; NAS, National Academy of Sciences; PM, Philip Morris; RSP, respirable suspended particles; TNO, Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek (Netherlands Organization for Applied Scientific Research)

redirecting attention from secondhand smoke to the broader issue of indoor air quality (IAQ).^{25–27} In 1987, PM began to discuss conducting studies of in flight air quality (IFAQ) with the objective of resisting smoking restrictions and reversing “scientific and popular opinion that ETS is harmful to health”.²⁸ We describe how PM conceived of, and the industry executed, one such study of air quality on the Scandinavian airline SAS, excised results that did not serve the industry’s interests, and eliminated statements regarding the study’s health implications.

METHODS

We analysed tobacco industry documents available on the internet as a result of tobacco litigation. We searched for documents on the following websites: Philip Morris (www.pmdocs.com), the Tobacco Institute (www.tobaccoinstitute.com), Tobacco Documents Online (www.tobaccodocuments.org), the Legacy Tobacco Documents Library (legacy.library.ucsf.edu), and the UCSF British American Tobacco documents collection (www.library.ucsf.edu/tobacco/batco). Searches were conducted from August 2002 to May 2003. We also examined paper copies of British American Tobacco Company documents from the Guildford depository identified in a manual search of the documents conducted in November 2002.

RESULTS

IFAQ study

In 1987, Philip Morris employees identified Scandinavian countries, Sweden and Finland in particular, as priority areas for action because the dangers of secondhand smoke had received extensive media coverage there and because both SAS and Finnair, the national airlines of Sweden and Finland, had contemplated or were preparing to implement smoking restrictions. Moreover, SAS’s charter airline, Scanair, planned to offer smoke-free charter flights during the winter of 1988–89. PM employees met with each airline during the summer of 1988 to discuss conducting IFAQ studies, presenting IFAQ studies as a means of addressing an issue that concerned both the tobacco industry and the airline industry: customer preference.^{17 28–31} Finnair declined to participate in an IFAQ study because it might publicly mark them as having an air quality problem³²; SAS showed more interest, however, perhaps because of its continuing attempts to address the issue of smoke in the cabin.

SAS had tested in-flight smoking restrictions twice, in 1981 and 1983, in response to customer and cabin crew complaints about smoke. Complaints from passengers had increased sharply after the introduction in 1981 of length-wise separation of smokers and non-smokers in DC-9s. Results of a passenger survey taken after the 1983 smoke-free trial indicated strong support for restrictions, especially from non-smokers. SAS analysts remained concerned, however, that SAS would lose passengers (revenue) if they implemented a permanent smoke-free policy.³³ Due to those financial concerns, SAS returned to allowing smoking. However, the report on the 1983 smoke-free trial concluded that an ongoing shift in Scandinavian public opinion would eventually lead to reconsidering such policies.^{33 34} Five years later, in the summer of 1988, SAS planned another smoke-free trial.²⁹

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 *This conclusion is surprising based on the actual results of the survey. While 7% of customers said that they had considered alternative travel arrangements because of the smoke-free policy, 5% said that they had avoided air travel because of the secondhand smoke. This difference is well within the margin of error associated with the survey. A more accurate conclusion would have been that the policy was having no effect on revenue.

At a 1988 meeting with SAS, PM International’s manager of corporate affairs, Mary Pottorff, suggested an IFAQ study funded by the tobacco industry as a means to address both industries’ customers’ preferences and to provide “scientifically sound, statistically valid data” which could “counter balance” customers who wished “to impose their preference of no smoking on all other passengers”.³¹ SAS, searching for a way to satisfy both smoking and non-smoking customers, agreed to cooperate with the tobacco industry funded study.^{31 35}

The tobacco industry and the International Flight Attendants Association

Passengers were not the only group concerned about secondhand smoke in the cabin. An SAS poll of flight attendants in 1980 found that smoke bothered 95% of all flight attendants (69% to “a great extent” and 26% to a “certain extent”). Finnair representatives reported to Pottorff that “smoke accumulation in the back of DC 10’s [sic] has been given as a reason their flight attendants don’t want to work in the aft cabin”, and also that in response to complaints Finnair had “reconfigured the aft cabin galley and non-smoking areas on the Airbus in an effort to minimize the impact of ETS in the aft cabin”.³²

PM recognised the need to neutralise flight attendants’ concerns and sought the help of flight attendant unions and associations in order to spread its IFAQ message.^{26 36} Philip Morris had established a relationship with the International Flight Attendants Association (IFAA) in 1987, when PM agreed to be a sponsor of the IFAA 7th World Congress. PM’s 1988 public relations plan included “convey[ing] the story of the broad issue of IFAQ and the minimal role of ETS at the IFAA Congress in October”.²⁶ PM’s letter to IFAA president Peter Tronke outlining the terms of PM’s sponsorship included stipulations that PM could provide an “independent” speaker to address a plenary session on the subject of IFAQ.³⁷ That speaker, Dr Phillip Witorsch, a Tobacco Institute consultant the tobacco industry used around the world to support its positions on a variety of issues related to secondhand smoke,^{38 39} spoke of all of the possible factors affecting IFAQ and dismissed the importance of secondhand smoke as one of those factors. Witorsch ended by noting that the 1986 NAS study’s recommendation to end smoking on all commercial flights seemed “unreasonable” and “inappropriate” in view of available data.⁴⁰ The IFAA granted PM a two hour IFAQ panel discussion at the 1989 World Congress featuring tobacco industry ETS/IFAQ/IAQ consultants Charles Caliendi, Larry Holcomb, and Gray Robertson.^{41–43} PM considered the relationship with IFAA valuable enough to sponsor at least three more conferences—in 1989, 1991, and 1993—usually providing funding ranging from CHF 50 000 (\$37 000) in 1987 to CHF 80 000 (\$60 000) in 1993.^{37 44–46}

PM’s relationship with the IFAA offered other opportunities to spread the industry message that smoking restrictions would do little to solve the problem of IFAQ. For example, in 1988 PM’s director of corporate affairs, EEMA region, discussed drafting a letter IFAA president Peter Tronke could mail to heads of airline attendant unions and organisations with a copy of a Tobacco Institute sponsored paper “Impact of ETS on Cabin Air Quality” with “the letters individually typed for his signature on his letterhead” and “postage [put] on the envelopes, etc.,” but, he warned, “PLEASE do not discuss such details in writing with Peter/IFAA” (emphasis in original).^{36 47} PM also planned to “encourage IFAA president to participate, perhaps host, a panel discussion on airline workplace issues, of which smoking would be a minor part”.²⁶ In 1988 Tronke sent a letter to British Airways, at PM’s request, urging the airline to

do IFAQ studies; British Airways declined Tronke's offer of help.^{41 48 49} A 1990 "PM EEC Corporate Affairs Agenda 1991" suggested using Tronke to lobby the German airline Lufthansa.⁵⁰

The documents do not reveal any direct payments to Tronke, but PM did budget money for IFAA in addition to the conference sponsorship—for example, a 1991 budget included under the heading "Special Projects" the item "IFAA \$25,000".⁵¹ A 1993 budget draft allocated IFAA \$90 000 under the heading "Support for key third parties and programs".⁵² This \$90 000 appears to be about \$30 000 more than PM contributed to support the 1993 IFAA Congress. The documents did not reveal the purpose of the additional funds.

PM saw its relationship with the IFAA as a means to add legitimacy for the planned IFAQ study, which PM sought to fund and publish without exposing industry involvement. In a March 1987 memo to PM Europe public affairs and R&D executives, PM's director of corporate affairs, EEMA Region, heralded the possibility of "negotiating a sponsorship agreement by which IFAQ studies could be funded through and published in the name of the IFAA", perhaps in order to gain legitimacy for the results. The final agreement between PM and IFAA, spelled out in a June 1987 letter to IFAA president Peter Tronke, specified that IFAA would "endeavor to have a report on such study published in scientific, medical and airline journals..."^{37 53}

Industry control

PM later abandoned the idea of publishing IFAQ study results via the IFAA, perhaps because the creation of the Center for Indoor Air Research (CIAR) by US tobacco companies in 1988 provided PM with a better mechanism for controlling such studies while obscuring industry involvement. The CIAR, while funding some independent peer reviewed research, was used as a means for paying for work that met the industry's political, legal, and regulatory needs while maintaining the fiction that it was independent of the tobacco industry.^{39 54-58} PM eventually opted to have CIAR officially fund the SAS study so that CIAR could "correctly be named as a sponsor" of the study and thereby "diminish the effectiveness of Antis [anti-smoking] PR efforts to challenge the credibility of the research".^{29 36} Efforts to obscure the study's origins suggests concern that public knowledge of industry participation might expose the research to criticism.

In addition to funding its portion of the IFAQ study through CIAR, PM sought other ways to obscure industry participation in the SAS IFAQ study. Final plans called for "ETS whitecoats" to publish the study in airline trade press and scientific and medical journals.^{29 36} ("Whitecoats" were "independent" scientists PM hired to conduct research intended to dispel concerns about the health risks of SHS as part of the industry's secret "International ETS Consultancy Project".^{57 59}) As a June 1988 memo by Pottorff and Stig Carlson, director, corporate affairs, PM EEMA, noted, industry law firm Covington & Burling's John Rupp (who managed industry scientific and regulatory responses to secondhand smoke worldwide, including the International ETS Consultancy Project^{59 59}) was responsible for "coordinating the selection and use" of scientists to undertake the study.³⁰ Rupp oversaw the selection of toxicologist Torbjorn Malmfors, statistician Daniel Thorburn, and occupation hygienist Arne Westlin, all three of whom were already working for PM as Nordic ETS consultants.^{30 60 61} In fact, Malmfors, "Chief Expert" PM ETS consultant in the Nordic countries, had helped form and direct the EGIL group (Swedish acronym for the tobacco industry's "Expert Group for Indoor Air") in 1987.^{62 63} As in other parts of the

world,^{39 58 59} Covington & Burling coordinated the consultants because PM recognised that, in general, ETS consultants should not appear to be working directly for the tobacco industry.¹⁸ The independence was illusionary; CIAR's draft budget for the project indicated that CIAR paid all three scientists for their participation in the SAS study,⁶⁴ though their status as PM ETS consultants was never disclosed.

Aided by the ETS "whitecoats" who eventually published the study, as well as by other industry scientists, PM employees designed a study to examine the air quality in passenger cabins of DC-9 and MD-80 aircraft on 48 representative flights.^{60 63} RJ Reynolds' Guy Oldaker, for example, assisted with the statistical methods.⁶⁵ Oldaker attended an August 1988 meeting to review the study design, wherein the participants "proceeded to go through the [proposed project design], asking questions, making comments and suggesting changes".⁶⁶ PM's Pottorff and Helmut Gaisch, industry IAQ consultant Charles Caliendi, Lorillard's V Norman, Covington & Burling's Rupp, and the three PM ETS consultants also attended the planning meeting.⁶⁶ The study proposed to measure the following: respirable suspended particles (RSP), nicotine, carbon monoxide, and carbon dioxide.

PM chose an outside laboratory, the Netherlands Organization for Applied Scientific Research or Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek (TNO) to collect data for the study, again in an attempt to cover industry involvement and provide legitimacy. "It's advisable," Pottorff and Carlson wrote in a 1988 memo, "to use government and semi governmental laboratories to conduct IFAQ research, as this factor will enhance the credibility of the research."³⁰ According to Helmut Reif, director of science and technology, PM Europe, TNO could "carry out the IFAQ tests without tobacco industry fingerprints".^{30 36} Nevertheless, PM's Reif was charged with carefully monitoring the scientific execution of the study, and Reif and his staff supervised TNO closely.^{48 67 68} According to Helmut Gaisch, PM employees coached "TNO scientifically from the earliest stages to the very last stages of the project" and "Reif and PM Senior Scientist Peter Martin have spent the last few weeks on de-bugging the TNO data and assisting TNO in making the basic statistical analysis of the results".⁶⁹ TNO then turned the data over to CIAR,^{70 71} where industry representatives could carefully control its presentation.

Deleting information

In addition to supervising TNO's data collection,⁶⁸ the industry exercised complete control over explanation and presentation of the results. As Gaisch wrote in a January 1989 status report: "The interpretation and the statistics are to be made by independent experts for the CIAR."⁷¹ Handwritten notes (author unknown) of a January 1989 meeting at the Washington DC offices of Covington & Burling attended by RJ Reynolds, PM, Covington & Burling, and EGIL, noted concerns about "inappropriate explanations"⁷² in a draft of TNO's report that highlighted high levels of exposure to secondhand smoke, and indicated that TNO should delete this information before PM could deliver the results to SAS.^{66 72 73} Pottorff stressed that it was CIAR's decision what went into TNO's report and noted that TNO had not been asked to draw conclusions and should concentrate instead on experimental techniques. Gaisch later wrote: "All chapters of the narrative part of TNO [report], going beyond the mere description of the experimental part, should be eliminated".⁷¹⁻⁷³ The group designated CIAR executive director Max Eisenberg to approach TNO to request that the lab omit the material that concerned the industry.^{71 72}

At CIAR's request, TNO removed an entire 21 page section entitled "Analysis of the results." Among the information deleted were the following conclusions^{74 75}:

- Nicotine concentrations of 10 µg/m³ were measured in the smoking sections, the tourist non-smoking section, and the two rows in front of the smoking section in the business class. In the two rows of the tourist non-smoking section in the front of a smoking section (“worst cases”) nicotine concentrations of more than 40 µg/m³ were measured.
- The respirable dust concentrations often exceeded the World Health Organization guideline of 70 µg/m³ for PM 10 particulate matter. The probability of this was about 30% in the business non-smoking section and about 95% in the other sections.
- The carbon dioxide (CO₂) concentrations in the various sections did not differ significantly. The CO₂ concentrations measured in the cabin were higher than the concentrations calculated from the data on the ventilation and the numbers of passengers in the cabin.
- The cumulative frequency distribution of the ETS components nicotine, respirable dust, and carbon monoxide were close to each other in the two smoking sections and in the tourist non-smoking section.

In addition, a table summarising the results was also deleted entirely from the executive summary, together with the following statement^{74 75}:

- The results for the environmental tobacco smoke (ETS) components, nicotine, respirable dust and CO₂ indicate that substantial longitudinal transport of cabin air takes place. Relatively high nicotine concentrations of 10 µg/m³ or more were measured in the tourist non-smoking section and in the two rows of the business non-smoking in front of the smoking section.
- The CO₂ concentrations were not significantly different in the different sections and were usually higher than calculated from the data on the ventilation system and the emission of the passengers. They often exceeded standards (1000 or 1200 ppm).

The industry in particular wanted TNO’s conclusions about RSP and CO₂ removed,^{72 76 77} possibly because RSP levels are one of the most reliable indicators of and damaging components of secondhand smoke, and because the high CO₂ levels may have been a result of the combustion process associated with smoking the cigarettes. The industry group considered the RSP levels “unexpectedly high”⁷³ and decided to double check TNO’s numbers, having another laboratory (International Technology Corporation) reanalyse the samples; International Technology Corporation confirmed TNO’s results.^{71 73 78}

The excised data demonstrate that the simple separation of smokers from non-smokers in airplanes did not protect people in the non-smoking section from secondhand smoke. Indeed, TNO observed significant migration of secondhand smoke constituents into the tourist non-smoking section. The conclusions about CO₂ concentrations also suggest that the aircraft ventilation systems were not adequate to deal with the combustion products put in the air by the burning cigarettes. Since SAS had already recognised the need to “improve the division between smokers and non-smokers”,⁷⁹ PM may have been sensitive to releasing data that underscored that need. The final report,⁷⁵ when delivered to SAS, would not give a busy executive the clear view that smoking on airplanes presented a serious air quality problem on aircraft; the original version⁷⁴ of the report, before it was revised by industry scientists and lawyers, would have.

Misleading presentation of results

In addition to managing and directing TNO’s efforts, tobacco industry interests also carefully controlled the report written

and published by “ETS whitecoats” Malmfors, Thorburn, and Westlin. On 16 March 1989, Mary Pottorff circulated a draft version of the SAS study to senior industry scientists CR Green and Guy Oldaker (RJ Reynolds), Tom Osdene (PM), A Spears (Lorillard), and Covington & Burling’s Rupp.⁸⁰ On 21 March 1989, the same group, plus the study’s authors and representatives from British American Tobacco and the Nordic National Tobacco Manufacturers Association, met in Stockholm to discuss the study further.⁸¹ After the March meeting in Stockholm, CIAR’s Eisenberg forwarded another draft of the study to the same group, asking for comments by 5 April.⁸² That further drafts were circulated is evident from comments on the draft received from Green and Spears in June. Industry lawyers, as well as industry scientists, participated in the revisions. A 30 May 1989 bill to CIAR from Covington & Burling contained charges for “continued work in connection with the SAS project, including consulting with Professor Malmfors and others in Washington and Stockholm concerning their research report, consulting with the Executive Director and Company scientists concerning the draft report and related matters, and editing the draft report...”⁸³

A substantial difference existed between the published IFAQ study results paper “Air Quality in Passenger Cabins of DC-9 and MD-80 Aircraft”⁸⁴ published under Malmfors’ authorship in the journal *Environmental Technology Letters* in 1989, and the draft report TNO had produced.⁷⁴ While the TNO draft reported standard deviations and full ranges for recorded values (reproduced in fig 1), Malmfors *et al* reported standard errors of the mean and 5%/95% range in separate tables (reproduced in fig 2 and 3). This presentation, while not wrong, is misleading, since a casual reader would probably underestimate the range of exposures. The presentation in Malmfors *et al* is unusual, since the original presentation in the TNO report provides more information in a more compact and clearer form and is a more common way of reporting such information; compare fig 1 with fig 2 and 3. This presentation is particularly important, since it is the maximum, not the mean, levels that are generally important for regulatory purposes.⁸⁵

Another important difference in presentation existed between TNO’s report and the published paper. The industry group that met at Covington & Burling in January 1989 had suggested that Malmfors compare measured levels of secondhand smoke components with existing standards. Malmfors agreed to this approach.⁷³ When the paper appeared, however, it contained a table (fig 4) that omitted RSPs on the grounds that no standard “for RSP resulting from ETS” existed. This statement ignored the fact that there were standards for RSPs in general, though not for ETS in particular. Indeed, material the industry had TNO delete from the original TNO report⁷⁴ had noted that the measured values of RSP exceeded the WHO standard of 70 µg/m³ 95% of the time in all but the business non-smoking sections.

The final industry edited paper “Air Quality in Passenger Cabins of DC-9 and MD-80 Aircraft”⁸⁴ published in the journal *Environmental Technology Letters* diverged not only from TNO’s draft report but also from earlier drafts of the paper circulated within the industry.⁸⁶ The industry was careful not only to see that the substance was presented in ways that met the industry’s needs, but also was careful in the choice of words. For example, a section title was changed from “Levels of air contaminants” to “Levels of air components.”

More significant, reporting of an important result changed considerably. TNO’s results showed that secondhand smoke levels in the tourist non-smoking section, sandwiched between business and tourist smoking sections, were much closer to levels found in the smoking sections than in the business non-smoking section, located in the front of the

Table 2 Concentrations per section. Nicotine and respirable dust (RSP) in $\mu\text{g}/\text{m}^3$ CO and CO_2 in ppm.

Component	Section	n	GM	GSD	AM	STD	Range
Nicotine	B/NS	47	3.85	2.72	6.66	9.11	0.4-50
"	B/S	48	30.8	1.79	36.1	20.9	7-104
"	T/NS	48	19.0	1.87	22.8	13.9	5-64
"	T/S	47	24.3	1.94	29.3	17.2	5-73
Respirable dust	B/NS	47	50	2.15	70	74	15-440
"	B/S	48	187	1.90	218	113	11-600
"	T/NS	48	155	1.67	176	92	45-560
"	T/S	47	187	1.71	213	105	45-500
CO	B/NS	45	0.40	2.46	0.55	2.46	0.1-1.5
"	B/S	47	0.92	1.62	1.03	0.50	0.3-2.5
"	T/NS	46	0.76	1.73	0.86	0.44	0.1-2.5
"	T/S	45	0.97	1.53	1.05	0.41	0.3-2.2
CO_2	B/NS	45	1213	1.23	1239	254	700-2000
"	B/S	47	1200	1.27	1232	282	700-1950
"	T/NS	46	1216	1.24	1244	262	650-1920
"	T/S	46	1357	1.24	1387	286	750-2100

Figure 1 Summary table of results included in the original report from TNO⁷⁴ delivered to the tobacco industry. Note that the table presents the fact that levels of several components were high and presents the range of observations.

plane. Malmfors' first draft stated: "Any such [health effects of SHS exposure] in the tourist non-smoking section would have been closer to those in the smoking sections."⁸⁶ This statement was deleted from the published version of the paper. Instead, the published version noted "the levels of measured ETS-components in [the tourist nonsmoking section] is lower than in the smoking sections",⁸⁴ which, while true, was misleading. As clearly indicated in the

original report, the levels in the non-smoking section were only slightly lower than in the smoking section.

A second significant change between the versions was in the study's attributions and acknowledgements. The draft paper reported that the CIAR had sponsored the study and had asked the authors "to give advice about the conduct of the study and to evaluate the results".⁸⁶ That statement made explicit the relationship between the authors and CIAR. The

Table 3: Average level of air components by section

	Class and section							
	BNS		BS		TNS		TS	
RSP ($\mu\text{g}/\text{m}^3$)	60	(7)	250	(18)	160	(15)	220	(21)
TRP Average reading (mV)	0.6	(0.1)	1.9	(0.1)	1.3	(0.1)	1.7	(0.2)
TRP Maximum reading (mV)	4	(0.8)	29	(4.4)	7	(0.8)	18	(3.2)
Nicotine ($\mu\text{g}/\text{m}^3$)	5	(0.9)	41	(3.6)	21	(2.5)	32	(3.5)
Concentration of CO (ppm)	0.6	(0.06)	1.1	(0.08)	0.8	(0.07)	1.1	(0.11)
Concentration of CO_2 (ppm)	1310	(41)	1310	(42)	1270	(36)	1430	(36)
Mean Relative Humidity (%)	25	(0.7)	25	(0.8)	25	(0.6)	25	(1.0)

Cell content: - Weighted mean value, all flights
- Standard error for mean value in parenthesis

Figure 2 One element of the presentation of results in the paper published by Malmfors⁸⁴; compare with the simpler and more compact presentation in fig 1. Note that the standard deviations have been replaced with the standard errors of the mean.

Table 4: Ranges in the levels of air components between flights – Business Non-Smoking (BNS), Business Smoking (BS), Tourist Non-Smoking (TNS) and Tourist Smoking (TS).

	BNS		BS		TNS		TS	
	5%	95%	5%	95%	5%	95%	5%	95%
RSP ($\mu\text{g}/\text{m}^3$)	12	180	93	540	50	400	65	560
TRP-Average	0.1	2.0	0.5	5.1	0.4	3.6	0.3	5.5
TRP-Maximum	0.6	14	4	110	1.8	20	2.3	69
Nicotine ($\mu\text{g}/\text{m}^3$)	0.8	17	13	98	4.8	62.1	15	98
Concentration of CO (ppm)	0.1	2.2	0.4	2.7	0.3	2.1	0.4	2.5
Concentration of CO ₂ (ppm)	900	1840	850	1930	860	1810	1020	1950
Mean Relative Humidity (%)	17	34	16	36	17	34	15	38

This table shows estimated quantities. For example 5% of the passengers in BNS were exposed to less than 12 $\mu\text{g}/\text{m}^3$ RSP, and 95% of the passengers in the same section were exposed to less than 180 $\mu\text{g}/\text{m}^3$ RSP.

Figure 3 One element of the presentation of results in the paper published by Malmfors⁸⁴; compare with the simpler and more compact presentation in fig 1. Note that the range has been replaced with the 5% and 95% points.

published version stated simply: "The authors have served as consultants to CIAR."⁸⁴ This carefully worded statement suggests that the authors had, in the past, worked with CIAR, and not that they were paid by CIAR to interpret and publish the present study. There was no mention of the role of the industry lawyers or scientists in the development and conduct of the study, much less the writing of the report and paper.

Since CIAR involvement in the study might raise questions of bias, PM attempted to deflect queries about the study's origins. PM provided SAS with answers to questions airline management was likely to receive when announcing completion of the study.⁸⁷ If asked who sponsored the research, for example, SAS was told to respond, CIAR, "an American-based non-profit group which sponsors research of different kinds regarding the indoor environment". If asked

Table 7: Air quality standards

	Value	Time period	Source
INDOOR AIR IN GENERAL			
Nicotine	500 $\mu\text{g}/\text{m}^3$	8 hrs	OSHA US
Carbon monoxide	50 ppm	8 hrs	OSHA US
	35 ppm	8 hrs	ASS SWEDEN
	35 ppm	1 hr	EPA US
	9 ppm	8 hrs	EPA US, WHO
Carbon dioxide	5000 ppm	8 hrs	OSHA US
	1000 ppm	8 hrs	ASHRAE, JAPAN
AIRLINE CABIN AIR			
Carbon monoxide	50 ppm		FAA US
Carbon dioxide	30000 ppm		FAA US

OSHA - Occupational Safety and Health Administration
 ASS - Workers Protection Board
 EPA - Environmental Protection Agency
 ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers
 FAA - Federal Aviation Administration

Figure 4 Presentation of international standards in paper published by Malmfors.⁸⁴ Note that the standards for particulates, which had been stressed in the original TNO report,⁷⁴ have been dropped.

about tobacco company involvement, the suggested response was “We understand that CIAR receives grants from various sources, including some from the tobacco industry”. If tobacco money is involved, how can research be unbiased? “The results were analyzed by three independent Swedish scientists” and published in a peer-reviewed journal so “the scientific integrity of the research is beyond reasonable question”.⁸⁷ Nowhere is it noted that the “three independent Swedish scientists” were also part of the tobacco industry’s International ETS Consultants project.^{59–62}

The illusion of independence was important, since the authors promoted industry positions. Although both the abstract and the body of the paper specified that “no observation of health effects were made”, the study contained a lengthy discussion of health consequences, concluding that long term health effects of exposure to secondhand smoke on airplanes “were most likely insignificant in passengers and cabin crew with or without compromising medical conditions”.⁸⁴ There were no data presented in the paper to support this statement. The authors also emphasised the effectiveness of the aircraft ventilation systems, though the paper provided no data demonstrating that ventilation systems could reduce the levels of smoke pollutants to levels deemed acceptable by international health authorities such as the WHO.⁸⁴ Indeed, the results on CO₂ in the original TNO report⁷⁴ indicated that the ventilation system was not adequate to control the combustion products from burning cigarettes. Malmfors dismissed this observation by speculating that the ventilation system “airflows, which have not been measured, are lower than intended” (emphasis added). He seemed not to consider the possibility that the ventilation system was being operated according to specification and was simply not adequate to control the levels of combustion products put into the air by burning cigarettes. Disregarding results that clearly showed secondhand smoke polluting the cabin, the paper instead pushes industry positions.

IFAQ study did not stop smoke-free policies in Scandinavia

In spite of initial enthusiasm for IFAQ studies as a means of forestalling smoking restrictions,¹⁸ PM and the rest of the industry cooled on the idea after completion of the SAS study. The dampened interest may or may not be attributable to the fact that, on the recommendation of the Nordic Council, an interparliamentary body charged with developing cooperation between Scandinavian nations, both SAS and Finnair ended smoking on all Nordic area flights effective 1 November 1989, just a few months after publication of the SAS study. News that SAS planned to host a meeting of airlines servicing the Nordic countries in an effort to have them adopt smoke-free policies^{42–88} may have discouraged further studies. A more obvious explanation is that the SAS study failed to support PM’s position that “most seats in no-smoking sections are untouched by ETS” and that “ventilation systems in aircraft are extremely efficient”.²⁷

Smoking continued on SAS outside of the Nordic region

Although SAS implemented smoking restrictions within Scandinavia, smoking continued on SAS flights to the rest of Europe and beyond. When SAS extended its smoke-free flight policy to cover all of Europe in March 1993,⁸⁹ PM reacted vigorously, applying some of the other tactics the industry deployed to resist smoking restrictions. These tactics included applying economic pressure by boycotting SAS and by attempting to create a stir in the Danish investor community (SAS is listed on the Danish stock exchange);

issuing press releases and articles calling bans “discrimination”; and mobilising Scandinavian and international smokers’ rights groups.⁹⁰ A Norwegian news item two months later, *Ban on smoking goes up in smoke*,⁹¹ reported that SAS had rescinded the expanded restrictions because “anti-smokers protest[ed]”. Although SAS denied that pressure from the tobacco industry precipitated the turnaround, PM’s Matthew Winokur, manager for worldwide regulatory affairs for PM Europe, took credit for the turnaround in a July 1993 memo to senior vice president for corporate affairs Craig Fuller. “We have had mixed results combating [voluntary smoke-free policies]. However, success is possible. SAS recently overturned its decision to ban smoking on longer flights.”⁹²

SAS went entirely smoke-free in 1997. According to an SAS press release: “We have chosen to introduce non-smoking in stages and our customer surveys show that an overwhelming majority prefer a totally smoke-free environment on board. Our surveys also show that as many as 60 percent of our passengers who smoke accept the introduction of a non-smoking policy.”⁹³

DISCUSSION

This story of the IFAQ study follows the now familiar pattern of the tobacco industry working in the shadows to fund and control studies designed and presented in a way to support industry positions on secondhand smoke. As with other secondhand smoke related issues, industry lawyers, scientists, and consultants cooperated to produce “studies” that appeared to be legitimate, unbiased scientific research but which were controlled by industry at all levels.^{54–59–94–95} For example, the industry generated a study to counter findings that showed an association between lung cancer and exposure to secondhand smoke.⁹⁴ As in the SAS IFAQ study, several participants, including an industry scientist as well as a representative of Covington and Burling, were unacknowledged.

PM conceived of IFAQ studies as part of an overall strategy to “reverse scientific and popular opinion that ETS is harmful to health” and restore the “social acceptability of smoking”.²⁷ IFAQ studies were to provide a means for spreading the industry’s message that secondhand smoke was an insignificant factor in air quality onboard aircraft.¹⁹ Tobacco industry funded IFAQ studies, like those funded by governments and non-governmental organisations, clearly showed that secondhand smoke polluted aircraft in which smoking was permitted.⁸⁵ Four industry funded studies (including the SAS study) yielded similar concentrations of contaminants as did government and airline sponsored studies but offered different conclusions.⁸⁵ In the SAS example, the industry chose to disregard the study’s implications and focused instead on propagating its message that secondhand smoke on airplanes posed no health risk to passengers and crew and that adequate ventilation would alleviate problems perceived to be created by secondhand smoke.

The industry also avoided comparing RSP and other secondhand smoke components with values collected on flights during which smoking was not permitted, despite suggestions from its own employees to do so.⁹⁶ Indeed, other studies done by non-industry sources demonstrated that RSPs in smoke-free airliner cabins were generally below 10 µg/m³,⁸⁵ well below those observed when smoking was present and well within accepted standards of exposure.^{84–97–99}

Sponsoring IFAQ studies was but one of several delaying tactics the industry employed in its efforts to reverse or delay implementation of in-flight smoking restrictions. For example, the industry fought smoking restrictions at the legislative and regulatory levels,^{100–105} pressured individual airlines that instituted restrictions,^{90–106–108} and generated letter writing

What this paper adds

The tobacco industry has used consultants and other third parties to mask involvement in second hand smoke studies and to argue that ventilation is a solution to problems posed by secondhand smoke.

The industry used an identical strategy to fight airline smoking regulations. Industry lawyers and scientists edited report results to downplay the health risks of secondhand smoke. The authorship disclosures did not describe fully the level of industry involvement in designing, executing, and interpreting the results. This case adds to the growing body of evidence that no scientific studies associated with the tobacco industry can be taken at face value.

campaigns from “consumers” protesting proposed or actual restrictions.^{109–114} Overall, industry tactics helped slow implementation of no smoking policies: SAS and many other airlines permitted smoking for almost 20 years after activists first called for eliminating the practice. As a result, airline patrons and employees, particularly flight attendants, continued to be exposed to levels of pollution from secondhand smoke, particularly particulates, that the industry’s own consultants had noted exceeded international standards in the late 1980s.

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