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Submission to the Legislative Council
Bills Committee on Smoking (Public Health) (Amendment) Bill 2005

Further Comments by British American Tobacco on 24 October 2005 Meeting

OVERVIEW

On 24 October 2005 the Legislative Council Bills Committee on Smoking (Public Health) (Amendment) Bill 2005 ("Bills Committee") received views on both the health effects of environmental tobacco smoke ("ETS") and on the possible effect of ventilation in reducing exposure to ETS from Mr. James Repace and from Dr. Christopher Proctor.

This further submission seeks to comment on the credibility and validity of the evidence provided by Mr. Repace to the Bills Committee. With regard to Mr. Repace's assertion that 150 catering workers died from ETS each year in Hong Kong, we want to point out that such calculation involves the application of an aged, overseas risk model to local data. The inapplicability of the overseas model to local situation as well as questions over the validity of the local data make the 150 deaths claim unconvincing. While we believe that ETS is an issue of public importance, we also strongly believe that the risk of exposure to ETS has been overstated. Most studies on ETS and chronic health effects in non-smokers to date are not definitive and at most suggest that if there is a risk from ETS exposure, it is too small to measure with any certainty.

Mr. Repace also argued that tornado-like levels of ventilation are necessary to reduce ETS risks. Unfortunately, such assumption is based on exaggerated risks models, and assumes that levels of ETS should be taken to levels far lower than current air quality standards dictated. Nowadays, ventilation is routinely used and has been proven effective worldwide in reducing contaminants to acceptable levels. Tobacco smoke, containing the common gases from combustion and airborne particulate, can surely be reduced to level that meets government-mandated indoor air quality standards through application of various solutions including but not limited to ventilation, filtration, segregation and separation.

We believe that ETS should not be singled out for special treatment. The constituents of ETS should be regulated on the same basis as the same substances originated from other sources. Regulations should protect staff against involuntary exposure and to unacceptable levels of contamination. We therefore propose that hospitality operators should be given the choices of either providing compliant air quality standards throughout the premises through natural or mechanical ventilation, or providing a "protected" environment for staff by enclosing customers when they choose to smoke in smoking lounges or booths.

The following sets out the rationale behind our views stated above in detail.

1. CREDIBILITY OF MR. REPACE AND HIS ARGUMENTS

1.1. Self Referential

Mr. Repace cited the following references as the basis used in reaching his arguments that 150 catering workers died from ETS each year and ventilation of tornado-like rates is required to attain a safe level of ETS:

- Repace et. al. *Passive Smoking and Risks for Heart Disease and Cancer in Hong Kong Catering Workers*. Hong Kong Council on Smoking and Health, Report No. 8 (2001)
- James Repace. *Controlling Tobacco Smoking Pollution*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc, ASHRAE IAQ Applications Vol. 6, No.3 (2005)

Moreover, in providing an estimate on the number of lung cancer deaths from secondhand smoke in the US and the UK, Mr. Repace cited further the following:

- Repace JL, and Lowrey AH. *A Quantitative Estimate of Nonsmokers' Lung Cancer Risk From Passive Smoking*. Environment International 11: 3-22 (1985).
- Repace JL, and Lowrey AH. *An Indoor Air Quality Standard For Ambient Tobacco Smoke based on Carcinogenic Risk*. N.Y. State Journal of Medicine: 85: 381-383 (1985).
- Repace JL, and Lowrey AH. *Risk Assessment Methodologies in Passive Smoking-induced Lung Caner.* Risk Analysis, 10: 27-37 (1990).
- Repace et. al. *Air Nicotine and Saliva Cotinine as Indicators of Passive Smoking Exposure and Risk*. Risk Analysis 18: 71-83 (1998).
- Repace. *A Killer on the Loose – An Action on Smoking and Health Special Investigation into the Threat of Passive Smoking to the UK Workforce* (2003).

By looking at these references, it becomes apparent that all the research and studies cited by Mr. Repace to support his arguments were works conducted by himself and his co-workers. The fact that Mr. Repace's arguments are largely self referential has a serious implication on the validity and limitation of his claims.

1.2. Tornado Assumption Not Peer-reviewed

We are concerned that evidence used in support of a ban on smoking in indoor spaces has been characterised by hyperbole rather than scientific accuracy.

It greatly calls into question the quality of the "expert" evidence provided by Mr. Repace when he claims that "tornado strength" ventilation is required to clear ETS. The source is an assertion by Mr. Repace himself in a commercially produced study that was not subject to peer review and provided no scientific evidence to substantiate the claim, and followed two years after his 1998 receipt of the Action on Smoking and Health Certificate of Appreciation and the Americans for Nonsmokers' Rights Plaque of Appreciation.

The claim is a logical absurdity as tornados and hurricanes do not only ventilate houses but destroy them, and should not form part of a serious debate about the health welfare and livelihoods of many Hong Kong citizens.

It is the exaggerated risk model that leads to the conclusion that a "tornado" like air flow would be needed to reduce ETS risks. Mr. Repace assumes that respirable particles from ETS should be taken to levels far lower than current air quality standards dictated. Unsurprisingly, the predicted amount of air movement is so large that it would appear as unpractical.

1.3. Applicability of Mr. Repace's Overseas Assumption and Validity of Hong Kong Data

Mr. Repace's estimate that 150 catering workers died from secondhand smoke each year in Hong Kong was based on a study conducted by the Hong Kong Council on Smoking and Health ("COSH") and Repace in 2001, which applied an overseas, aged risk model by Repace and others (Repace et al., 1998) to local data. From simply looking at the summary table presented in the COSH report suggest that the US-specific assumptions used in developing the risk models have been applied to Hong Kong data on ETS exposure. Obviously, many of these US-specific assumptions are hardly applicable to Hong Kong. For example:

Assumption on US Smoking Demographic		Hong Kong Smoking Demographic
• That one in three US adults smoke, at an average of 32 cigarettes per day	**VS.**	• In Hong Kong, only one in 6.5 adults smoke, at an average of 14 cigarettes per day (Tobacco Control Office, 2003)
• That 38% of men and 30% of women in the US smoke	**VS.**	• In Hong Kong, 26.1% of men and 3.6% of women smoke (Tobacco Control Office, 2003)

These assumptions, many of which rely on statistics from the US rather than Hong Kong, have not been clearly presented, making it very difficult to assess the likelihood that the assumptions are reasonable. However, from what is known of the epidemiology of ETS, it seems that 150 deaths per year in hospitality workers is an enormous exaggeration, and may well actually be zero.

The COSH study also calls into question the validity of the local data on ETS exposure. The study does not record any deaths, but rather uses data on exposure to nicotine collected in 165 people to estimate exposure to ETS, makes a series of assumptions including that the amount of exposure recorded just one time in 2001 will be the same over the next 40 or so years, which is unlikely to be an accurate measure of even current exposure, let alone long-term exposure. Another assumption is that hospitality workers work in the same type of environment for 40 or so years, which is again unlikely as few hospitality workers work in the same job over a 40-year period.

The COSH study also assumes that the risks associated with passive smoking for heart disease are ten times those for lung cancer. We want to point out that this is an unsustainable assumption since the whole set of published epidemiological studies on passive smoking (See ANNEX 1) does not support this assessment. The published studies show relative risks for lung cancer and heart disease both close to one. Moreover, given that the relative risks for active smoking are far greater for lung cancer than heart disease, it would seem extremely unlikely that the risks for passive smoking would be greater for heart disease than lung cancer.

For a full list of the other assumptions used in developing the risks models based on earlier publications of Mr. Repace and co-workers, please refer to ANNEX 2.

2. HEALTH RISKS - ETS IS DIFFERENT FROM ACTIVE SMOKING

ETS is a dilute mixture of sidestream and exhaled mainstream smoke. The chemical and physical properties of secondhand smoke and active smoking are very different. Also, the route of inhalation for them vary as ETS tends to be breathed through the nose, while mainstream smoke is breathed through the mouth. As a result, ETS exposure is much lower than that of active smoking.

The concentrations of the various substances that make up ETS are generally extremely low and many of the chemicals that are present in the ETS are, irrespective of smoking, likely to be emanated from other sources and present in the air anyway. Therefore, scientists and public health groups decided that separate epidemiology was needed on ETS exposure, rather than extrapolations from smoking.

While we agree that ETS is an issue of public importance, we also strongly believe that the risk of exposure to ETS has been overstated.

It is also important to note that most scientists accept that there is a threshold for carcinogenesis and other disease processes. That is, while a substance taken at high concentrations may cause disease, there may be no detectable health risk to exposure to the same substance at lower concentrations.

It is our view that studies on ETS and chronic health effects in non-smokers are weak and unconvincing against normal standards (See ANNEX 1). Where a statistically significant association was reported, the magnitude of relative risk reported was so small i.e., typically below 2.0, that it would be generally regarded as too weak, by normally accepted epidemiological standards, to form a basis for public health policy. For example, Baroness Jay of Paddington, providing Her Majesty's Government's view on relative risk factors, stated that "A stronger association - of greater than 2 - is more likely to reflect causation than is a weaker association - of less than 2 - as this is more likely to result from methodological biases or to reflect indirect associations which are not causal."

Small increases in relative risk are sometimes reported in percentage terms. A relative risk of 1.2, for example, is often popularized as 20% increase in risk, giving an impression that if 100 people were exposed to the risk, 20 of them would contract the disease. This is highly misleading. A 20% increase in a number - which is small - produces a number that is still small. Again, as Baroness Jay of Paddington noted "The practical significance of risk factors, also needs to be considered and depends on how great is the underlying risk. Doubling a very small probability (risk) - say one in 10,000,000 - still results in only a very small risk of illness." If the relative risk is not statistically significant, then it cannot be ruled out with the scientifically accepted level of certainty that there was no increased incidence of the disease.

Most studies on ETS and heart disease do not report statistically significant increases in risk. Given that the coronary heart disease relative risks for active smoking are substantially lower than the risks for lung cancer, it seems implausible that an effect in non-smokers could be detected. A report of the United States Surgeon General in 2000 noted that "because smoking is but one of the many risk factors in the etiology of heart disease, quantifying the precise relationship between ETS and this disease is difficult." Writing an Editorial in the New England Journal of Medicine, Professor John Bailar stated "I regretfully conclude that we still do not know, with accuracy, how much or even whether exposure to environmental tobacco smoke increases the risk of coronary heart disease."

3. VENTILATION EFFECTIVENESS

In today's world, ventilation is routinely used to reduce the level of contaminants to acceptable levels – whether in the form of natural ventilation by opening a window to the outside, or mechanical ventilation by using fans to push "fresh" air into a building and extract stale air from it.

In a modern commercial or industrial environment every space is contaminated with gases and particles. This is even true for hi-tech "clean rooms" where the highest standard permits one particle larger than 0.5 microns in any given cubic foot of air. This is an extremely high standard but is routinely achieved with the application of ventilation and filtration technology at obviously vastly less than "hurricane" strength airflows.

These are extreme and expensive examples. In Hong Kong, "Good Class" grading as specified by the Environmental Protection Department's "Indoor Air Quality Objectives for Offices and Public Places" are used in other circumstances where the level of contamination is less critical and the costs and logistical inconvenience far outweigh the benefits.

Tobacco smoke is clearly a significant contributor to indoor air quality in Hong Kong, containing the common gases from combustion and airborne particulate. Real world experience shows that with effective ventilation and if necessary segregation, it is possible to reduce this contamination to level that meets "Good Class" air quality standards and certainly below the level experienced from time to time in many Hong Kong streets.

The attached "Black Dog" study sponsored by the Hotel Association of Canada (See Attachment) shows that using the sort of pressure ventilation used in operating theatres (at a much more cost-effective level) tobacco smoke can effectively be kept out of a non-smoking area; even without a floor to ceiling partition. This demonstrates that the level of particles in such a non-smoking area (not room) was actually less than in a completely non-smoking food court, presumably contaminated by particles from the cooking processes.

Also attached are the results from one of the smoking lounges at the Hong Kong International Airport (See ANNEX 3) – which show most of the standards being met despite the presence of very heavy smoking. It should be noted that no staff work in these rooms and the exposure of the occupants is entirely voluntary. Such smoking arrangement at the airport continues to be allowed by the Hong Kong Government, showing that feasible technology is being used locally to deliver highly effective solutions already.

So total smoking ban is not the single available solution to address concerns on indoor air quality. There are other more balanced solutions, which include but not limited to ventilation, filtration, segregation and separation. The presence of smoking adds contaminants to the air but it should be up to the outlet operator how he meets the “Good Class” air quality standards – whether by banning smoking, or taking other measures to improve air quality.

There is a strong logical argument that ETS is just one of many sources of airborne contaminants, many of which merely derive from the presence of people at relatively high density in a room with particles from the clothes and skin, compounds from cleaning fluids, etc. Ventilation technology is available and in use that reduces not only ETS contaminants but also all other pollutants to meet the “Good Class” standards.

4. OVERSEAS APPROACH

Other countries have taken a variety of approaches in dealing with ETS. With a few exceptions, most countries have either no restrictions, voluntary codes, mandatory restrictions or bans with exemptions. For example, even in countries with very stringent regulations, like Norway, smoking is still allowed in areas of bingo halls that are not directly serviced by staff, recognizing that the exposure of customers is entirely voluntary and they can “vote with their feet”. Italy, Sweden and South Africa have opted for separate and ventilated smoking rooms. Malaysia has chosen to implement air quality standards, and to allow operators to choose how to achieve the standards.

5. SOLUTION FOR HONG KONG

We believe that ETS should not be singled out for special treatment. The constituents of ETS should be regulated on the same basis as the same substances originated from other sources. Regulations should protect staff against involuntary exposure and to unacceptable levels of contamination. It therefore follows that hospitality operators should be provided with two choices:

1. Provide compliant air quality standards throughout the premises through natural or mechanical ventilation, or
2. Provide a “protected” environment for staff by enclosing customers when they choose to smoke in smoking lounges or booths.

5.1. Total Ventilation

To demonstrate that ventilation can significantly reduce ETS and improve indoor air quality at large, BATHK has recently been working with the Hong Kong Bars and Karaoke Rights Advocacy ("the Advocacy") in undertaking a showcase project to upgrade the ventilation system of a selected bar venue. This project aims at improving the air quality of the entire venue, making every corner of the premise comfortable for staff and customers even when heavy smoking takes place.

Riding on BAT's global experience in this arena, we approached the ventilation project for Hong Kong by first involving an IAQ expert in the planning stage. The expert makes recommendations on the ventilation improvements required to ensure a high IAQ at a bar of the Advocacy chosen as the showcase venue. These recommendations are then developed into a concrete engineering and mechanical proposal by a qualified engineering consultant, and implemented by a selected contractor. Upon completion of the improvement works expectedly in early 2006, members of the Bills Committee will be invited to visit the showcase venue to experience the effectiveness of ventilation.

5.2. Smoking Lounge

Besides ventilating the entire venue, another feasible technology involves setting up a ventilated "smoking room". While smokers can continue to enjoy smoking at the "smoking room", effective separation would prevent ETS constituents from "leaking" out of the room and provide an environment of "Good Class" air quality for workers and non-smokers outside. Ventilation at the "smoking room" will also remove ETS constituents to very low levels before employees enter into the room to conduct cleaning works after hours.

BATHK is in the progress of undertaking another showcase project to demonstrate the feasibility of allowing smoking in "smoking rooms" in bars and karaoke in Hong Kong.

5.3. Smoking Booth

The technological development of ventilation has given rise to an open-fronted "smoking booth", which is intended to replace the traditional smoking room or outside smoking (see ANNEX 4). The air handling system of the booth pulls the air from around the smokers – including all of the tobacco smoke – and through two types of filters, which are designed to remove more than 99% of the particles from the smoke as well as harmful gases and odours before returning the cleaned air to the room.

This technical solution is highly effective as the smokers are enclosed and the airflow is powerful enough to prevent any smoke drift. Units are sold throughout Europe even in countries with very restrictive smoking regulations as there are claimed to be no emissions from the units.

We believe this solution would be applicable to bars in Hong Kong as it is relatively cheap and small and can be sited close to smokers enabling them to avoid a long walk to smoke outside the building. The booth also has an appealing outlook, which can become part of the venue rather than a place apart.

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ANNEX 1

ETS Health Studies - List of all studies published, with their relative risks

TABLE 1: Relative risk of lung cancer among lifelong nonsmoking women in relation to smoking by the husband

	Author	Year	Location	Type	Cases	RR (95% CI)		
1	Garfinkel 1	1981	USA	P	153	1.17 (0.85-1.61)		a
2	Chan	1982	Hong Kong	CC	84	0.75 (0.43-1.30)		u
3	Correa	1983	USA	CC	25	2.07 (0.81-5.25)		u
4	Trichopoulos	1983	Greece	CC	77	2.08 (1.20-3.59)	+	u
5	Buffler	1984	USA	CC	41	0.80 (0.34-1.90)		u
6	Hirayama	1984	Japan	P	200	1.45 (1.02-2.08)	+	a
7	Kabat 1	1984	USA	CC	53	0.79 (0.25-2.45)		mr
8	Garfinkel 2	1985	USA	CC	134	1.23 (0.81-1.87)		mr
9	Lam W	1985	Hong Kong	CC	75	2.01 (1.09-3.72)	+	u
10	Wu	1985	USA	CC	31	1.20 (0.50-3.30)		a
11	Akiba	1986	Japan	CC	94	1.50 (0.93-2.76)		ar
12	Lee	1986	UK	CC	32	1.00 (0.37-2.71)		a
13	Brownson 1	1987	USA	CC	19	1.68 (0.39-6.90)		ar
14	Gao	1987	China	CC	246	1.30 (0.89-1.91)		ar
15	Humble	1987	USA	CC	20	2.20 (0.76-6.56)		ar
16a	Koo	1987	Hong Kong	CC	88	1.64 (0.87-3.09)		ar
17	Lam T	1987	Hong Kong	CC	202	1.65 (1.16-2.35)	+	u
18	Pershagen	1987	Sweden	CC	83	1.20 (0.70-2.10)		ar
19	Butler	1988	USA	P	8	2.02 (0.48-8.56)		ab
20	Geng	1988	China	CC	54	2.16 (1.08-4.29)	+	u
21	Inoue	1988	Japan	CC	28	2.25 (0.77-8.85)		a
22	Shimizu	1988	Japan	CC	90	1.08 (0.64-1.82)		mr
23	Choi	1989	Korea	CC	75	1.63 (0.92-2.87)		u
24	Hole	1989	Scotland	P	6	1.89 (0.22-16.12)		uv
25	Svensson	1989	Sweden	CC	38	1.36 (0.53-3.49)		a
26	Janerich	1990	USA	CC	146	0.75 (0.47-1.20)		mrz
27	Kalandidi	1990	Greece	CC	91	2.11 (1.09-4.08)	+	ar
28	Sobue	1990	Japan	CC	144	1.13 (0.78-1.63)		ar
29	Wu-Williams	1990	China	CC	417	0.70 (0.60-0.90)	-	ar
30	Liu Z	1991	China	CC	54	0.77 (0.30-1.96)		ar
31	Brownson 2	1992	USA	CC	432	1.00 (0.80-1.20)		ar
32	Stockwell	1992	USA	CC	210	1.60 (0.80-3.00)		ar
33	Du	1993	China	CC	75	1.09 (0.64-1.85)		dmr
34	Liu Q	1993	China	CC	38	1.72 (0.77-3.87)		r
35a	Fontham	1994	USA	CC	653	1.29 (1.04-1.60)	+	ar
36	Layard	1994	USA	CC	39	0.58 (0.30-1.13)		ar
37	deWaard	1995	Netherlands	CC	23	2.57 (0.84-7.85)		u
38	Kabat 2	1995	USA	CC	69	1.08 (0.60-1.94)		mr
39	Schwartz	1996	USA	CC	185	1.10 (0.72-1.68)		arz
40	Sun	1996	China	CC	230	1.16 (0.80-1.69)		ar

41	Wang S-Y	1996	China	CC	82	2.53 (1.26-5.10)	+	u
42	Wang T-J	1996	China	CC	135	1.11 (0.67-1.84)		m
43a	Cardenas	1997	USA	P	246	1.20 (0.80-1.60)		ar
44	Zheng	1997	China	CC	69	2.52 (1.09-5.85)	+	u
46	Boffetta 1	1998	W. Europe	CC	509	1.11 (0.88-1.39)		ar
47	Shen	1998	China	CC	70	0.75 (0.31-1.78)		a
48	Zaridze	1998	Russia	CC	189	1.53 (1.06-2.21)	+	ar
49	Boffetta 2	1999	Europe	CC	66	1.00 (0.50-1.90)		ar
50	Jee	1999	Korea	P	79	1.72 (0.93-3.18)		ar
51	Rapiti	1999	India	CC	41	1.20 (0.50-2.90)		ar
52	Speizer	1999	USA	P	35	1.50 (0.30-6.30)		a
53	Zhong	1999	China	CC	504	1.10 (0.80-1.50)		ar
54	Lee C-H	2000	Taiwan	CC	268	1.87 (1.29-2.71)	+	arv
55	Malats	2000	EU/Brazil	CC	105	1.50 (0.77-2.91)		arz
56	Wang L	2000	China	CC	200	1.03 (0.60-1.70)		ar
57	Johnson	2001	Canada	CC	71	1.20 (0.62-2.30)		arv
58	Lagarde	2001	Sweden	CC	242	1.15 (0.84-1.58)		artz
59	Nishino	2001	Japan	P	24	1.80 (0.67-4.60)		ar
60	Ohno	2002	Japan	CC	191	1.00 (0.67-1.49)		acr
62	Seow	2002	Singapore	CC	176	1.29 (0.93-1.80)		u
63	Enstrom	2003	USA	P	177	0.94 (0.66-1.33)		ar
64	Zatloukal	2003	Czech Rep	CC	84	0.48 (0.21-1.09)		apr
65	IARC: Kreuzer	2004	Germany	CC	100	0.80 (0.50-1.30)		ar
66	McGhee	2005	Hong Kong	CC	179	1.38 (0.94-2.04)		ar
67	Vineis	2005	W. Europe	P	70	1.05 (0.55-2.02)		arz

Notes for Table 1

Study 33 (Du) also reported that ETS was not statistically associated with lung cancer in an earlier similar study.
Study 67 (Vineis) reported two type of analysis, each giving estimates of relative risk. The result quoted here is from the analysis of the whole cohort using Cox's proportional hazards model. A nested case-control analysis gave an odds ratio of 1.42 (0.63-3.20). Using this value rather than the result quoted above made no difference to meta-analyses of spousal smoking.

Index of exposure is based on smoking by the spouse or, if not available, the nearest equivalent as described below under 'Indices of ETS exposure used other than husband smoked'

- Study author is name of first author in publication from which data extracted, see references.
- Study year is year of that publication.
- Study type: CC case control; P prospective
- Number of lung cancers in lifelong nonsmokers are study totals for females; for specific exposures numbers may be less.
- Where necessary, relative risks and 95% confidence limits were estimated from data presented.

- Significance: + statistically significant increase at 95% confidence level - significant decrease.
- Notes: see 'Notes column' below.

Notes column:

a adjusted for age;
b based on "Spouse-Pairs Cohort" as "AHSMOG Cohort" not never smokers;
c based on data for hospital controls. Data for population controls not used as non-response rate very high;
d based on data for two control groups combined;
m lifelong nonsmoking cases and controls matched for age but no age adjustment in analysis;
p based on data for two pathological groups of lung cancer combined;
r adjusted or matched for other factors (shown below);
t based on data by radon exposure;
u unadjusted for age or other factors;
v relative risks were presented adjusted for age but only by level of exposure;
z relative risks were presented for sexes combined and assumed to apply to each sex separately, with confidence intervals weighted according to numbers of subjects by sex.

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TABLE 2: Studies providing information on risk of heart disease in relation to ETS exposure in lifelong non-smokers

Study					Endpoints		Number of heart disease cases in lifelong non-smokers		
Ref	Author	Year	Location	Type	Fatality	Disease	Females	Combined	Males
1a	Hirayama	1984	Japan	P	F	IHD	494		
2	Garland	1985	USA/California	P	F	IHD	19		
3	Lee	1986	England	CC	NF	IHD	77		41
4	Martin	1986	USA/Utah	CS	NF	PHA	23		
5	Svendsen	1987	USA	P	F,NF	IHD,IHD			69
6	Butler	1988	USA/California	P	F	IHD	80		
7	Palmer	1988	USA/?	CC	NF	MI	336		
8	Hole	1989	Scotland	P	F,NF	IHD,A/E	55		65
9	Jackson	1989	New Zealand	CC	F,NF	IHD,MI	73		230
10	Sandler	1989	USA/Maryland	P	F	AHD	988		370
11	Humble	1990	USA/Georgia	P	F	CVD	76		
12	Dobson	1991	Australia	CC	F+NF	IHD+MI	160		183
13	La Vecchia	1993	Italy	CC	NF	FMI	44		69
14	Layard	1995	USA	CC	F	IHD	914		475
15	LeVois (CPS-I)	1995	USA	P	F	AHD	7133		7758
16	Mannino	1995	USA	CS	NF	CVD	*		*
17	Muscat	1995	USA/4 cities	CC	NF	NMI	46		68
18	Tunstall-Pedoe	1995	Scotland	CS	NF	IHD		428	
19	Steenland	1996	USA	P	F	IHD	1325		2494
20	Janghorbani	1997	Iran	CC	NF	IHD	200		
21	Kawachi	1997	USA	P	F+NF	IHD+MI	152		
22	Ciruzzi	1998	Argentina	CC	NF	FMI	180		156
23	McElduff	1998	Australia	CC	F+NF	MI+MI	85		198
24	Spencer	1999	Australia	CC	NF	FMIS			91
25a	He	2000	China	CC	NF	MI/CS	115		
26	Iribarren	2001	USA	CS	NF	HD	1856		2945
27	Rosenlund	2001	Sweden	CC	NF	FMI	135		199
28	Pitsavos	2002	Greece	CC	NF	FMI/UA		279	
29	Enstrom	2003	USA	P	F	IHD	3645		2287
30	Chen	2004	Scotland	CS	NF	IHD		385	
31	Nishtar	2004	Pakistan	CC	NF	CAD	*		*
32	Whincup	2004	Great Britain	P	F+NF	IHD			111
33	McGhee	2005	Hong Kong	CC	F	IHD	225		359

Notes for Table 2

McElduff (ref 23) reported results for 3 samples. Only those for Newcastle 1992-94 are included under study 23. Results for Auckland 1986-88 and for Newcastle 1988-89 are additional to earlier reports by Jackson (ref 9) and Dobson (ref 12) and are considered under studies 9 and 12 respectively.

- The study author is usually the first author of the publication providing the data - see references.
- The study year is the year of that publication.
- The study types are CC=case control, CS=cross-sectional and P=prospective.
- Fatality is indicated by F=fatal heart disease and NF=non-fatal heart disease. F + NF implies data only available for fatal and non-fatal heart disease combined.
- Disease is indicated by A/E = angina or ECG abnormality, AHD = arteriosclerotic heart disease, CAD = coronary artery disease, CVD = cardiovascular disease, FMI = first myocardial infarction, FMI/UA = first myocardial infarction or unstable angina, FMIS = first myocardial infarction surviving 28 days, HD = heart disease, IHD = ischaemic (coronary) heart disease, MI = myocardial infarction, MI/CS = myocardial infarction or coronary stenosis, NMI = newly diagnosed myocardial infarction, PHA = previous heart attack.
- Numbers of heart disease cases in lifelong non-smokers are totals in the study; for analyses relating to specific types of exposure numbers may be less than this. For studies 16 and 31 (indicated by *) numbers were not given. For studies 18, 28 and 30, data were only provided for sexes combined. For study 6, numbers relate to the spouse-pairs cohort only, the AHSMOG cohort including ex-smokers.

ANNEX 1

TABLE 3: Relative risk of heart disease among lifelong non-smokers in relation to smoking by the spouse (or nearest equivalent)

Study Ref	Study Author	Sex	Exposure Index	Fatality	Relative risk (95% confidence limits)	Significance
1a	Hirayama	F	E	F	1.16 (0.94-1.43)	
2	Garland	F	E	F	2.70 (0.63-11.58)	
		F	C(N)	F	2.25 (0.32-15.74)	
3	Lee	M	E	NF	1.24 (0.59-2.59)	
		F	E	NF	0.93 (0.54-1.61)	
4	Martin	F	E	NF	2.60 (1.20-5.70)	+
		F	C	NF	3.40	?
5	Svendsen	M	C	F+NF	1.61 (0.96-2.71)	
6	Butler	F	E	F	1.07 (0.65-1.75)	
		F	C(N)	F	1.40 (0.51-3.84)	
7	Palmer	F	E	NF	1.20	?
8	Hole	M	E	F	1.73 (1.01-2.96)	+
		F	E	F	1.65 (0.79-3.46)	
9	Jackson	M	C	F+NF	1.06 (0.39-2.91)	
		F	C	F+NF	3.74 (1.15-12.19)	+
10	Sandler	M	C	F	1.31 (1.05-1.64)	+
		F	C	F	1.19 (1.04-1.36)	+
11	Humble	F	C(N)	F	1.59 (0.99-2.57)	
12	Dobson	M	C	F+NF	0.97 (0.50-1.86)	
		F	C	F+NF	2.46 (1.47-4.13)	+
13	La Vecchia	M	E	NF	1.09 (0.47-2.53)	
		F	E	NF	1.27 (0.52-3.09)	
		M	C(N)	NF	1.09 (0.39-3.01)	
		F	C(N)	NF	1.36 (0.46-4.05)	
14	Layard	M	E	F	0.97 (0.73-1.28)	
		F	E	F	0.99 (0.84-1.16)	
15	LeVois (CPS-I)	M	E	F	0.97 (0.90-1.05)	
		F	E	F	1.03 (0.98-1.08)	
		M	C(N)	F	0.98 (0.91-1.06)	
		F	C(N)	F	1.04 (0.99-1.09)	
16	Mannino	M+F	C	NF	1.12	?
17	Muscat	M	E	NF	1.38 (0.70-2.75)	
		F	E	NF	1.33 (0.59-2.99)	
18	Tunstall-Pedoe	M+F	C	NF	1.34 (1.07-1.67)	+

TABLE 3 (continued): Relative risk of heart disease among lifelong non-smokers in relation to smoking by the spouse (or nearest equivalent)

Study Ref	Author	Sex	Exposure index	Fatality	Relative risk (95% confidence limits	Significance
19	Steenland	M	E	F	1.09 (0.98-1.21)	
		F	E	F	1.04 (0.93-1.16)	
		M	C(N)	F	1.22 (1.07-1.40)	+
		F	C(N)	F	1.10 (0.96-1.27)	
20	Janghorbani	F	E	NF	1.38 (0.95-2.01)	
21	Kawachi	F	C	F+NF	1.53 (0.81-2.90)	
22	Ciruzzi	M	C	NF	1.18 (0.55-2.52)	
		F	C	NF	1.73 (0.89-3.36)	
23	McElduff	M	C	F+NF	0.82 (0.55-1.22)	
		F	C	F+NF	2.15 (1.18-3.92)	+
24	Spencer	M	E	NF	No significant association	
25a	He	F	E	NF	1.60 (0.94-2.90)	
26	Iribarren	M	C	NF	1.13 (1.00-1.27)	+
		F	C	NF	1.20 (1.09-1.30)	+
27	Rosenlund	M	E	NF	0.96 (0.64-1.44)	
		F	E	NF	1.53 (0.95-2.44)	
		M	C(N)	NF	0.98 (0.57-1.69)	
		F	C(N)	NF	2.59 (1.27-5.29)	+
28	Pitsavos	M+F	E	NF	1.33 (0.89-1.99)	
29	Enstrom	M	E	F	0.93 (0.83-1.04)	
		F	E	F	0.99 (0.92-1.08)	
		M	C(N)	F	0.92 (0.80-1.05)	
		F	C(N)	F	0.97 (0.89-1.06)	
30	Chen	M+F	C	NF	1.20 (0.70-2.20)	
31	Nishtar	M+F	U	NF	2.38 (1.04-5.42)	+
33	McGhee	M	P	F	1.30 (0.88-1.93)	
		F	P	F	1.39 (0.95-2.04)	

Notes for Table 3

In study 1, estimates are adjusted for the age of the husband. Alternative estimates, adjusted for the age of the subject are also given by Hirayama (1b), and are very similar.
In study 4 (exposure index E) and study 21, the estimates were given by Wells (34).
In study 8 the estimates were given by Wells (35).
In several studies (8,9,10,12,16,18,21,23,24,26,28,30,33) the index of exposure is actually based not on spousal smoking but on the nearest equivalent index (see Table 2).
See Appendix B for the covariates considered in adjusted analyses.

- The study author is usually the first author of the publication providing the data – see references.
- Exposure index: E = ever smoked (compared to never smoked); C(N) = current smoker (compared to never smoked); C = current exposure (compared to non-current exposure); P = in the past; U = undefined.
- Fatality: F = fatal; NF = non-fatal; F+NF = fatal and non-fatal combined.

• Significant (p<0.05) positive (negative) relative risks are indicated by + (or -). ? indicates not known if significant or not.

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Assumptions

From earlier publications of Mr. Repace and co-workers, it is possible to list some of the other assumption used in developing the models.

Assumptions on Exposure

	The US Demographic		An Elaboration on the applicability of the assumptions to Hong Kong
1	That one in three US adult smoked, at an average of 32 cigarettes per day	………	*One in 6.5 adult smokes at the average of 14 cigarettes a day (Tobacco Control Office, 2003)*
2	A single amount of exposure can be assigned to a home, an office, a restaurant etc	………	*It is unlikely that exposure to ETS will be the same at home, at work or at leisure. Many offices have self-regulated against smoking for many years, and ETS exposure at home will depend on many factors including size of the home, number of smokers, how often the smokers are at home and whether they smoke with windows open or shut, etc*
3	Total exposure can be calculated by simply adding up the time the population spends in each of these places	………	*This is unlikely to be applicable to Hong Kong given the above 2 factors.*
4	Employed persons, who spend between 2 and 3% of time out doors are representative of the whole population		
5	Assume that married housewives spend 20.5 hours per day at home.	………	*This is unlikely to hold for Hong Kong, or even for US housewives*
6	US worker breathe 8m^3 of air per 8 hour workshift		
7	90% of white-collar workplaces and 72.5 of blue collar workplaces allow smoking	………	*Given the 14.4% smoking incidence in Hong Kong, this is unlikely to be applicable to Hong Kong*
8	75% of all white collar workers are exposed to ETS at work, and that 50% of blue-collar workers are exposed	………	*Ditto*
9	The number of people in the workplace is a surrogate for the number of smokers Women work less hours per day than men, and that the average daily working time is 6.13 hours	………	*Number of working hours is likely to be higher in Hong Kong*
10	The average level of particulates in the workplace air throughout the 8 hour shift is 242 ug/m^3, resulting in an exposure of 1.47mg of tobacco respirable suspended particulates (RSP) per working day	………	*According to an IAQ survey conducted by Environmental Protection Department in 1995, the average indoor RSP levels at the 40 office premises were found to range from 6.8 to 163.6 µg/m^3 (mean = 29.7 µg/m^3, standard deviation = 24.2 µg/m^3).*
11	Men spend 34.4% of the waking day (with 8 hours asleep) at home, employed		

	women spend 45.9% of the waking day at home and housewives spend 81% of the waking day at home		
12	62% of homes with children have one or more smokers	………	*Given the 14.4% smoking incidence in Hong Kong, this is far from local reality*
13	38% of men and 30% of women smoke	………	*In Hong Kong, 26.1% of men and 3.6 of women smoke (Tobacco Control Office, 2003)*
14	Smoking wives smokes 22 cigarettes per day at home and the husband 11 cigarettes	………	*Smokers smoke an average of 14 cigarettes a day (Tobacco Control Office, 2003)*
15	Each cigarette smoked contributes to 0.88ug/m3 of respirable particulates in a typical home, and to 2.11 ug/m^3 in an "energy-efficient" home.*)*	………	*It is not possible to extrapolate exposure in US homes to exposure in Hong Kong homes, as many factors are very different*
16	Exposure from home averages 0.45mg per day	………	*Ditto*
17	From a study of 89 people average cotinine in saliva was1.0ng/ml for those living with a smoker and 0.8 ng/ml for those working with a smoker	………	*This study is based on a very small sample size in the US, and therefore, is unlikely to be translated to Hong Kong*

Assumptions on Risk

	The US Demographic		**An Elaboration on the applicability of the assumptions to Hong Kong**
1	Assume that in 1980, 108,504 people in the US died of lung cancer, and that 85% of these deaths were due to smoking	………	*Due to the reduction in smoking incidence, it is unlikely to apply some aging data in 1980 in the US to current situation in Hong Kong.*
2	Assume lung cancer only occurs at ages above 35 years		*This is very unlikely to be true*
3	Assume in 1980 in the US there were 29,335,000 smokers above 35 years of age	………	*See comment for Assumption #1*
4	Assume there was 3.156 x 10-3 lung cancer deaths per smoker of lung cancer age	………	*Such precision is inappropriate, and given that the underlying assumptions do not apply to Hong Kong, neither can the rate apply to Hong Kong*
5	Assume that the average cigarette had 17mg tar and the average smoke smoked 32 cigarettes a day, giving 544mg per day per smoker.	………	*Tar ceiling for any cigarette to be sold in Hong Kong is restricted below 17mg. Therefore, it is not meaningful to assume an average tar yield at 17mg. Besides, according Tobacco Control Office figure in 2003, smokers in Hong Kong smoke an average of 14 cigarettes a day.*
6	Assume that mainstream cigarette tar and ETS respirable particles have the same carcinogenic potential	………	*Science does not support this assumption. There is far less retention of ETS particles than mainstream smoke particles. ETS tends to be breathed in, and filtered through nose, while mainstream smoke was inhaled through mouth.*

7	Assume a 1980 lung cancer death is associated with a 20 to 40 year smoking history in which smoking rates doubled and tar levels halved.	………	*Due to the reduction in smoking incidence, it is unlikely to apply some aging data in 1980 in the US to current situation in Hong Kong.*
8	Assume 5.8 x 10-6 lung cancer deaths/year per mg/day per smoker.	………	*This is a mathematical assumption*
9	Assume passive smoking gives an exposure of 1.5mg per day and so annual lung cancer risk for passive smoking is 0.87 x 10-5	………	*See comment for Assumption #4*
10	Assume 63.8 x 106 passive smokers at risk, results in 555 lung cancer deaths per year in the US from passive smoking	………	*See comment for Assumption #4*
11	Take a group of Seventh Day Adventists from Southern California between 1960 and 1976 and assume few of the Seventh Day Adventists smoke or are exposed to smoke	………	*See comment for Assumption #4*
12	Take a group of non-Seventh Day Adventists from a similar place and compare the lung cancer rates with those that were Seventh Day Adventists	………	*See comment for Assumption #4*
13	Assume the entire death rate difference is due to passive smoking	………	*This is very unlikely to be true*
14	Assume all SDA are not exposed and all non-SDA are all exposed	………	*This is very unlikely to be true*
15	Assume there are no differences between men and women		*This is very unlikely to be true as there are obvious differences between men and women for lung cancer and heart disease risks*
16	Assume there are no other differences between the groups	………	*This is very unlikely to be true*
17	Assume, using the differences that ETS is associated with 4,666 lung cancer deaths per year in the US	………	*This is very unlikely to be true* *See comment for Assumption #4*
18	Assume a relative risk of lung cancer from workplace exposure is 2	………	*WHO suggested an assumption that uses a relative risk much higher even than that*
19	Assume a linear dose response relationship	………	*While there are clearly dose response relationships for active smoking and lung cancer and heart disease, they are not always linear*

Smoking Lounge Sponsored by BAT HK (Lounge 5.3)

In 2000 – 2003, British American Tobacco sponsored to set up and maintain a smoking lounge with the state-of-the-art ventilation system in the Hong Kong International Airport, catering the needs of smoking travellers who are unable to smoke in open areas due to security reasons. The Lounge was designed based on two international standards for smoking area. They are widely adopted by building engineers in designing ventilation to maintain acceptable indoor air quality.

1. **ASHRAE Standard 62 – 2001 (USA)** (American Society of Heating, Refrigerating and Air-Conditioning Engineers)
2. **CIBSE Guide A (UK)** (Chartered Institution of Building Services Engineers)

Based on the results of an independent study that measured the indoor air quality of the smoking lounge as compared to the EPD IAQ objectives, the air quality of the lounge was considered satisfactory. This case demonstrates that even in the most congested environment concentrated with tobacco smoke, an advanced and properly managed ventilation system is still effective in ensuring high indoor air quality. The Hong Kong Airport Smoking Lounge experience can serve as an important reference for the government in addressing the ETS issue in catering and entertainment premises.

The Ventilation system

- The ventilation system adopted the concept of "Displacement Flow" and "Localized Source Control" to maximize the ventilation effectiveness and to reduce the level of pollutants.
- The raised-floor ventilation system ensured treated air to supply via floor grills from the adjacent hall while the stale air was extracted and filtered via ceiling exhaust air grilles and vented outdoors. The floor-to-ceiling displacement flow can yield excellent thermal comfort and air quality by removing tobacco smoke.
- In addition, local exhaust points were provided at each ashtray such that tobacco smoke can be extracted locally into filters of the floor air grilles before diffusing throughout the space.
- The lounge was maintained at a negative pressure in order to avoid the tobacco smoke from entering the adjacent space.

Maintenance

Daily	Monthly	Quarterly	Annually
▪ Routine cleaning at least 4 times a day for ashtray cleaning and room maintenance	▪ Cleaning and maintenance of floor and ceiling ventilation systems, including exhaust fans, air-conditioning and bio-oxygen generator	▪ Quarterly maintenance of ductworks and filter units ▪ IAQ tests	▪ Annual ventilation and ductworks overhaul ▪ Remedial works (when necessary)

Indoor Air Quality Control

- Indoor air quality of the smoking lounge was closely monitored and controlled in accordance to EPD guidance. IAQ tests were carried out on a quarterly basis by a registered IAQ Laboratory to ensure that the indoor air quality will be acceptable to occupants.

Parameters	EPD IAQ Objectives		IAQ Test Results (on 17 Dec 2002)			
	Level 1	Level 2	Smoking Lounge	Level	Intake Air	Level
Carbon Dioxide	<800	<1,00	660	1	610	1
Carbon Monoxide	<2,000	<10,000	1,600	1	1,800	1
Respirable Suspended Particulates	<20	<180	410	> 2	58	2
Nitrogen Dioxide	<40	<150	160	> 2	110	2
Ozone	<50	<120	< 50	1	<50	1
Formaldehyde	<30	<100	52	2	49	2
Total Volatile Organic Compounds	<200	<600	180	1	170	1
Radon	<150	<200	Not Measured		Not Measured	
Airborne Bacteria	<500	<1,000	85	1	29	1
Room Temperature	20 – 25.5	< 25.5	20.5	1	20.1	1
Relative Humidity	40 – 70	< 70	51	1	47	1
Air Movement	<0.2	<0.3	0.25	2	0.21	2

Smoking Booth

ATTACHMENT

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Environmental Tobacco Smoke in the Nonsmoking Section of a Restaurant: A Case Study

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This study tested the concentrations of environmental tobacco smoke (ETS) components in a small restaurant/pub with smoking and nonsmoking areas—a facility outfitted with a heat-recovery ventilation system and directional airflow. The ETS levels in the nonsmoking area were compared with those in other similar restaurants/pubs where indoor smoking is altogether prohibited. The results indicate that ETS component concentrations in the nonsmoking section of the facility in question were not statistically different ($P < 0.05$) from those measured in similar facilities where smoking is prohibited. The regulatory implications of these findings are that ventilation techniques for restaurants/pubs with separate smoking and nonsmoking areas are capable of achieving nonsmoking area ETS concentrations that are comparable to those of similar facilities that prohibit smoking outright. © 2001 Elsevier Science

INTRODUCTION

Several studies have examined environmental tobacco smoke (ETS) concentrations and/or personal exposure in a variety of public restaurants and drinking establishments ("hospitality facilities"). Earlier studies tended to focus on either short duration area measurements or personal monitoring measurements on surrogate "customers" (Brunnemann *et al.*, 1992; Thompson *et al.*, 1989; Oldaker *et al.*, 1990; Turner *et al.*, 1992; Collett *et al.*, 1992; Lambert *et al.*, 1993). More recent investigations have focused on the personal exposure to ETS of night-club musicians (Bergman *et al.*, 1996), casino workers (Trout *et al.*, 1998), or wait staff and bartenders (Maskarinec *et al.*, 2000). With the strict segregation of smoking and nonsmoking areas in those hospitality facilities that still permit smoking, the use of directional airflow and heat-recovery ventilation systems has become increasingly popular. However, little data have been reported with which to assess the effectiveness of such systems in securing adequate air quality in the nonsmoking areas of such facilities. The intuitive benchmark for such a comparison is the air quality level in hospitality facilities where indoor smoking is prohibited. In most instances, such facilities will not be absolutely free of ETS, since smoking is often permitted immediately outside the establishments and traces of ETS components could be introduced from human and material traffic and other sources extraneous to smoking. The purpose of this study was to test a directional-flow heat-recovery ventilation and filtration system in a pub that segregates smoking and nonsmoking areas and its effectiveness in providing nonsmoking areas ETS concentrations comparable to the ETS concentrations in similar facilities where indoor smoking is prohibited.

METHODS

Two organizations were involved in the conduct of the study. The Chemical and Analytical Sciences Division of Oak Ridge National Laboratory (Oak Ridge, TN) was responsible for overall protocol development, preparation of the ETS sampling media and analysis of the collected samples, interpretation of the data, and overall reporting. Finn Projects (Toronto, Ontario, Canada) was responsible for the system conceptual design and modifications, field sampling, and real-time field measurements.

Facilities Surveyed

The facility to be studied, the Black Dog Pub, is located in Scarborough, Ontario, Canada, a suburb of Toronto. Prior to the selection of the Black Dog Pub as the test site, a number of restaurants were reviewed and inspected. The Black Dog was selected as the owner had already shown commitment to improving air quality, having previously invested in heat-recovery ventilation technology, and was willing to cooperate in retrofitting the ventilation system. Also, it was believed that the test facility should have a very high

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average occupancy and a high percentage of smokers, so that it could represent a wide spectrum of bars and restaurants.

The Black Dog Pub has a designated smoking area of approximately 110 m^2, with a seating capacity of 45 individuals. Patrons may order drinks from a bar in this area (15 seats at the bar) and/or food from several (8) tables located around the bar. A nonsmoking eating area, approximately 70 m^2 in area, with a seating capacity of 99, is located adjacent to the smoking bar/eating area. It is separated from the smoking area by a wall with two pass-through windows and by two open doorways. Patrons may order drinks or food in this area from one of 20 tables. Note that there are no physical barriers in the pass-through and doorways, in order to ensure the free flow of air from the nonsmoking to the smoking section.

Ventilation for the Black Dog Pub is provided by a 3100 ft^3/min (cfm) energy/heat recovery ventilation system (ERV or HRV), with a desiccant wheel that was retrofitted in 1999. The HRV is tied into two existing rooftop heating, ventilation, and air conditioning (HVAC) units, with a capacity of 5 tons each. The new system creates directional flow of air (west to east of the facility in Fig. 1) from the nonsmoking area to the smoking area where it is exhausted, while energy (heating and cooling) is recovered by the HRV desiccant wheel on the exhaust side. The ventilation system was redesigned such that 1600 cfm of fresh air was introduced from the west side into the nonsmoking area and 1500 cfm was introduced at the borderline between the smoking and nonsmoking areas through three new ceiling diffusers. Also, the design included two new exhausts on the opposite (east) side of the bar, near the entrance doorway, with an exhaust volume of 1550 cfm each.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE 62-99) for food and beverage service facilities prescribes a rate of 20 cfm/occupant fresh-air input for dining room areas and 30 cfm/occupant for bars and cocktail lounges. Thus, based on an occupancy of 90 in the dining room and 45 in the bar/lounge, 3150 cfm of outdoor air is required to meet this standard for the Black Dog Pub. No make-up air is provided to the pub; only 100% fresh outdoor air is provided.

The rooftop intake hood of the HVAC unit is fitted with an aluminum mesh prefilter and a secondary bank of disposable filters to remove pollen, dust, etc. The filters are replaced ever 3 months. Since 100% fresh air is used, the filtration system only needs to reduce outdoor contaminants and does not have to address ETS, cooking fumes, or other indoor contaminants. The net result is that the air flows from the nonsmoking area into the smoking area, where it is exhausted, while the energy (heat/cool) is transferred to the incoming fresh air. It is estimated that 78% of the energy is recovered by the HRV unit.

Smoke tests were carried out to ensure that the directional airflow prevented intrusion from the smoking to nonsmoking areas of the Black Dog Pub. The tests were primarily concentrated at the interface of the two sections, i.e., at the open doorway and pass-through in the walls that separate the areas (Fig. 1). Smoke tests

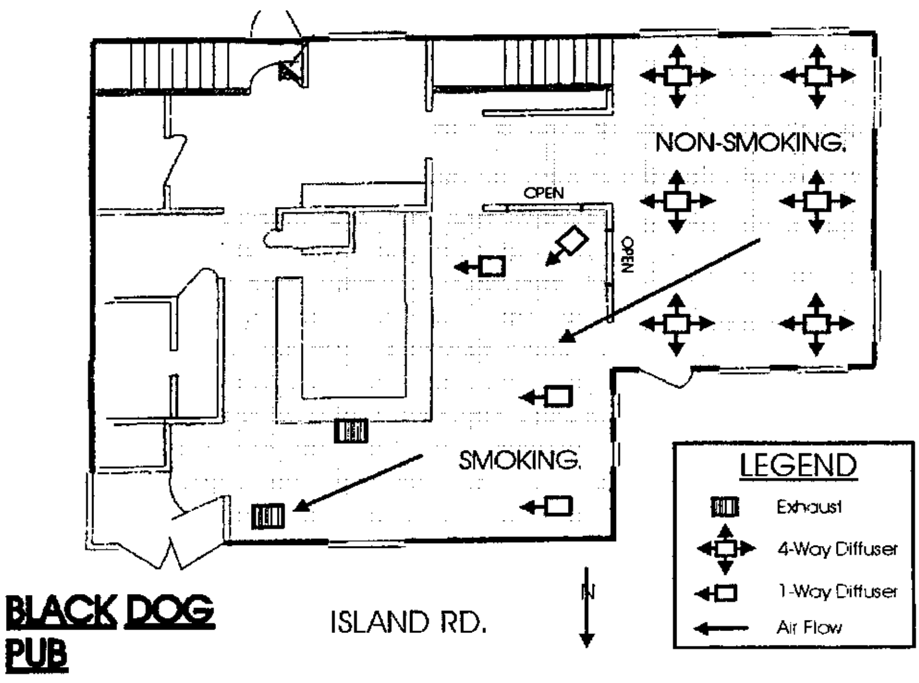

FIG. 1. Schematic diagram of layout of Black Dog Pub.

were also carried out in the smoking section to ensure effective removal of the ETS in that section as well.

Following initial sampling of the Black Dog Pub in December 2000, a purge unit was added to the HRV unit, to correct a potential carry over of the exhausted air into the fresh air stream from 4% to a much reduced 0.4%. At the same time an additional bank of filters was added downstream of the HRV to capture any nicotine/particles that might be carried over to the fresh air supply.

Control Facilities

Three "control" facilities were regulated by local ordinance as nonsmoking hospitality establishments and were used for comparative purposes. No smoking was observed in any of the facilities during the test periods.

The Eaton Centre North Food Court is located in the north end of the Eaton Centre Building in downtown Toronto. An atrium extends from the third level below grade to the second floor above grade. Three levels of escalators lead down to the food court after entering the complex from the Yonge & Dundas street level entrance, and access is also provided by elevators. The building in which the food court is contained is a regulated nonsmoking establishment. The only areas where smoking is allowed in this facility are in the restaurants located on the ground level and second floor above grade, a significant distance from the North Food Court and separated by several levels of escalators.

Facility M is located approximately 15 km southeast of Kitchener, Ontario, Canada. The building in which the facility is located is an indoor sports complex including indoor climbing walls, batting cages, a video arcade, etc. On one side of Facility M is the bar, with seating at the bar and at tables for approximately 70 people. The bar has an exit to the patio where staff and customers can smoke. On the other side of the facility is the restaurant area with seating at tables for approximately 150. The entrance to the kitchen is located in the restaurant area. In between the bar and the restaurant area is the host/hostess station at the entrance to the facility.

Facility B is located on the second and third floors of an historic hotel in downtown Waterloo, Ontario, Canada. The hotel consists of three bars, one of which is Facility B. A pool hall is located on the second floor, and a restaurant occupies the basement. One entrance to Facility B is from the stairwell at the entrance of the hotel; Facility B can also be accessed through an entrance from the pool hall. Facility B has seating for approximately 75 people on its first level and another 60 people on its second level. The entrance to the kitchen and the washrooms are located on the first level. Also on the first level is an exit to an outdoor patio with additional seating. The patio is often used as a smoking area year-round.

Details of the ventilation systems in the control facilities were not sought, for they had been installed in accordance with local building codes.

Real-Time Measurements

Respirable suspended particulate concentrations were determined in real time, using a DustTrak 8520 aerosol monitor (TSI, Minneapolis, MN). The DustTrak operates on the principle of nephelometry (light scattering by particles) and employs a 90° light-scattering laser photometer. The instrument had been recently factory calibrated using the respirable fraction of standard ISO 12103-1 for A1 test dust (Arizona Test Dust). Although data were measured continuously (once per second), data were reported as 1-min averages. For these studies, the calibration factor was maintained at 1.00. Average particle concentrations were determined by calculating the mean concentration reported from 1-min averages over the duration of the measurement interval. In each facility, the single DustTrak was colocated with an ETS component sampler in the facilities in question. In the Black Dog Pub, this was at the cashier/wait station in the nonsmoking section of the facility. In two of the other facilities, the DustTrak was located behind the bar. In the food court, the DustTrak was located in the middle of the seating section.

The carbon dioxide (CO_2), humidity, and temperature monitor used was the YES-206LH Falcon (Young Environmental Systems, Richmond, British Columbia, Canada), acquiring data at a 2-min interval. In all cases except the food court, the CO_2 (a nondispersive infrared-based sensor) and humidity/temperature sensor was colocated with the DustTrak. In the food court, the sensors were placed in the southwestern corner of the seating area. The data were measured continuously and reported as 2-min time-weighted averages.

Sampling Durations and Schedules

All facilities were sampled during a traditionally very busy time at Toronto/Waterloo/Kitchener restaurants: the week between Christmas and New Years 2000. The Black Dog Pub was sampled on two evenings, whereas the others were sampled for one evening each. Following a minor modification in the ventilation system, the nonsmoking areas of the Black Dog Pub also were resampled on two evenings in early January 2001. All facilities were sampled during what was perceived to be their busiest time of day. For the taverns, this was typically in the time period of 5:30 PM until 11:30 PM. For the food court, sampling was conducted between 10:20 AM and 3:40 PM. Sampling periods are summarized in Table 1. The number of patrons present in the facility was counted on an hourly basis and averaged over the course of the sampling period. Those data are presented in Table 1 as well.

TABLE 1
Dates and Times of Indoor Air Quality Sampling

Facility	Date	Sampling time	Average hourly patron count
Black Dog Pub			
Night 1	December 29	6:10 PM–11:30 PM	79
Night 2	December 30	5:30 PM–10:20 PM	58
Night 3	January 9	5:20 PM–11:10 PM	29
Night 4	January 10	5:10 PM–10:35 PM	25
Nonsmoking Facility M	December 27	6:20 PM–11:25 PM	123
Nonsmoking Facility B	December 28	6:20 PM–11:25 PM	34
Mall food court	December 28	10:20 AM–3:40 PM	216

Sampling Locations at the Designated Facilities

The initial sampling at the Black Dog Pub included simultaneously collecting two ETS marker samples from the smoking section and three from the nonsmoking section. The sampling locations in the nonsmoking area were located at the cashier station (immediately adjacent to the smoking station), on a fireplace (across from the opening to the smoking section), and on a window sill (south wall of the nonsmoking section) (see Fig. 1). In the second sampling at the Black Dog Pub, samples were collected only in the nonsmoking section. For the mall food court, three ETS marker samples were collected: one in the northwest corner of the food court, one in the southwest corner, and one on the east side of the court. In Facility M, five ETS marker samples were collected, one each from the following locations: left of the fireplace in the restaurant area, one at the condiment station at the kitchen entrance in the restaurant, one at the hostess station, one near the entrance to the outdoor patio/smoking area in the bar, and one behind the circular bar. In Facility B, five samples were also collected, one each in the northwest and northeast corners of the bar, one behind the bar, one near the entrance to the outside patio and smoking area, and one near the wait station.

ETS Constituent Sampling System

The sampling equipment for ETS markers and particle phase species was similar to that described by Ogden *et al.* (1996) and is now commercially available as the Double Take sampler, manufactured by SKC, Inc. (Eighty-Four, PA). Two sound-insulated constant-flow pumps are built into a single unit and were used to collect the vapor phase and particulate phase samples. Vapor phase samples were collected using XAD-4 cartridges (Cat. No. S2-0361, SKC, Inc.) at a rate of approximately 1.1 L/min. Particulate phase samples were collected using 37-mm Fluoropore filters at a flow rate of 2.2–2.3 L/min, through a BGI-4 (BGI, Waltham, MA) cyclone separator. The cyclone vortex provided a 50% cutoff of particles of 4-μm diameter. Primary differences between the sampling system described by Ogden *et al.* (1996) and the units used in this study were the use of two pumps in a single unit, an opaque conductive plastic sampling train for the particles, and a modified cyclone vortex. Particle phase markers determined as part of this study were ultraviolet-absorbing particulate matter (UVPM), fluorescing particulate matter (FPM), and solanesol. The filter cassette was fabricated from opaque conductive plastic. A cyclone vortex assembly preceded the filter cassette, such that the material collected on the filter was all of respirable (50% cutoff at 4 μm mass median aerodynamic diameter) size. The sampling systems were assembled in a nonsmoking office area in a building geographically removed from the establishments to be sampled, using the following procedure. Filters were placed in cassettes identified by unique labels that were, in turn, affixed in the sampling head. Vapor phase samples were collected on XAD-4 cartridges located in a secondary airflow path and analyzed for nicotine and 3-ethenyl pyridine. XAD-4 cartridges were labeled, and the glass tips were broken off and installed in the sampling head. Using two mass flow meters, the particulate phase flow was adjusted to 2.2–2.3 L/min, vapor phase flow was adjusted to 1.0–1.1 L/min, and both were recorded. When the sampling systems were returned to the nonsmoking office area at the end of the sampling period, sample durations and flow rates were recorded again. Average flow rates (mean of start and ending) and sampling duration were used to calculate the volume sampled and thus the ETS marker concentrations. Following sample collection, samples were stored at 4°C and shipped while being maintained at this same temperature to Oak Ridge National Laboratory for analysis. Field blanks were collected for each facility sampled.

Analysis of Indoor Air and ETS Components

Analytical chemical procedures used in this study were identical to those used in our previous studies (Jenkins *et al.*, 1996; Maskarinec *et al.*, 2000). Vapor phase samples were analyzed for nicotine and 3-ethenyl pyridine, according to the method of Ogden (1991). The XAD-4 cartridges were extracted using 1.5 ml ethyl acetate containing 0.5% (v/v) triethylamine and 8.2 μg/ml quinoline (internal standard). The analysis was performed using a Hewlett–Packard Model 5890A gas chromatograph equipped with a Model 7673 autosampler, a 30-m DB-5MS fused silica capillary column (0.32 mm i.d., 1 mm film thickness) (Part No. 123-5533, J & W Scientific, Folsom, CA), and a nitrogen/phosphorus detector.

Methods used for the determination of particulate phase ETS markers have been described in detail elsewhere (Ogden *et al.*, 1990; Conner *et al.*., 1990 Ogden and Maiolo, 1992). UVPM, FPM, and solanesol were

TABLE 2
Environmental Conditions in Surveyed Establishments

Facility	Temperature, °C			Relative humidity, %			Carbon dioxide concentration, ppm			DustTrak particle concentration,[b] μg/m³		
	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum
Black Dog Pub												
Night 1	20.6	15.9	21.6	20.8	13.5	31.4	701	468	1216	24	11	49
Night 2	21.7	15.5	22.4	23.4	20.5	36.5	578	471	691	21	4	162
Night 3	21.9	14.0	23.1	18.7	16.8	27.4	504	446	630	NA	NA	NA
Night 4	21.4	15.3	22.0	23.2	21.7	34.0	587	535	723	49	34	132
Nonsmoking Facility M	23.6	12.9	24.5	25.0	20.9	49.6	1083	769	1277	16	0	61
Nonsmoking Facility B	19.4	15.4	20.1	27.9	24.0	36.9	1156	674	1734	36	27	57
Mall food court	21.2	16.7	22.8	19.0	17.5	28.9	841	557	1270	127	45	269

[a] Average responses were determined by taking the mean response of 1-min averages over the duration (see Table 1) of the measurements.
[b] Note that DustTrak reading may over- or underrepresent actual gravimetric respirable suspended particulate values in these venues.

determined after extraction of the filter with 1.5 ml methanol. UVPM and FPM were determined simultaneously using a Hewlett–Packard Model 1090 HPLC equipped with an autosampler, a short section of 0.2-mm tubing (to replace the column), and sequential diode array and fluorescence detectors. 2,2′,4,4′-tetrahydroxybenzophenone was used as a surrogate standard for the UVPM measurement, while scopoletin was used for the determination of FPM. Solanesol was determined using a Hewlett–Packard Model 1090 HPLC equipped with an autosampler, a Deltabond ODS column, 250 × 3 mm, 5 μm particle diameter (Part No. 255-204-3, Keystone Scientific, Inc., Bellefonte, PA), and a diode array detector operated at 205 nm. The mobile phase was acetonitrile/methanol (95/5 v/v), operated at 0.5 ml/min.

All values were measured in micrograms per sample and converted to micrograms per cubic meter using the flow rate and duration data. Conversion factors (to convert the response to the standard to a particulate matter equivalent) were taken from those reported by Nelson *et al.* (1997) for a sales-weighted average for Canadian cigarettes. Actual conversion factors used were as follows: FPM, 41; UVPM, 7.3; Sol-PM, 68. Limits of detection for an individual sample depends on the sample volume, which in turn is dependent on the sampling flow rate and duration. Assuming a 5-h sample collection period, estimated limits of detection (typically 3× the signal background) for UVPM, FPM, Sol-PM, nicotine, and 3-EP were 0.9, 0.8, 9.4, 0.09, and 0.11 μg/m³, respectively. This assumes a total volume sampled for the particle phase and vapor phase constituents of 0.66 and 0.33 m³, respectively.

RESULTS AND DISCUSSION

The environmental conditions, CO_2, and optical particle concentrations measured in the facilities are reported in Table 2. Average temperatures ranged from ca. 19 to 24°C. Since this study was conducted in the winter, outside air was especially dry, and thus, as expected, the relative humidity (RH) inside these facilities was relatively low. Average RHs ranged from ca. 19 to 28%. The effect of the improved heat recovery ventilation in the Black Dog Pub is evident in the CO_2 concentrations. Average CO_2 concentrations ranged from 500 to 700 ppm, compared with average concentrations of ca. 840–1150 ppm in the other facilities. In general, the maximum observed concentrations were also lower in the Black Dog Pub, compared with the wholly nonsmoking facilities. Differences in overall ventilation is likely to contribute to some of these differences. Interestingly, the highest maximum CO_2 concentration was observed in the facility with one of the lower mean patron counts, Facility B.

The optical particle concentrations, as measured by the DustTrak (only in nonsmoking areas) were, on the whole, quite low. The highest observed average concentrations were in the food court facility, where the mean level was 127 μg/m³. It should be noted that using a calibration factor of 1.00, when measuring ETS, the DustTrak will tend to overestimate the actual respirable suspended particulate matter (RSP) levels considerably. For example, in some as-yet-unpublished studies in hospitality venues in the United States conducted by our laboratory, the mean ratio of the time-averaged DustTrak reading to gravimetric RSP was 3.01 ± 0.92 for 56 instances in which a DustTrak was colocated with a gravimetric RSP sampler. Some preliminary measurements in our laboratory suggest that the instrument may underreport gravimetric particle concentrations that are composed predominantly of cooking oil aerosol. Given that this represents a relatively limited data set, probably the most useful information to be gleaned from the optical particle measurements is relative airborne

TABLE 3
Concentrations of Environmental Tobacco Smoke Constituents Nonsmoking Areas in Black Dog Pub vs Comparative Nonsmoking Facilities

	Concentrations, $\mu g/m^3$				
	UVPM	FPM	Sol-PM	Nicotine	3-EP
Black Dog Pub nonsmoking areas, $N = 12$					
Median	3.4	5.4	0.0	0.00	0.18
Mean	3.5	5.8	2.5	0.44	0.23
SD	1.8	2.5	3.7	0.76	0.28
80th percentile	4.9	7.6	7.0	0.77	0.48
95th percentile	6.4	9.6	8.1	1.75	0.70
Nonsmoking tavern/food court data, $N = 13$					
Median	5.2	8.6	1.5	0.00	0.00
Mean	4.6	7.2	2.6	0.21	0.07
SD	2.3	4.0	3.0	0.28	0.10
80th percentile	6.3	10.7	5.5	0.49	0.16
95th percentile	7.9	12.1	7.1	0.64	0.23

particle concentrations, rather than absolute quantitative measures.

Based on the data collected in this study and reported in Table 3, mean ETS component concentrations in the nonsmoking section of the Black Dog Pub were not statistically different (at the 95% confidence level, i.e., $P < 0.05$, for all measured constituents) from those determined in the control nonsmoking facilities. (Note that the number of measurements in each category is not large, so that while medians and percentiles are reported to provide a sense of the data distribution, absolute values for anything other than means should be used with caution.) In the Black Dog Pub nonsmoking section, mean concentrations of UVPM, FPM, and ETS particles as Sol-PM, nicotine, and 3-EP were 3.5, 5.8, 2.5, 0.44, and 0.23 $\mu g/m^3$, respectively. This compared with levels of 4.6, 7.2, 2.6, 0.21, and 0.07, respectively, for the control facilities. Maximum levels of constituents observed in the Black Dog Pub nonsmoking section were 6.7, 9.8, 9.1, 2.54, and 0.82, $\mu g/m^3$, respectively.

Note that for the combustion-derived particles (UVPM and FPM) the FPM levels were determined to be somewhat higher than those of UVPM. At these low particle concentrations, the differences may be due to minor compositional differences in the atmospheres. The ETS-specific components were present in many of the samples in measurable concentrations. While initially counterintuitive for nonsmoking facilities, it is not unexpected to find low but measurable levels of ETS components in nonsmoking establishments. Virtually all of these facilities permit outdoor smoking immediately outside their establishments, and thus it is not unexpected that, depending on the location of air intakes for the facilities (including entryway doors), some ETS would be entrained into incoming air. Moreover, certain ETS components are generated from sources other than tobacco smoking. Field or analysis blanks did not contribute to the apparent level of ETS components in the comparative facilities. All blanks contained no detectable levels of the measured components. Note that the nonsmoking area levels are lower that those determined for the limited number of studies that have examined such in similar venues. For example, Lambert *et al.* (1993) reported mean nicotine levels in the nonsmoking sections of seven restaurants to be 1 $\mu g/m^3$, with a range of 0.2–2.8 $\mu g/m^3$, compared with a mean level of 0.44 $\mu g/m^3$ (and a median of 0.00) for this study. In a previous study (Jenkins and Counts, 1999), we reported that subjects in workplaces where smoking was banned or banned but smoking was observed (which did not include hospitality venues) experienced 8-h time-weighted average mean nicotine concentrations of 0.086 and 0.122 $\mu g/m^3$, respectively.

In Table 4, the smoking area concentrations observed in this study are compared with those determined from a subset of establishments (single room bars) most similar to the layout existing at the Black Dog Pub in a study of area and personal exposure samples in the hospitality industry reported previously (Maskarinec *et al.*, 2000; Jenkins and Counts, 1999). With the exception of 3-EP concentrations, there are no statistically significant differences ($P < 0.05$) between the levels of

TABLE 4
Comparison of ETS Component Concentrations in Smoking Areas Black Dog Pub vs Single-Room Bars

	Concentrations, $\mu g/m^3$, mean ± SD				
	UVPM	FPM	Sol-PM	Nicotine	3-EP
Black Dog Pub ($N = 8$)	95 ± 32	153 ± 32	165 ± 49	12.2 ± 19.3	1.7 ± 2.7
Knoxville single-room bars ($N = 26$)[a]	146 ± 107	133 ± 104	123 ± 113	21.9 ± 17.1	5.2 ± 3.3

[a] From Maskarinec *et al.* (2000) (these data are a subset of those facilities which resemble most closely those described in this study.)

measured ETS components in the Black Dog Pub and those determined in similar facilities in the comparative establishments. Mean 3-EP levels were about one-third those found in the comparative establishments. This suggests that the smoking levels in the smoking areas of the Black Dog Pub were not inordinately low, even though somewhat lower readings could be expected on account of the superior ventilation system installed. Thus, even though expected concentrations of ETS markers were observed in the smoking section of the Black Dog Pub, those of the same constituents in its nonsmoking areas were both low and comparable to those measured in similar nonsmoking establishments.

REGULATORY AND POLICY IMPLICATIONS

Since the publication of the 1992 EPA report entitled *Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders*, wherefrom the agency classified ETS as a Group A carcinogen (US EPA, 1992), in the United States and Canada, and to a lesser extent in other industrialized countries, smoking is increasingly proscribed in enclosed public spaces. Despite unresolved ambiguities and controversies about the interpretation of epidemiologic data, the regulatory process to prohibit smoking in enclosed public areas has continued to gain momentum. This process has raised significant issues for the hospitality industry where many of the industry's restaurant and bar patrons wish to smoke. Some hospitality facilities have prohibited smoking, but many other facilities have sought to provide segregated smoking and nonsmoking areas, in an attempt to accommodate the preferences of all their customers. This, in turn, has led to a renewed concern on the part of both regulators and nonsmokers, about whether mechanical filtration and air handling systems are capable of ensuring adequate air quality standards in nonsmoking areas contiguous to smoking areas.

Here, the intuitive air quality benchmark is the average levels of ETS constituents that prevail in hospitality facilities where smoking is prohibited, since no stricter standard could be fairly imposed. ETS levels in nonsmoking facilities cannot be zero, for many ETS constituents are generated from sources other than tobacco or can be introduced in nonsmoking facilities from outdoor-air ETS residues, from material exchanges, from human traffic, and from sources other than tobacco smoking.

This small study provides important evidence to the regulator, the hospitality industry and the nonsmoking public that there are cost-effective alternatives to a prohibition of smoking in hospitality establishments, alternatives that can satisfy the concerns and interests of both nonsmoking and smoking customers. A system such as installed at the Black Dog Pub would cost the owner $329 per month on a 5-year lease, including installation and maintenance costs. ERV units use enthalpy wheel heat exchangers that reduce cooling loads in the summer and heating/humidification loads in the winter. HRV units use flat-plate heat exchangers and can be used in reducing heating loads in the winter. Directional airflow can be easily retrofitted at most facilities by creating sufficient positive pressure in the nonsmoking section with the introduction of a forced air supply. The air then flows toward the negative pressure area of the smoking section, where the exhausts are located. Supply air grills must also be positioned and conformed to direct the air toward the exhaust in the most unidirectional way.

Although limited in size, this study clearly shows that a suitably designed ventilation system installed in a restaurant/bar with both smoking and nonsmoking sections can produce ETS levels in the nonsmoking section that are not statistically different from those found in venues where smoking is prohibited. This alternative would avoid the contentious debate about "safe" ETS exposure limits by taking the level of ETS found in nonsmoking hospitality establishments as the baseline standard. If the hospitality venue that provides both smoking and nonsmoking areas can assure its nonsmoking customers that the ETS level in their area is comparable to that which they would find in a completely nonsmoking facility, then there would seem to be no rational reason for a prohibition of smoking in the controlled areas. As a word of caution, it should be noted that this study addresses only the issue of nonsmoking patron exposure to ETS, and it does not examine the issue of employee exposure.

CONCLUSIONS

This small study focuses on a restaurant/pub in which the smoking and nonsmoking sections were segregated and a heat-recovery ventilation system was installed, combined with directional airflow. Although additional studies are desirable, the data indicate that it is possible to reduce ETS in the nonsmoking section to levels that are comparable to those encountered in similar facilities in which smoking is prohibited altogether. The findings suggests that effective segregation of smoking and nonsmoking areas in hospitality facilities is both achievable and economically viable if sufficient attention is given to overall system design, robust air exchange rates, directional airflow, and the use of appropriate heat-recovery systems.

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