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A 32-country comparison of tobacco smoke derived particle levels in indoor public places

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What This Paper Adds

The Framework Convention on Tobacco Control (FCTC) calls for all ratifying nations to implement stronger secondhand smoke protection policies (among many other provisions). Studies that use quantitative means for assessing levels of secondhand smoke exposure have generally been conducted in selected cities, primarily in wealthier Western nations. Little data exists in non-Western nations to document levels of exposure. Such localized information can be more salient to policymakers.

The results from this 32-country indoor air quality comparative study show that fine particle concentrations in bars, restaurants, and other locations that allow smoking are typically far greater than what the World Health Organization and the US Environmental Protection Agency has concluded is harmful to human health, regardless of geographic location. In contrast, indoor particle concentrations in countries that have implemented comprehensive smoke-free regulations are on average 87% lower than in countries without such comprehensive regulations. These results underscore the importance of comprehensive smoke-free policy adoption in accordance with the FCTC.

Abstract

Objective: To compare tobacco smoke-derived particulate levels in transportation and hospitality venues with and without smoking in 32 countries using a standardized measurement protocol.

Methods: The TSI Sidepak AM510 Personal Aerosol Monitor was used to measure the concentration of particulate matter less than 2.5 microns in diameter (PM_{2.5}) in 1,822 bars, restaurants, retail outlets, airports, and other workplaces in 32 geographically dispersed countries between 2003 and 2007.

Results: Geometric mean PM_{2.5} levels were highest in Syria (372 µg/m³), Romania (366 µg/m³), and Lebanon (346 µg/m³), while they were lowest in the three countries that have nationwide laws prohibiting smoking in indoor public places (Ireland at 22 µg/m³, Uruguay at 18 µg/m³, and New Zealand at 8 µg/m³). On average, the PM_{2.5} level in places where smoking was observed was 8.9 times greater (95% C.I.: 8.0 to 10) than the level in places where smoking was not observed.

Conclusions: Levels of indoor fine particle air pollution in places with observed smoking are typically greater than what the World Health Organization and US Environmental Protection Agency have concluded is harmful to human health.

Introduction

Secondhand smoke (SHS) is a complex mixture of the gases and particles from the burning end of a cigarette and exhaled mainstream smoke. Particles emitted from burning cigarettes are in the fine to ultrafine particle size range¹ (0.02 μm – 2 μm) and have been shown to be inhaled deep into the lungs and to cause an array of adverse health effects which are detailed in recent reports by the U.S. Surgeon General², the International Agency for Research on Cancer³, and the California Environmental Protection Agency⁴. In recognition of the health risks posed by secondhand tobacco smoke, the World Health Organization (WHO) has encouraged countries to expand the adoption of smoke-free policies as part of the Framework Convention on Tobacco Control (FCTC).⁵

Partly driven by the FCTC calling for greater secondhand smoke protection policies, several countries have initiatives to implement smoke-free regulations at the national or sub-national level. For example, in 2004, Ireland, Norway, and New Zealand became the first countries to enact comprehensive smoke-free indoor air laws. In 2006, Uruguay became the first South American country to implement a 100% smoke-free regulation in workplaces, restaurants, and bars. Other countries throughout Europe, Asia, North and South America, Africa, and the Pacific have taken action to reduce exposure to secondhand smoke in workplaces and public places.⁶ While this is encouraging, smoking in indoor public places is still the norm in the vast majority of nations worldwide as they work toward achieving the FCTC standard.

Several studies have demonstrated that smokefree policies are effective in decreasing SHS exposure and improve health outcomes. Farrelly et al. showed a significant decrease in both salivary cotinine concentrations and sensory symptoms in hospitality workers after New York State's smoke-free law prohibited smoking in their worksites.⁷ Other studies found that respiratory health improved rapidly in samples of bartenders after a state smoke-free workplace laws were implemented in California⁸ and Scotland.⁹ Another study reported a 40% reduction in acute myocardial infarctions in patients admitted to a regional hospital during the 6 months that a local smoke-free ordinance was in effect.¹⁰

Some studies have shown that venues that permit smoking in indoor locations have particle levels approximately 10 times greater than in places where smoking is not allowed. In a longitudinal study of 22 hospitality venues in Western New York, Travers et al. found a 90% reduction in PM_{2.5} levels in bars and restaurants, an 84% reduction in large recreation venues such as bingo halls and bowling alleys, and even a 58% reduction in locations where only SHS from an adjacent room was observed at baseline.¹¹ In a recent study in the UK, air quality was found to be poorest in smoky pubs that were located in economically deprived areas.¹² A cross-sectional study of 53 hospitality venues in 7 major cities across the U.S. showed 82% less indoor air pollution in the locations subject to smoke-free air laws, even though compliance with the laws was less than 100%.¹³ Repace studied 15 hospitality venues in the state of Delaware and the city of Boston, Massachusetts before and after a statewide prohibition of smoking in these types of venues and found that about 90% to 95% of the fine particle pollution could be attributed to tobacco smoke.^{14,15} Others who have examined levels of ambient air nicotine concentrations instead of particle concentrations have obtained similar results.¹⁶ While these studies are informative, they are typically small-scale studies done in small geographic areas, and there is little research in this area in developing countries.

The goal of this study was to provide the latest scientific equipment and methods to practitioners around the world to determine secondhand smoke exposures in a wide

range of geographically and economically disparate countries. Hypotheses to be examined include: 1) levels of indoor air pollution will be higher where smoking is observed compared to the facilities where no smoking is observed; 2) levels of smoke pollution will be higher in countries that have weak or non-existent clean indoor air policies compared to places that have comprehensive policies; and 3) levels of smoke pollution will be correlated with smoker density.

Methods

Overview

Fine particle concentration, an indicator of air quality, was assessed in 1,822 places in 32 countries. Data was collected in most countries from September 2005 to November 2006; however, data collection in Canada took place in 2004, data collection in the United States took place between 2003 through 2006, and data collection in Argentina and Uruguay took place in 2007. The places tested included restaurants, bars, transportation areas, including airports, bus and train stations, and train cars, and other types of venues, including hotels, shopping malls, offices, casinos, and schools. In general, researchers in each country took a convenience sample of venues, although some countries employed a stratified random sampling scheme. Guideline principles for venue selection were to obtain samples from different cities as well as venues of different type and size within each city. Testing was completed in smoking and smoke-free places on all the days of the week and at all times of the day, although generally during busy times for the given establishment. For example, in Germany locations were sampled in 10 different cities from 9 federal states across the country. In each city, visits were made to bars, restaurants, coffee bars, train restaurant cars, and discotheques as these were considered the primary public entertainment and transportation venues in Germany. In Syria, on the other hand, only one city, Aleppo, was sampled but a random sample of the city population of cafés/restaurants/bars was employed. In many countries and cities it was not feasible to identify the entire population of venues to conduct true random sampling

Selection of Countries and Coordination of Data Collection

Countries included in the study were identified first through existing contacts in individual countries with the help of the International Agency for Research on Cancer (IARC). Specific tailored venue sampling frames were developed for each country taking into account conditions in those countries while striving to maintain comparability across countries. The types of public hospitality venues are not necessarily the same across countries. For example, a bar or pub in the U.S., Canada, or Ireland is a readily identifiable establishment whose primary purpose is the sale of alcoholic beverages. The same type of establishment is much less prevalent in Syria or Pakistan for example where a sample of cafes serving non-alcoholic beverages was more appropriate. For this cross-country summary, locations sampled were ultimately collapsed into: 1) “bars”, whose primary purpose is the sale of beverages; 2) “restaurants” whose primary purpose is the sale of food; 3) “transportation” venues which includes airports, bus and train stations, and train cars; and 4) “other” venues which is a catch-all for those not falling into one of the other 3 categories and includes hotels, shopping malls, offices, casinos, retail outlets, and schools.

This report includes data from 1,822 air quality assessments conducted in 32 countries that have been divided up for analysis according to WHO world regions¹⁷: the Americas (Argentina, Brazil, Canada, Mexico, United States, Uruguay, Venezuela),

Europe (Armenia, Belgium, Faroe Islands, France, Germany, Greece, Ireland, Poland, Portugal, Romania, Spain, United Kingdom), Eastern Mediterranean and Africa (Ghana, Lebanon, Pakistan, Syria, Tunisia), and South-East Asia and Western Pacific (China, Laos, Malaysia, New Caledonia, New Zealand, Singapore, Thailand, Vietnam). The data from 25 air quality assessments conducted in Ireland as part of a separate study by an independent group of investigators are included to serve as a reference group to the data in this study.¹⁸

Training of Data Collection Staff

Initially, trainings were performed via face-to-face meetings. One meeting conducted in November 2005 in Paris, France in collaboration with IARC and the French National Cancer Institute involved seven countries (Belgium, France, Germany, Poland, Spain, Cote d'Ivoire [did not ultimately participate in the study], Egypt), while additional trainings were conducted in Bangkok, Thailand and Beijing, China in February 2006. Subsequently, we developed a web-based training course (www.tobaccofreeair.org). This training module includes step-by-step instructions on the operation of the air monitoring equipment, study protocol, and data management. In addition, project staff at Roswell Park Cancer Institute provided telephone and email technical support throughout the project.

Measurement Protocol

A standard measurement protocol was used by data collectors across study sites. Establishments were tested for a minimum of 30 minutes. The number of people inside the venue and the number of burning cigarettes were recorded every 15 minutes during sampling. Lebanon (n=6), Pakistan (n=1), Syria (n=20), and Tunisia (n=8) had locations with waterpipe smoking in addition to cigarette smoking. A burning waterpipe was counted the same as a single cigarette in these instances as a cigarette smoked for a typical duration of about 10 minutes will emit an amount of particles similar to a waterpipe session lasting 30 minutes.¹⁹ These observations were averaged over the time inside the venue to determine the average number of people on the premises and the average number of burning cigarettes and waterpipes. For most establishments, a sonic measure (Zircon Corporation, Campbell, CA) was used to measure room dimensions and hence the volume of each of the venues. When using the sonic measure to calculate room dimensions was not possible, room measurements were made through estimation. Some venues are large and consist of multiple rooms. If there was a significant physical barrier between different spaces in a venue, such as a normal doorway separating two rooms, the volume and counts were measured only in the room where the aerosol monitor was located.

In each establishment, respirable suspended particles (RSP) were measured using a TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN, USA) – see Figure 1. The SidePak uses a built-in sampling pump to draw air through the device where the particulate matter in the air scatters the light from a laser. The mass concentration of particles is not measured directly but instead is determined by the amount of light scattering. This portable light-scattering aerosol monitor was fitted with a 2.5 µm impactor in order to measure the concentration of particulate matter with a mass-median aerodynamic diameter less than or equal to 2.5 µm, or PM_{2.5}. Tobacco smoke particles are almost exclusively less than 2.5 µm with a mass-median diameter of 0.2 µm.¹ The Sidepak was used with a calibration factor setting of 0.32, suitable for secondhand smoke. This calibration factor was determined in an experiment with the SidePak collocated with another light-scattering instrument that had been previously calibrated against standard pump-and-filter gravimetric methods and used in SHS

exposure studies.¹⁴ Klepeis et al. found a similar SHS calibration factor for the Sidepak when compared to a Piezobalance (Kanomax, Inc.) which provides direct measurements of RSP mass concentrations.²⁰ This calibration factor has also been confirmed by another researcher who compared Sidepak measurements of SHS to gravimetric measurements using a Personal Environmental Monitor (PEM for PM_{2.5}, MSP Corporation, Shoreview, MN).²¹

The equipment was set to a one-minute log interval, which averages the previous 60 one-second measurements. The SidePak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications. Sampling was discreet in order not to disturb the occupants' normal behavior. The monitor was generally located in a central location on a table or bar and not on the floor so the air being sampled was within the occupants' normal breathing zone. For each venue, the first and last minute of logged data were removed because they are averaged with outdoors and entryway air. The remaining data points were averaged to provide an average PM_{2.5} concentration within the venue. Associates in each country did the air sampling, and Roswell Park Cancer Institute staff analyzed the data.

Statistical Analyses

The primary goal was to assess the difference in the average levels of PM_{2.5} in places that were smoke-free (no smoking observed during sampling) and places that were not (smoking was observed during sampling). All statistical analyses were done using the log-transformed PM_{2.5} concentrations because these data are log-normally distributed, hence geometric means are compared. The comparison between smoking and smoke-free places was performed within each country and pooled across all countries. A comparison was also made between the overall geometric mean concentration in the three smoke-free countries with comprehensive smoking policies (Ireland, New Zealand, and Uruguay) and the other 29 countries. In addition, the comparison between smoking and smoke-free locations was also stratified by type of venue and world region. The four types of venues considered in this study were: 1) bars; 2) restaurants; 3) transportation venues; and 4) other types of venues. The generalized linear model (GLM in SPSS 14.0) was used to test for differences in PM_{2.5} levels and construct 95% confidence intervals. Multiple post-hoc pairwise comparisons were adjusted using the Bonferroni method, although the choice of adjustment method had no effect on the significance of any results. An alpha of 0.05 was used for all significance testing.

The active smoker density (ASD) was also calculated for each location sampled. This is defined as the average number of burning cigarettes and waterpipes per 100 cubic meters. Spearman's rho was used to determine the correlation between the ASD's and average PM_{2.5} levels.

Results

Table 1 provides a summary of the data collected in 1,822 places in 32 countries and shows the geometric mean PM_{2.5} concentrations. The three countries with the highest geometric mean (GM) PM_{2.5} levels were Syria (372 µg/m³), Romania (366 µg/m³), and Lebanon (346 µg/m³). The geometric mean PM_{2.5} levels in Ireland (22 µg/m³), Uruguay (18 µg/m³), and New Zealand (8 µg/m³) where there are comprehensive clean indoor air policies at the national level, were lowest. The compliance rate with the smoke-free air laws in Ireland and New Zealand was 100% in the places visited, meaning there was no observed smoking, while the compliance rate was 95% in Uruguay. Across all countries, the PM_{2.5} level in places where smoking was observed was 8.9 times greater (95% C.I.: 8.0 to 10.0) than the level in places where smoking was not observed. The overall PM_{2.5} levels, including smoking and smoke-free venues, were 7.5 times higher (95% C.I.: 5.9 to 9.7) in the 29 countries without comprehensive clean indoor air policies compared to Ireland, New Zealand, and Uruguay.

Table 1 also compares smoking and smoke-free places within each country. While a randomized, population-based sample was not used, the number of places with and without smoking in each country generally reflects the availability of smoking or non-smoking venues within each country. For example, in the U.S., where there are many smoke-free air laws in effect, 28% of venues sampled were smoke-free, compared to 2% smoke-free in Romania where there are minimal smoking restrictions. In the 23 countries where both smoking-observed and smoke-free locations were sampled, Table 1 shows the ratio of PM_{2.5} level in smoking-observed versus smoke-free places. This ratio was significantly greater than one in all of these 23 countries except for Uruguay and Vietnam where there were only 3 smoking-observed and 4 smoke-free places respectively for comparison.

Overall, there were 584 places where no smoking was observed, and the geometric mean PM_{2.5} level in these places was 21 micrograms per cubic meter (µg/m³), ranging from 0 to 573 µg/m³. The geometric mean PM_{2.5} level in the 1,238 places where smoking was observed was 188 µg/m³, ranging from 1 to 3,764 µg/m³. The PM_{2.5} concentration was 89% lower in the places with no observed smoking compared to those where smoking was observed (95% C.I.: 88% to 90%). This difference was slightly lower after adding country and type of venue to the model at 85.4% (95% C.I. 83%-88%).

Figure 2 compares the average air pollution levels in places with and without smoking stratified by four types of locations; 1) bars, 2) restaurants, 3) transportation places, and 4) other types of places. Places with smoking had significantly higher levels of PM_{2.5} compared to smokefree places in all 4 types of locations. Bars with smoking had the highest average levels (303 µg/m³) and were 15.4 times higher (95% C.I.: 12.5-34.5) than smokefree bars. The difference between smoking and smokefree places was 6.2 times for restaurants (95% C.I.: 5.3-7.2), 8.8 times for transportation places (95% C.I.: 5.4-14.2), and 7.0 times for other places (95% C.I.: 5.4-9.0). The high PM_{2.5} level in bars is consistent with the high geometric mean active smoker density in these places of 1.59, compared to 0.81 in restaurants, 0.74 in transportation venues, and 0.71 in other types of venues.

Figure 3 shows the average air pollution levels found across world regions by observed smoking: the Americas, Europe, E. Mediterranean and Africa, and S.E. Asia/Pacific. The average PM_{2.5} levels in the venues where smoking was observed was fairly consistent across all regions considered and was approximately 10-times greater than the levels observed in the smoke-free venues, although there were some statistical

differences noted. PM_{2.5} levels in smoking observed venues were highest in the Eastern Mediterranean and Africa, followed by Europe, S.E. Asia, and Americas respectively. The difference between PM_{2.5} levels in smoking locations in Americas and S.E. Asia is not significant, whereas all other pairwise comparisons are statistically significant. There was no statistically significant difference in PM_{2.5} levels in venues without observed smoking across regions. The PM_{2.5} levels in smoking places by region correlates with the active smoker densities, with the highest geometric mean ASD in Eastern Med. and Africa (4.12), followed by 1.04 in Europe, 0.58 in the Americas, and 0.57 in S.E. Asia and Pacific.

The overall smoker density was much greater in the places where smoking was observed (mean=2.48, GM=1.01 burning cigarettes or waterpipes per 100m³) compared to the smoke-free locations (0.00 burning cigarettes per 100m³). Average PM_{2.5} levels were significantly positively correlated (Spearman's rho= 0.74, p < 0.001) with smoker density. The relation between active smoker density and PM_{2.5} concentrations is modified by differences in ventilation and differences in emission rates per cigarette. Other sources of PM_{2.5} and measurement error for venue volumes and active smoker counts will also affect this correlation.

Discussion

The results from this study show that levels of PM_{2.5} in bars, restaurants, transportation venues, and other outlets are at higher levels in countries where smoking is permitted in these venues without restriction. In contrast, countries with comprehensive smoke-free regulations, such as those in Ireland, New Zealand, and Uruguay have PM_{2.5} levels that are about 89% lower than in countries where smoking is permitted without restriction.

These results are consistent with previous studies examining this topic, although, this is one of the only studies to provide international comparisons and for some countries provides the first data on the level of indoor air pollution inside venues where smoking is permitted. The general comparability of conclusions across different types of venues and in different countries adds to the generalizability of the finding that fine particle air pollution levels are higher in places where smoking occurs. Statistically higher particle concentrations were observed in bars and in some regions of the world; however, the main finding is that regardless of the type of venue assessed or its geographic location, the amount of smoking was a major force driving PM_{2.5} levels. In addition, these findings looking at differences in air quality measurements between countries where smoking is and is not permitted in indoor public venues closely mirrors the changes in cotinine levels of New Zealand bar patrons where a 90% reduction was observed²².

The results of this study stress the importance of governments prohibiting smoking in indoor public places in order to comply with Article 8 of the FCTC. In light of recent evidence indicating that SHS cannot be controlled through improved ventilation or filtration,^{23,24} and no evidence that these measures can eliminate the health risk of SHS exposure, only the creation of 100% smoke-free environments is known to effectively achieve the goal of Article 8.

The data from Greece also provide compelling evidence that providing separate sections for smokers and nonsmokers does not protect individuals from SHS exposure. Only non-smoking sections of venues that allowed smoking were tested in Greece, and the average PM_{2.5} level with observed smoking (GM=223 µg/m³) was similar to other countries. The current Greek law calls for 50% of the area of hospitality establishments to be non-smoking, but these data show that it is ineffective in markedly reducing SHS exposure.

To protect public health, the WHO has established air quality standards and an air quality guideline (AQG). The AQG is a guideline for reducing the health impacts of air pollution. According to this guideline, an annual mean PM_{2.5} concentration of 35 µg/m³ or higher is associated with 15% higher long-term mortality risk.²⁵ Many of the places where data was collected for this study (764 out of 1,822 venues or 42%) had average PM_{2.5} levels that would result in an average annual exposure of over 35 µg/m³ solely from occupational exposure alone for a full-time employee. 60% of places with observed smoking exceeded this limit compared to only 4.5% of places with no observed smoking. The WHO's target air quality guidelines for PM_{2.5} are much lower - 10 µg/m³ annual mean and 25 µg/m³ 24-hour mean.

A limitation to be considered when interpreting these data is that secondhand smoke is not the only source of indoor particulate matter. Ambient particle concentrations and cooking are additional sources of indoor particle levels, although smoking is generally the largest contributor to indoor air pollution.¹³ The level of outdoor particles in a given country and frequency with which venues were open to outside air impacts the magnitude of the difference in particle levels in places with and without smoking. In the United States and Canada for example, venues were primarily

closed and the only common source of particles was cigarette smoke, therefore there was a large, 12- to 15-fold difference between particle concentrations in places with smoking compared to those without smoking. In China, however, ambient particle concentrations were much higher, partially explaining the smaller difference in particle levels (2-fold) between places with and without observed smoking. Malaysia and Singapore are close geographically but particle levels in places with smoking in Singapore are higher than in Malaysia. This can be partially explained by the higher active smoker density in Singapore but is also likely related to the greater ventilation and dilution of tobacco smoke in Malaysia due to the larger number of venues that were partially open to the outside. In some countries, the level of pollution in smoke-free places was higher than in other countries. There are a few possible explanations for this discrepancy. The higher levels of indoor air pollution seen in some places with no observed smoking could be due to other factors, such as cooking, open fireplaces and higher levels of ambient air pollution. Restaurants in Brazil frequently had open fires for cooking, contributing to higher particle levels in restaurants with no smoking compared to countries like the U.S. and Canada. In some cases there may also have been residual tobacco smoke particles in the air of these locations from smoking that was occurring before the data collection, or tobacco smoke particles that drifted from adjacent outdoor areas or indoor areas that were not observed.

Restaurants, bars, transportation outlets, and other types of places that are “smoke-free” are significantly less polluted than places where smoking occurs, and this is true around the globe. Comprehensive smoke-free regulations are the most effective strategy to reduce secondhand smoke exposure. These findings underscore the importance of compliance with the FCTC Guiding Principle 4.2 to “take measures to protect all persons from exposure to tobacco smoke”.

Figure 1. The TSI SidePak AM510 Personal Aerosol Monitor



Table 1. Summary of Smoke-free Versus Smoking Places by Country

Country	Smoking Observed?	N	Mean Active Smoker Density*	Geometric Mean PM _{2.5} (ug/m ³)	95% C.I. for Geometric Mean	PM _{2.5} Ratio Smoking/S smoke-free	95% C.I. for Ratio
Argentina	No	142	0.41	26	(22-31)	3.5	(2.4-5.0)
	Yes	38	1.54	65	(46-91)		
Armenia	No	44	1.71	70	(42-119)	6.0	(1.8-19.6)
	Yes	9	0.00	17	(4-67)		
Belgium	No	35	2.14	101	(60-171)	14.9	(8.0-27.5)
	Yes	68	1.67	229	(167-314)		
Brazil	No	6	0.00	20	(4-92)	2.0	(1.3-3.0)
	Yes	62	1.72	291	(225-376)		
Canada	No	78	0.89	78	(63-97)	14.8	(8.0-27.5)
	Yes	43	0.00	58	(45-74)		
China	No	35	2.14	114	(79-163)	2.2	(1.4-3.4)
	Yes	20	0.20	23	(12-45)		
Faroe Islands	No	13	0.00	9	(6-13)	15.4	(7.1-33.2)
	Yes	7	0.57	133	(69-257)		
France	No	92	0.38	167	(137-203)	4.1	(1.6-10.3)
	Yes	20	0.00	91	(55-153)		
Germany	No	72	0.49	197	(161-241)	11.7	(3.6-38.2)
	Yes	44	1.01	52	(30-90)		
Ghana	No	18	0.00	10	(6-19)	37.0	(23.4-58.6)
	Yes	26	1.79	158	(96-258)		
Greece	No	59	1.99	128	(82-200)	4.1	(1.6-10.3)
	Yes	14	0.00	18	(9-35)		
Ireland**	No	45	2.56	238	(159-354)	14.6	(6.7-31.6)
	Yes	100	1.77	198	(160-247)		
Lebanon	No	3	0.00	18	(7-45)	11.7	(3.6-38.2)
	Yes	97	1.82	214	(174-263)		
Malaysia	No	86	6.77	299	(214-417)	37.0	(23.4-58.6)
	Yes	14	0.00	15	(11-20)		
Mexico	No	72	8.10	537	(442-653)	4.1	(1.6-10.3)
	Yes	51	2.66	205	(162-259)		
New Zealand	No	3	0.00	54	(27-109)	4.1	(1.6-10.3)
	Yes	48	2.83	223	(178-280)		
Pakistan	No	25	0.00	22	(16-31)	-	-
	Yes	51	2.74	124	(100-154)		
Poland	No	9	1.46	346	(201-594)	-	-
	Yes	50	1.58	79	(57-110)		
Portugal	No	11	0.00	33	(18-58)	3.1	(1.5-6.5)
	Yes	39	2.02	102	(71-146)		
Romania	No	19	1.02	93	(58-148)	-	-
	Yes	29	1.79	153	(96-244)		
Singapore	No	44	0.00	8	(6-12)	-	-
	Yes	27	2.75	113	(75-168)		
Spain	No	74	0.98	98	(69-140)	5.2	(2.9-9.5)
	Yes	41	0.00	46	(31-68)		
Syria	No	33	2.20	241	(151-385)	3.0	(1.4-6.2)
	Yes	28	0.98	144	(102-204)		
Thailand	No	5	0.00	56	(35-89)	8.2	(2.2-31.3)
	Yes	23	1.16	178	(123-256)		
Tunisia	No	41	2.71	366	(292-460)	8.2	(2.2-31.3)
	Yes	1	0.00	386	(313-475)		
United Kingdom	No	15	1.74	131	(50-344)	22.6	(9.5-53.7)
	Yes	6	0.00	20	(13-32)		
United States	No	9	2.71	456	(227-916)	12.5	(4.0-39.1)
	Yes	13	0.31	89	(34-233)		
Uruguay	No	6	0.00	23	(8-64)	12.5	(4.0-39.1)
	Yes	7	0.78	287	(125-657)		
Venezuela	No	40	6.42	372	(296-468)	-	-
	Yes	53	0.68	60	(42-86)		
Vietnam	No	29	0.00	26	(22-32)	6.3	(3.7-10.6)
	Yes	24	1.53	164	(95-283)		
Other	No	33	2.37	147	(94-230)	7.1	(3.8-13.3)
	Yes	12	0.00	43	(24-76)		
Total	No	21	3.73	328	(242-445)	-	-
	Yes	64	2.28	193	(153-242)		
Total	No	227	0.73	89	(74-107)	11.4	(8.8-14.9)
	Yes	64	0.00	15	(12-19)		
Total	No	163	1.03	177	(153-203)	1.9	(0.8-4.6)
	Yes	66	0.01	18	(13-24)		
Total	No	63	0.00	17	(14-22)	10.3	(5.7-18.5)
	Yes	3 [†]	0.18	33	(10-103)		
Total	No	80	0.96	46	(32-65)	2.3	(0.8-6.9)
	Yes	24	0.00	9	(7-12)		
Total	No	55	1.38	92	(64-132)	2.3	(0.8-6.9)
	Yes	49	0.77	165	(121-224)		
Total	No	4	0.00	77	(38-156)	2.3	(0.8-6.9)
	Yes	45	0.84	176	(127-244)		

* Active Smoker Density is the average number of burning cigarettes and waterpipes per 100m³. Waterpipes were observed in Lebanon (n=6), Pakistan (n=1), Syria (20), and Tunisia (8).

** Data from Ireland come from another study and serve as a reference group to the data in this study (Mulcahy et al., 2006)

[†] While all locations sampled in Uruguay were supposed to be smokefree by law, smoking was observed in 3 venues in violation of the law.

Figure 2. Geometric Mean Fine Particle Air Pollution With and Without Smoking by Type of Place

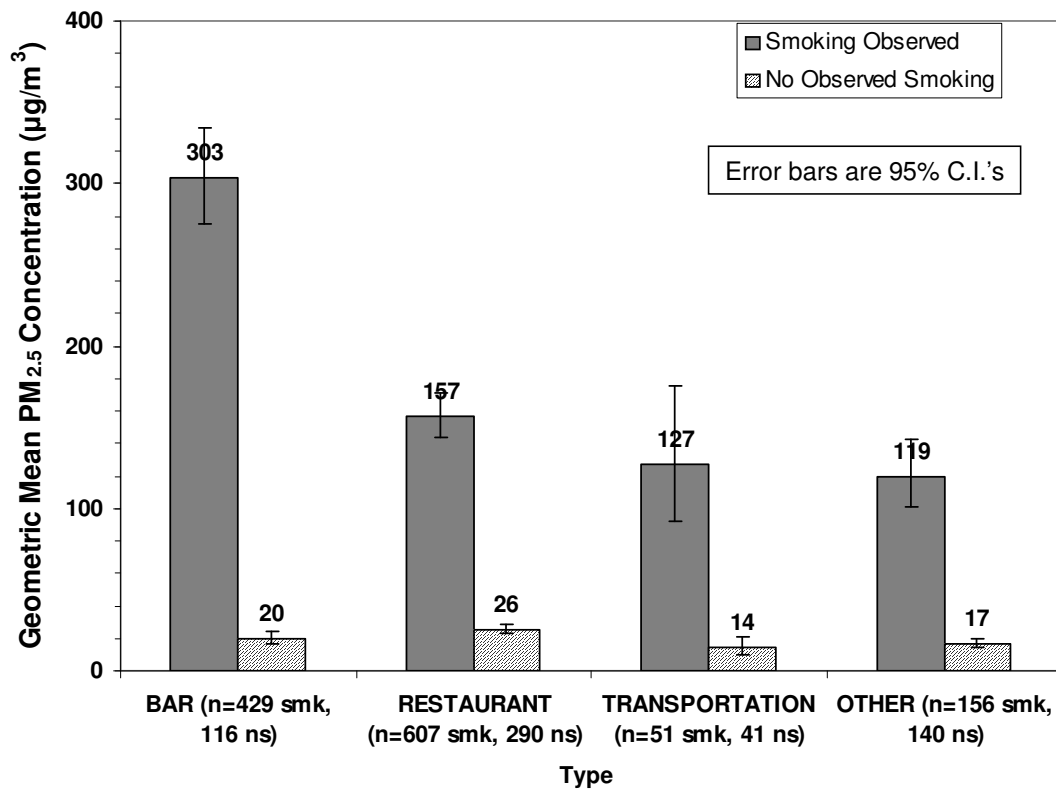
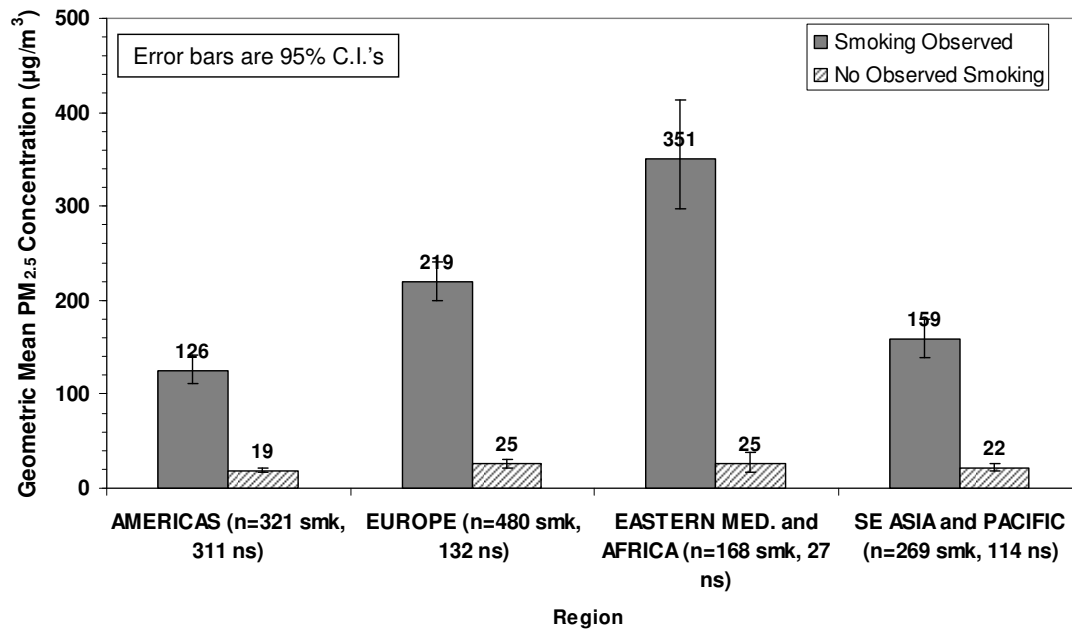


Figure 3. Geometric Mean Fine Particle Air Pollution With and Without Smoking by World Region



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