Secondhand smoke levels in public building main entrances: outdoor and indoor $PM_{2.5}$ assessment

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Received 3 May 2011
Accepted 24 August 2011
Published Online First
29 September 2012

ABSTRACT

Background/Objectives To describe secondhand smoke (SHS) levels in halls and main entrances (outdoors) in different buildings by measurement of $PM_{2.5}$ and airborne nicotine.

Methods Cross-sectional study in a sample of 47 public buildings. The authors studied SHS levels derived from $PM_{2.5}$ (micrograms per cubic metre) using TSI SidePak Personal Aerosol Monitors. The authors tested four locations within buildings: hall, main entrance (outdoor), control (indoor) and control (outdoor). The authors also measured airborne nicotine concentration (micrograms per cubic metre) in main entrances (outdoor). The authors computed medians and IQRs to describe the data. Spearman correlation coefficient (rsp) was used to explore the association between $PM_{2.5}$ concentrations simultaneously measured in halls and main entrances as well as between $PM_{2.5}$ and nicotine concentrations.

Results The authors obtained an overall median $PM_{2.5}$ concentration of hall 18.20 $\mu g/m^3$ (IQR: 10.92—23.92 $\mu g/m^3$), main entrance (outdoor) 17.16 $\mu g/m^3$ (IQR: 10.92—24.96 $\mu g/m^3$), control (indoor) 10.40 $\mu g/m^3$ (IQR: 6.76—15.60 $\mu g/m^3$) and control (outdoor) 13.00 $\mu g/m^3$ (IQR: 8.32—18.72 $\mu g/m^3$). The $PM_{2.5}$ concentration in halls was more correlated with concentration in the main entrances (outdoors) (rsp=0.518, 95% CI 0.271 to 0.701) than with the control indoor (rsp=0.316, 95% CI 0.032 to 0.553). The Spearman correlation coefficient between nicotine and $PM_{2.5}$ concentration was 0.365 (95% CI −0.009 to 0.650).

Conclusions Indoor locations where smoking is banned are not completely free from SHS with levels similar to those obtained in the immediate entrances (outdoors) where smoking is allowed, indicating that SHS from outdoors settings drifts to adjacent indoors. These results warrant a revision of current smoke-free policies in particular outdoor settings.

INTRODUCTION

Exposure to secondhand smoke (SHS) has been associated with many adverse health effects, such as lung cancer, cardiovascular disease and respiratory tract diseases.[1] SHS is a complex mixture of >4.000 chemical substances defined as diluted and dispersed air pollutant emission generated from the consumption of tobacco products.[2] When occurring outdoors, SHS has been called outdoor tobacco smoke.[3]

Since the entry into force of the WHO Framework Convention on Tobacco Control in 2005, several countries have implemented smoke-free policies. The objective of these policies has been to protect people from SHS exposure, following the Article 8 guidelines recommendations.[4] In the beginning, these recommendations focused on providing universal protection from SHS in all indoor public places, workplaces and public transport. In 2007, the Article 8 guidelines development went further promoting quasi-outdoor and outdoor public places to be smoke-free under some circumstances, as a requirement to an effective protection.[5] They consider it is 'appropriate' to require protections in those areas, and they call on countries to 'adopt the most effective protection against exposure wherever the evidence shows that hazard exist'.[6 7]

There is no consensus about whether or not smoking should be prohibited in certain areas outdoors.[8–11] Opponents of the prohibition argue that it is ethically unsustainable because it does not respect the principle of freedom and autonomy of individuals, and there is insufficient evidence that SHS in these environments have an impact on health.[9 10] Contrary to the first objection to prohibit smoking outdoors, some research indicates that, in a number of jurisdictions, the majority of the public supports restricting smoking in various outdoors settings.[12] Otherwise, scientific evidence has firmly established that there is no safe level of exposure to SHS[13] and that exposure of non-smokers to levels of SHS is as high as or higher than that received in indoor spaces where smoking is unrestricted[8 14] Due to these new evidences, some governments have enacted smoking bans in outdoor areas such as parks, beaches, outdoor dining facilities and entrances to buildings in the recent years.[6] However, there are few data on actual levels of outdoor SHS exposure in those settings. Some recent articles show that levels of outdoor SHS can be comparable or even superior to indoor levels.[15–19] Moreover, it must be considered that levels of outdoor SHS are more susceptible to variations because they do not tend to accumulate and, because of their physicochemical characteristics, outdoor tobacco smoke can disperse influenced by environmental conditions such as temperature, humidity and ventilation. Studies of the California Air Resources Board[20] also demonstrates that the number of cigarettes being smoked, the position of smokers relative to the receptor and atmospheric conditions can lead to substantial variation in average exposures. Thus, although smoking is prohibited indoors, high levels of SHS can be

detected in those settings due to smoke from the surroundings outside the building.[15 16 18]

As a consequence of workplace indoor tobacco regulations, many smokers have moved to the entrances of the buildings. However, objective assessments of the levels of SHS due to the placement of these smokers at the entrances are scarce. The main objective of our study was to assess the SHS levels in halls and main entrances (outdoors) in public buildings by measuring $PM_{2.5}$ and airborne nicotine.

MATERIALS AND METHODS

Study design

We conducted a cross-sectional study between April and July 2010 among a convenience sample of 47 public places in the city of Barcelona and its metropolitan area. Smoking was prohibited by a national ban (Law 28/2005) in these buildings since 1 January 2006.[21]

We classified the buildings into four different types: public administration (n=9), educational places (n=17), public transport stations (n=8) and healthcare centres (n=13).

The buildings were included in the study according to the following criteria: have an interior space adjacent to an outdoor area, separated by a doorway providing direct access; have at least one room physically separated from the hall; in case of having cooking facilities, they should be physically separated from the hall and from the other interior room. Moreover, there would be at least two lit cigarettes in main entrances (outdoor) during the time of the measurement.

The fieldwork took place on days when the weather conditions were favourable for the measurements (not rainy days, relative humidity <85%) and between 9:00 and 17:00, when most workers and visitors attend the building.

Measurements and variables

We measured respirable particles <2.5 μm in diameter ($PM_{2.5}$) as a well-established marker of tobacco[22] smoke with two precalibrated hand-held-operated monitors of particle size and mass concentration (TSI SidePak AM510 Personal Aerosol Monitor)[23] according to a common protocol based on previous studies.[24 25] The TSI 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 two monitors were fitted with a 2.5 μm impactor to measure the concentration of particulate matter with a mass median aerodynamic diameter ≤2.5 μm. The sample flow rate through the TSI SidePak monitors was set at 1.7 l/min and logged $PM_{2.5}$ concentrations at 1 s intervals. The TSI SidePak monitors were calibrated in an experiment with a BAM-1020 instrument that measures and records airborne particulate concentration levels using the principle of β ray attenuation. The TSI SidePak measurements were made using a default K factor of 1.00 during the course of 4 h, and the experiment was repeated three times. The correlation between the TSI SidePak and BAM-1020 measurements was very high (r>0.98) in the three tests performed, and the K factor derived from the experiments was 0.52.[26] In addition to calibration with the gold standard, we tested whether both monitors provide similar measurements when used simultaneously in various environments (an indoor and an outdoor environment free of tobacco smoke and an outdoor environment with presence of tobacco smoke from active smokers). We found no differences in the median $PM_{2.5}$ concentrations between both monitors in these tests. $PM_{2.5}$ concentrations are expressed in $\mu g/m^3$. Both monitors were set to a 1 s sampling interval and zero-calibrated prior to use in each occasion by attachment of a high-efficiency particulate air filter according to the manufacturer's specifications.[23]

We defined four locations at each sample site to be tested as systematically represented in figure 1: hall (A, A'), defined as the interior space adjacent to an outdoor area; main entrances (outdoor) (B), as the area within a radius of 5 m over the door with direct access to public road and the most likely to be accessed by the public; control indoor (C), which was one room physically separated from the hall and placed at least 10 m of this and control outdoor (D), defined as the nearby outdoor spaces located >10 m from the main entrance (outdoor) where smoking was not present. We registered $PM_{2.5}$ concentrations simultaneously in the hall (A) and main entrance outdoors (B) during 30 consecutive minutes. The data collectors were situated 2 m of distance from the door, one in hall and the other in main entrance outdoors. We took another simultaneous measurement in the hall (A') and control indoor (C) during 10 min. Afterwards, we tested the control outdoor (D) during an additional 10 min period. All locations should not be potentially exposed to sources of $PM_{2.5}$ other than tobacco smoke during the measurements (mainly from combustion sources as those generated in kitchens or vehicles). All the measurements were collected as unobtrusive as possible hiding the TSI SidePack in a backpack.

For each location, we registered the time of measurement onset and completion. All data registered by the two TSI SidePak monitors were downloaded into a personal computer for management and statistical analysis.

We also sampled for airborne nicotine in main entrances outdoors at the same time as we recorded simultaneous $PM_{2.5}$ concentrations in the halls (indoor) and main entrances (outdoors). Because of operational reasons, we had to restrict our analysis to a subsample of buildings. We selected 28 of the 47 trying to maintain the proportionality of the types of building according to the full sample. We used nicotine sampler's devices connected through a tub to a pump (flow 3.02 ml/min) to take the measures. Nicotine samplers contained a filter that was 37 mm in diameter and treated with sodium bisulphate.[27 28] Nicotine was analysed in the Laboratory of the Public Health Agency of Barcelona by gas chromatography/mass spectrometry. The time-weighted average nicotine concentration (micrograms per cubic metre) was estimated by dividing the amount of nicotine extracted by the volume of sampled air multiplied by the total number of minutes the filter was exposed. Airborne nicotine concentrations are also expressed in micrograms per cubic metre, with a quantification limit of 5 ng per filter, equivalent to 0.06 $\mu g/m^3$ of nicotine per an exposure time of

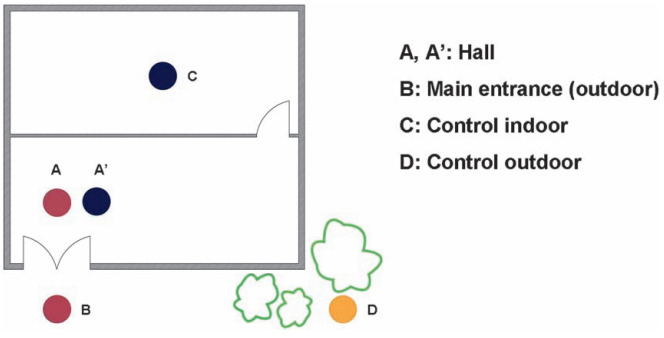

Figure 1 Outdoor and indoor locations of assessment of secondhand smoke levels in buildings. Repeated colours represent simultaneous measurements.

30 min. Samples with values below the quantification limit were assigned half of this value (limit of detection=0.03 μg/m^3).

We recorded additional information for every measurement sampling: location area (m^2), location volume (m^3), temperature (°C), relative humidity (%), outdoor or quasi-outdoor main entrance (outdoors) and distance to roadways. We considered quasi-outdoor main entrances (outdoors) when there were overhead cover and/or side walls. Overhead covers are defined as any permanent or temporary structure that impedes upward airflow. Walls are defined as any structure that impedes lateral airflow. We also registered different indicators of the presence of tobacco smoking such as the number of cigarettes lit in main entrance (outdoors) (counting continuously all cigarettes lit during the observation in a perimeter of 5 m), presence of ashtrays, presence of cigarette butts and tobacco smell as has been done in previous studies.[24 25] The same two investigators made all measurements and observations.

We did not require approval from the ethics committee because the study did not involve interventions or measurements in humans but rather environmental measures in public buildings.

Data analyses

To describe the data, we provide medians, geometric means, maximum values, IQRs and 95% CIs of the geometric means by building type and by location. We compared $PM_{2.5}$ medians with the non-parametric test for medians by location and the corresponding 95% CI, and we used the Spearman rank correlation coefficient (rsp). We describe medians and their corresponding IQR in hall and main entrance (outdoors) by selected characteristics: number of lit cigarettes in main entrances (<10, ≥10); outdoor or quasi-outdoor main entrance (outdoor); signs of tobacco smoking in hall (yes, no) and distance to roadways (<15 m, ≥15 m). We compared $PM_{2.5}$ medians in hall and in main entrances (outdoor) with the non-parametric test for medians. We studied the correlations between $PM_{2.5}$ concentrations for the simultaneous measurements (hall–main entrances (outdoors); hall–control indoor).

We also describe nicotine concentrations using medians and IQRs, and we evaluated correlations between $PM_{2.5}$ concentrations and nicotine concentrations using the Spearman rank correlation coefficient (rsp). For all analyses, we used SPSS V15.

RESULTS

Data were collected over 47 public buildings, with no statistically significant differences in the median $PM_{2.5}$ concentrations by type of building. As shown in table 1, the overall $PM_{2.5}$ median obtained in halls was 18.20 μg/m^3 (IQR: 10.92–23.92 μg/m^3), similar to the 17.16 μg/m^3 (IQR: 10.92–24.96 μg/m^3) $PM_{2.5}$ median concentration simultaneously obtained in main entrances (outdoor) (p=0.662). The $PM_{2.5}$ concentrations obtained in control locations were statistically significantly lower, 10.40 μg/m^3 (IQR: 6.76–15.60 μg/m^3) for indoors and 13.00 μg/m^3 (IQR: 8.32–18.72 μg/m^3) for outdoors. The same pattern was observed by building type. Hall and main entrances (outdoors) showed statistically significant higher $PM_{2.5}$ median concentration than controls (indoors and outdoors) in all cases. The $PM_{2.5}$ concentration in halls was more correlated with concentration in the main entrances (outdoors) (rsp=0.518, 95% CI 0.271–0.701) than with the control indoor (rsp=0.316, 95% CI 0.032–0.553).

Figure 2 presents real-time plots of $PM_{2.5}$ concentrations during a measurement session in a public building (educational place) using 10 s average values of $PM_{2.5}$ (micrograms per cubic metre). Panel A (top) represents the simultaneous measurements recorded in hall and main entrance (outdoor). The overall $PM_{2.5}$ median concentration in hall was 34.22 μg/m^3 (IQR: 31.06–38.95 μg/m^3) with a maximum value of 66.56 μg/m^3. The $PM_{2.5}$ concentration obtained in main entrances (outdoor) was 38.01 μg/m^3 (IQR: 34.23–48.22 μg/m^3) with a maximum value of 193.65 μg/m^3. Panel B (bottom) shows simultaneous measurements in hall and control indoors. $PM_{2.5}$ median concentration in hall was 82.71 μg/m^3 (IQR: 67.25–107.11 μg/m^3) with a maximum value of 196.35 μg/m^3. The $PM_{2.5}$ concentration obtained in control

Table 1 Medians, IQRs, geometric means and 95% CIs and maximum values of $PM_{2.5}$ by building type, raw data (1 s average) Barcelona Metropolitan Area, 2010

		Simultaneous measurements*		Simultaneous measurements†		
Building type	**n**	**Hall 1**	**Main entrance (outdoor)**	**Hall 2**	**Control (indoor)**	**Control (outdoor)†**
Overall	47					
Median (IQR) (μg/m^3)		18.20 (10.92–23.92)	17.16 (10.92–24.96)	18.20 (11.44–24.96)	10.40 (6.76–15.60)	13.00 (8.32–18.72)
Geometric mean (95% CI) (μg/m^3)		16.70 (16.21 to 17.19)	17.17 (16.65 to 17.69)	17.52 (16.99 to 18.05)	10.01 (9.49 to 10.53)	12.76 (12.32 to 13.20)
Maximum value (μg/m^3)		128.44	54.08	86.32	36.40	30.16
Public administration and libraries	9					
Median (IQR) (μg/m^3)		14.04 (12.22–21.84)	16.12 (8.32–23.14)	13.52 (9.88–24.44)	8.32 (5.46–12.22)	8.84 (7.80–18.98)
Geometric mean (95% CI) (μg/m^3)		15.33 (14.27 to 16.39)	14.33 (13.09 to 15.57)	15.36 (14.30 to 16.42)	7.71 (6.56 to 8.86)	11.70 (10.60 to 12.80)
Maximum value (μg/m^3)		34.32	42.64	36.40	15.60	30.16
Educational places	17					
Median (IQR) (μg/m^3)		18.20 (8.32–28.08)	17.68 (8.32–24.70)	19.24 (11.18–28.34)	10.40 (6.76–18.46)	9.10 (7.80–18.72)
Geometric mean (95% CI) (μg/m^3)		16.51 (15.70 to 17.32)	14.53 (13.63 to 15.43)	18.13 (17.25 to 19.01)	11.04 (10.20 to 11.88)	11.05 (10.29 to 11.81)
Maximum value (μg/m^3)		46.80	37.44	48.36	36.40	23.92
Public transport	8					
Median (IQR) (μg/m^3)		16.64 (9.62–20.80)	24.18 (14.95–37.96)	16.12 (9.49–22.49)	14.56 (9.88–15.99)	16.64 (14.30–20.28)
Geometric mean (95% CI) (μg/m^3)		13.69 (12.48 to 14.90)	24.44 (23.27 to 25.61)	14.19 (13.04 to 15.34)	11.50 (10.18 to 12.82)	17.11 (16.26 to 17.96)
Maximum value (μg/m^3)		21.84	54.08	27.04	19.24	23.40
Healthcare centres	13					
Median (IQR) (μg/m^3)		21.32 (12.74–28.34)	17.16 (15.08–28.86)	18.72 (12.87–27.82)	9.36 (5.98–16.38)	13.52 (10.14–18.85)
Geometric mean (95% CI) (μg/m^3)		20.33 (18.93 to 21.73)	19.48 (18.55 to 20.41)	20.87 (17.23 to 24.51)	9.69 (8.54 to 10.84)	13.68 (12.55 to 14.81)
Maximum value (μg/m^3)		128.44	46.28	86.32	21.32	22.36

*30 min measurements.
†10 min measurements.

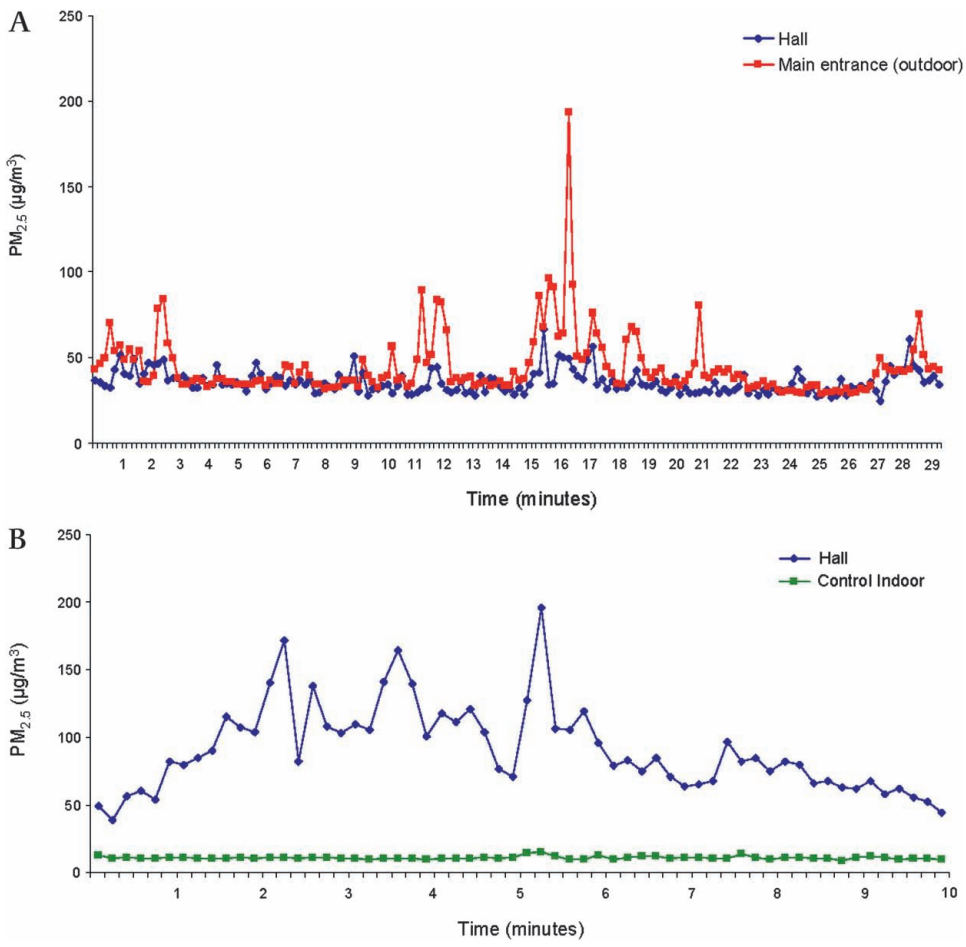

Figure 2 (A and B) Real-time plots of 10 s average values of $PM_{2.5}$ (micrograms per cubic metre) concentrations during a measurement session in a public building.

indoors was 10.74 µg/m^3 (IQR: 10.24–11.21 µg/m^3) with a maximum value of 15.08 µg/m^3.

Table 2 shows a descriptive analysis of $PM_{2.5}$ concentrations in halls and main entrances (outdoors) by different variables potentially related to tobacco smoke levels. Median $PM_{2.5}$ concentrations were higher but statistically non-significant in buildings with ≥10 lit cigarettes compared with <10 lit cigarettes both in halls (20.80 vs 16.38 µg/m^3, p=0.560) and main entrances outdoors (21.58 vs 15.86 µg/m^3, p=0.079). The same occurs when we compared outdoor and quasi-outdoor main entrances (outdoor) with higher $PM_{2.5}$ concentrations for quasi-outdoor areas both in halls and in main entrances (outdoor). The $PM_{2.5}$ levels in hall and main entrances (outdoor) did not substantially vary depending on signs of tobacco smoking in halls or the distance to the roadways. We did not find differences in concentrations obtained in halls and in main entrances (outdoors) according to the variables.

We studied nicotine concentrations in 28 of the 47 public buildings. The overall median nicotine concentration was 0.81 µg/m3 (IQR: 0.54–1.52 µg/m^3) with a maximum value of 3.74 µg/m^3. The Spearman correlation coefficient between nicotine and $PM_{2.5}$ concentration was 0.365 (95% CI −0.009 to 0.650).

DISCUSSION

Main findings and comparison with other studies

Our findings show that main entrances (outdoors) are a critical location to consider when promoting smoke-free environments for outdoors and for the adjacent areas indoors, such as halls. We did not find differences in $PM_{2.5}$ levels when comparing by building type. In all cases, $PM_{2.5}$ concentrations obtained in main entrances (outdoors) were very similar to those obtained in halls, and both of them were considerably higher than levels in indoors and outdoors control points.

A previous study conducted in 53 hospitals to evaluate SHS exposure found a correlation coefficient of 0.591 between $PM_{2.5}$ concentrations in hall and in main entrance (outdoor),[25] very similar to the correlation coefficient (rsp=0.518) in the present study. That correlation was higher than the one obtained between hall and control indoor. These results make sense with the real-time plots of $PM_{2.5}$ concentrations (figure 2). In general, there is an overlap of $PM_{2.5}$ concentrations in the case of hall and main entrance (outdoor) in contrast to what happens in hall and control indoor. All these results suggest that outdoor SHS drifts to immediate adjacent areas indoors where it can remain longer, as suggested in previous studies focused on outdoors levels of SHS.[3 15 18 19] Klepeis *et al*[3] studied SHS levels in outdoor public places (parks, side-walk café, restaurants and pubs), and they showed that outdoor SHS levels were comparable to indoor concentration under certain conditions. These studies also suggest that whereas the SHS levels indoors remained relatively high and slowly decayed for hours until the doors were opened to ventilate the venue, SHS outdoors concentrations dropped immediately to background levels when the cigarette source were extinguished.

There are some factors that can influence the levels of SHS outdoors as it has been suggested in other studies.[3 15–18] Although the difference was not statistically significant, we found slightly higher levels of SHS, both in hall and in main entrance (outdoor) when there were ≥10 lit cigarettes. This

Table 2 Medians, IQRs and maximum values of $PM_{2.5}$ measurements in halls and main entrances (outdoor) by selected characteristics, raw data (1 s average) Barcelona Metropolitan Area, 2010

	n	Hall Median (IQR)	Main entrance (outdoor) Median (IQR)	p Value*
Number of lit cigarettes in main entrance				
<10 lit cigarettes	32	16.38 (11.44–24.96)	15.86 (9.69–24.96)	0.285
≥10 lit cigarettes	15	20.80 (11.96–27.56)	21.58 (17.16–37.44)	0.495
Covered main entrance (outdoor)				
Quasi-outdoor	33	19.24 (11.44–26.00)	17.68 (13.00–27.56)	0.765
Outdoor	14	17.68 (11.31–22.62)	14.82 (7.67–21.65)	0.109
Signs of tobacco smoking in hall				
Yes	25	18.72 (9.88–24.44)	17.16 (10.14–23.92)	0.440
No	22	17.68 (11.44–26.78)	18.98 (10.85–35.88)	0.961
Distance to roadways				
<15 m	36	19.76 (12.03–26.91)	17.68 (12.48–28.34)	0.539
≥15 m	11	11.96 (10.92–19.24)	16.64 (9.36–20.28)	0.824

*Non-parametric test for medians for the comparison between hall and main entrance (outdoor).

finding is consistent with those of Kaufman *et al*, who showed that average levels of $PM_{2.5}$ in outdoor settings with ≥1 lit cigarettes present were two times higher than average levels of background air pollution.[17]

We found that SHS levels in quasi-outdoor main entrances were higher than those in hall and not covered main entrances. We concur with Klepeis *et al*[3] that highly enclosed outdoor areas may reduce the possibility of SHS naturally dissipating outdoors such as it is forced to drift into the adjacent indoor space. Moreover, we supposed that the more enclosed the outdoor area is, the more it allows the accumulation of cigarette emission indoors and outdoors.

Although our results were not averaged over 24 h, we found a high $PM_{2.5}$ median concentration with maximum values of 128.44 and 54.08 $\mu g/m^3$ in halls and main entrances (outdoor), respectively, higher than the 24 h outdoor average guideline value of 25 $\mu g/m^3$ recommended by the WHO Air Quality Guidelines.[29] Such levels of SHS and the recent evidence on effects of smoking in outdoor areas[6] has resulted in Framework Convention on Tobacco Control guidelines to require protection from SHS in outdoor and quasi-outdoor public places where it is 'appropriate'.[5]

Limitations of the study

One potential limitation of the study is that we did not control for wind conditions in our examination of outdoor $PM_{2.5}$ concentrations. SHS concentration outdoor are sensitive to wind speed and direction.[3 18] However, we performed the measurements in different hours and days during 4 months, and hence, potential bias due to the wind conditions might have occurred in a non-differential way. We recommend that future research include venue-specific wind measures to account for these effects. We did not take into account the distance between the monitor and lit cigarettes. A previous study controlled smoking activity at precise distances from monitored positions, and they observed a clear reduction in SHS levels outdoors as distance from a tobacco source increased.[18] While it would have been interesting to control for this variable, it is very difficult to calculate the proximity from every lit cigarette during the measurement in a non-controlled study since smokers may change their position during observation.

Finally, the number of buildings measured was limited for operational reasons. We included public buildings that followed the criteria established. In some cases, we selected the buildings because we knew it would be easy to find smokers in the main entrance (outdoor) (ie, some educational places and healthcare centres) and they were buildings of our interest. Other buildings were selected through an environmental scan. Anyway, our study includes a variety of public buildings that had not been studied so far.

Strengths of the study

To our knowledge, this is one of the few studies using simultaneous measurements of $PM_{2.5}$ levels in outdoor and indoor settings and the first one that includes both indoor and outdoor controls.

Moreover, this is real-life and real-time study. We are aware that we may have obtained some inconsistencies in the data as we did not control for some unpredictable variables. However, opposite to a controlled experiment, we got a realistic view of the behaviour of smokers and a real approach of the exposure to SHS in the building main entrances.

While $PM_{2.5}$ can originate from sources of combustion different to tobacco smoke, such as cooking or traffic-related air pollution, we took into account the traffic-related air pollution in the case of the outdoor measurements by registering each building's proximity to roadways. We observed that $PM_{2.5}$ concentrations did not substantially vary depending on the distance of the roadway. We also correlated $PM_{2.5}$ with airborne nicotine concentrations outdoors as also done in other studies with indoor measurements.[25 30] and we obtained a moderate correlation possibly due to the low SHS levels outdoors.

CONCLUSIONS

Our study shows that indoor locations where smoking is banned are not completely free from SHS with levels similar to those obtained in the immediate entrances (outdoors) where smoking

What this paper adds

- Indoor locations where smoking is banned show similar secondhand smoke levels to those obtained in the immediate entrances (outdoors), and both of them are considerably higher than levels in indoors and outdoors control points.
- Main entrances (outdoors) are a critical location to consider when promoting smoke-free environments for outdoors and for the adjacent areas indoors.

is allowed. This indicates that SHS from outdoors settings drifts to adjacent indoors. Scientific evidence has firmly established that there is no safe level of exposure to SHS. Consequently, these results warrant a revision of current smoke-free policies in outdoor building entrances to protect people from tobacco smoke exposure. Moreover, further studies should focus on SHS exposure in other outdoor or quasi-outdoor locations, such as terraces or patios, beaches, public parks, bus and train stops, and sports facilities to better evaluate the need of reinforcing smoke-free policies.

Acknowledgements We thank Francesc Centrich and Glòria Muñoz (Laboratory of Public Health, Agència de Salut Pública de Barcelona) for nicotine analysis.

Funding This study is partly funded by the Ministry of Science and Universities, Government of Catalonia (2009SGR192), and by Ministry of Health, Government of Spain (RTIC Cancer, RD06/0020/0089 and CIBERESP CB06/02/0032).

Competing interests None.

Contributors XS and EF designed the study to which all the authors contributed. XS and FA collected the data. XS, JMMS, MF and MJL prepared the database. XS analysed the data and JMMS, MF, ES and MN revised with her the results. All the authors contributed to the interpretation of results. XS drafted the manuscript, which was critically revised by all authors, who also approved the final version. EF is the guarantor.

Provenance and peer review Not commissioned; externally peer reviewed.

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Secondhand smoke levels in public building main entrances: outdoor and indoor $PM_{2.5}$ assessment

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Tob Control 2012 21: 543-548 originally published online September 28, 2011
doi: 10.1136/tobaccocontrol-2011-050040