ERJ Express. Published on February 27, 2009 as doi: 10.1183/09031936.00180708

Second-hand smoke exposure in a sample of European hospitals (2007)

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Short title: Second-hand smoke in European hospitals

Word counts: Abstract (196), Main text (2,346)

2 tables, 2 figures, 24 references

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ABSTRACT

Smoking in hospitals is banned in many European countries; nevertheless, their level of compliance is diverse, and in some cases there are still smoking areas. This study describes the levels of second-hand smoke, as derived from respirable suspended particles measurements, in a sample of European hospitals during the year 2007.

This is a multicenter, descriptive, cross-sectional study carried out in 30 hospitals in 7 European countries (Austria, Belgium, France, Germany, Greece, Romania, and Spain). We measured particulate matter <2.5 μm in diameter ($PM_{2.5}$) by means of a hand-held laser-operated monitor of particle size and mass concentration in six selected indoor locations. We computed medians and interquartile ranges of $PM_{2.5}$ concentrations to describe the data by country and location of measurement.

The median $PM_{2.5}$ concentration in all countries and locations was 3.0 μg/m^3, with half of the measurements between 2.0 and 7.0 μg/m^3. $PM_{2.5}$ levels were similar across countries. Eleven measures (5.5%) were over 25.0 μg/m^3, which is the 24-hour average limit recommended by WHO for outdoor air quality guideline.

Our results showed that exposure to second-hand smoke in this sample of European hospitals is very low and can be easily monitored to assure smoke-free legislation compliance.

Keywords: environmental tobacco smoke; Europe; hospitals; $PM_{2.5}$; second-hand smoke; tobacco smoke pollution

Second-hand smoke (SHS) or exposure to environmental tobacco smoke has important public health implications. It has been classified as a lung carcinogen [1] and it has been proved to have adverse health effects on children and adults, including heart disease, lung cancer, and other respiratory disorders [2].

Smoking in hospitals is completely banned in many European countries by national or regional laws [3]. In those countries, as well as in countries without complete bans on smoking, some hospitals have opted to go smoke-free on their own initiative or in association with National Networks integrated in the European Network for Smoke-free Hospitals (ENSH). The ENSH is a non-governmental organization coordinating national and regional Smoke-free networks from 20 European countries including about 1,400 hospitals. The ENSH promotes common strategies to obtain tobacco-free environments and to provide active support for quitting by patients, visitors, and staff among European hospitals. The ENSH activities are based on a "European code of smoke free hospitals & health services", providing various tools to support a successful implementation of tobacco-free policies in health facilities (http://www.ensh.eu).

To date, few studies have used direct measures of SHS to monitor the accomplishment of the Smoke-free Hospital policy [4, 5]. Exposure to SHS has been measured by different methods such as questionnaires (based on self-reports) and markers of SHS, namely substances found in tobacco smoke (such as nicotine) that can be objectively measured in body fluids (urine, blood, and saliva) or in the air providing an objective measurement of SHS exposure [6]. Airborne markers, such as vapour-phase nicotine or respirable suspended particles indicate the average level of exposure in a specific setting and are easier to obtain than biological samples [7]. Among respirable suspended particles, those of 2.5 μm in diameter and smaller (commonly known as fine particles or

$PM_{2.5}$) are widely used for SHS assessment in enclosed settings [8-10]. $PM_{2.5}$ are originated from all types of combustion, including motor vehicles, residential wood burning, forest fires, some industrial processes, etc. Although $PM_{2.5}$ particulates may derive from particles of dust and other combustion activities, smoking is generally the largest contributor to indoor air pollution [11]. The aim of the present study was to describe the levels of SHS, as derived from $PM_{2.5}$ measurements, in a sample of European hospitals during the year 2007.

MATERIAL AND METHODS

This is a multicenter, descriptive, cross-sectional study among a convenience sample of 30 hospitals in 7 European countries with different smoking prevalence rates and tobacco control activity (Table 1). We included one hospital from Austria, five from Belgium, three from France, five from Germany, seven from Greece, four from Romania, and five from Spain. Most hospitals were in urban areas and were general and specialized (maternities, oncological, children) hospitals. Most of them were affiliated to university (nursing or medicine schools) and all were members of the ENSH. The national coordinator of the Smoke-free Network in each country asked different hospitals to participate, taking into account the limited timeframe to do the measurements in each country (because the particle monitor had to go from one country to another, see below). Our initial goal was to include 5 hospitals in as many countries as possible, and we finally obtained collaboration from seven countries.

We used a common protocol (derived from a previous study [5]) to sample and record the $PM_{2.5}$ measurements. We defined 6 standard locations within each hospital to perform measurements by centrally trained investigators: main entrance hall, emergency

department waiting room, internal or general medicine hospitalisation unit, general surgery hospitalisation unit, cafeterias, and fire escapes. In addition, measurements were taken in other areas at the local investigators criteria when the standard sampling areas were not available. Smoking areas in hospitals with these zones were also measured. Except in halls, all locations were not affected by air flows that potentially can influence the distribution of particles in the air. For each $PM_{2.5}$ measurement the following data were recorded: hospital and location, date of measurement, sampling area, sampling volume, ventilation, and signs of smoking (tobacco smell, cigarette butts on the floor, presence of ashtrays, and persons smoking). Since the study only involves environmental measurements and not interventions or measurements in humans, approval from Ethics Committees was not required.

We measured the concentration of $PM_{2.5}$ with a pre-calibrated, hand-held laser-operated monitor of particle size and mass concentration (Aerocet 531, Metone Instruments Inc., Grants Pass, OR, USA) [12]. The operation was manual, with a user-friendly interface. The device was used with a short length of Tygon on a flat surface, not in the floor of the room, preferably in the middle, and away from any doors or windows. Due to logistic constraints and because all locations were indoors, short (2-minute) for a mass sample type monitoring sessions were carried out in each location. The device displayed on the screen $PM_{2.5}$ and relative humidity values, that kept registered in the same device, and were transferred to a computer in the coordinating center. We sampled the hospitals from March to July 2007 in all the countries except in Romania (September-October 2007). The measurements were done in one or two consecutive weeks by the local researcher, using the same device in the 7 countries.

Given the skewed distribution of $PM_{2.5}$ concentrations, we computed medians and interquartile ranges to describe the data, and we used box-plots in logarithmic scale to

graphically present the distribution of $PM_{2.5}$ concentrations by country and location. We computed tests for linearity to explore the trends in $PM_{2.5}$ concentrations by signs of smoking.

RESULTS

We obtained 199 measurements of $PM_{2.5}$ within 30 hospitals across 7 European countries: 30 measurements in halls or main hospital entrances, 29 in the emergency department waiting rooms, 22 in internal or general medicine hospitalisation units, 27 in cafeterias, 22 in fire escapes, 22 in general surgery hospitalisation units, and 39 in other places, including 8 smoking areas (in Belgium and Greece).

The overall median $PM_{2.5}$ concentration was 3.0 $\mu g/m^3$, half of the measurements between 2.0 and 7.0 $\mu g/m^3$. We found similar $PM_{2.5}$ levels across countries (Table 2), with the lowest median concentration in Germany (5 hospitals with a total of 30 measurements) and the highest in Romania (4 hospitals with a total of 24 measurements). Eleven measurements (Figure 1) were over the accepted 24-hour average limit for outdoor air quality guideline recommended by the WHO (25.0 $\mu g/m^3$) [13] and five measurements were over the value recommended by the US Environmental Protection Agency (35.0 $\mu g/m^3$) [14]. These measurements were taken in cafeterias, in smoking areas and in “other zones” in hospitals from Greece, Belgium and Romania, respectively.

The median $PM_{2.5}$ concentrations in all the countries by location (Table 2) ranged between 2.0 (surgery hospitalisation units) and 4.0 $\mu g/m^3$ (internal medicine hospitalisation units). Half of the measurements provided values between 2.0 and 8.0

μg/m^3, with a few values above 10.0 μg/m^3 in halls, waiting rooms at emergency departments, internal medicine hospitalisation units, cafeterias, and fire escapes (Figure 2). There were no wide variations across the 7 countries, with the exception of Greece, Spain, and Romania, that presented relatively higher values. The measurements taken in smoking areas showed the highest median $PM_{2.5}$ levels (i.e., 55.5 μg/m^3 in Belgium), with some values above 60 μg/m^3. The median $PM_{2.5}$ concentration in locations with no signs of smoking was 4.0 (interquartile range: 2.0, 8.0) and significantly increased to 6.0 (interquartile range 4.0; 32.5) when all smoking signs were present (test for linearity, p=0.020).

DISCUSSION

This study shows for the first time with a European perspective that the levels of exposure to SHS in hospitals, as measured by $PM_{2.5}$, are relatively low and without striking differences across countries. Most of the countries of the study had passed specific smoking bans for health care facilities at the time of the study [3]. Some of these bans, however, have exceptions and allow smoking in designated rooms within hospitals or even still permit smoking in cafeterias (with or without smoking areas). Those locations with values over 25 μg/m^3 were smoking zones, one cafeteria located in a separate building next to the hospital, and “other zones”. These “other zones” included areas with restrictions on smoking (such as consultation rooms, patient rooms, and doctors offices), and hence indicates a infringement of the smoke-free policy. Although $PM_{2.5}$ detected in cafeterias might also originate from cooking in kitchens, most cafeterias did not have cooking facilities, and all of them had well functioning built-in ventilation systems.

There are several particulate matter health effects on the respiratory and cardiovascular systems in children, adults and susceptible groups within general population; and the epidemiological evidence shows adverse effects of particles after both short- and long-term exposures [15]. Our results show overall low levels of $PM_{2.5}$ in hospital facilities; nevertheless, the risk for various outcomes increases with exposure, and there is little evidence suggesting a threshold below which no adverse health effects would be anticipated [15]. Thus, according to WHO air quality guideline, the aim must be to achieve the lowest concentrations possible in order to minimise risk effects.

Although all the hospitals in the study had implemented tobacco control policies following the ENSH Code and Standards, they do not have the same level of restriction, enforcement and fulfilment due to inter-country differences in legislation [3]. For example, smoking rooms inside the hospitals were permitted in Austria, Belgium, Germany, and Greece (Table 2). Differences in baseline tobacco consumption among the population and in the anti-smoking climate should be also taken into account. For example, Greece and Austria had high smoking prevalence, and with Germany, they had the lowest scores in the Tobacco Control Scale (Table 1) [16]. These facts could well explain the different levels of SHS found in some areas in some hospitals.

Most of the measurements were below the 24-hour average limit recommended by WHO and US Environmental Protection Agency in both outdoors and indoors [13,14]. The chemical composition of outdoor pollutants can be different from that of the indoor air measured in our hospitals. Outdoors PM concentrations used to be higher than indoors, although the time of exposure should be also considered for risk assessment. Moreover, the air quality guidelines refer to 24h or annual average level, instead of our spot measures. Although the site of exposure, indoors or outdoors, determines the

composition of the air and the concentration of the various pollutants, it does not directly affect the exposure-response relationship [13,15].

Few studies have assessed SHS in hospitals. A pioneer study that measured nicotine airborne concentrations in 22 hospitals of 7 European cities (Vienna, Paris, Athens, Florence, Oporto, Barcelona, and Örebro) [4, 17, 18] in 2001-2002 showed low but detectable SHS exposure in hospitals. Similar surveys conducted in 11 Latin American countries and China –including 1 hospital in each country between 2002 and 2006– also showed low but quantifiable nicotine concentrations [19-22]. In a previous study in Catalonia, Spain, we found low levels of airborne nicotine in 44 public hospitals before the new Spanish tobacco control law came into force in 2006, which in turn mostly decreased to unquantifiable concentrations after the ban [5]. However, $PM_{2.5}$ concentrations have been scanty used in the monitoring of SHS in hospitals, except some pilot experiences in Italy [23] and Greece [24]. These studies indicate that $PM_{2.5}$ concentrations are a feasible and sensible method of SHS assessment in hospitals.

Some limitations of our study deserve consideration. Firstly, the sample of participating hospitals was small (even considering that this is the first study to systematically survey 30 hospitals in different countries), and hospitals were recruited on a convenience framing approach and not selected at random. We tried to assure internal validity in the measurements by selecting the participating hospitals, given the complexity of the multicountry study. Secondly, we used a standard and accepted methodology to measure $PM_{2.5}$, by means of a commercial particle size monitor. The same monitor was used in all the hospitals and the local researchers in charge of the measurements were trained using a common protocol. Climate conditions may change from hospital to hospital and from country to country, given that the field work was extended during several months. However, the mean temperature during measurements in all the

countries was 22.1ºC and the mean relative humidity was 39.6% without huge variations across countries. Although we performed 2-minute measurements in each location, 10 to 20 minutes average measures have been used in other studies. However, the reliability of the recordings was warranted by the good consistency of the different data from smoke-free locations of the same hospital in the same day, like measurements in halls, emergency department waiting rooms, and internal medicine hospitalisation units. The differences in $PM_{2.5}$ concentrations found between locations where smoking was forbidden and allowed are also an indicator of the reliability of measurements. $PM_{2.5}$ variations in hospitals are supposed to be very small in comparison to measurements done in other more polluted environments, such as pubs or bars, where average concentrations for long periods are preferred. Thirdly, the number of sampling locations within each hospital was limited to 6 common places. We were not able to survey more locations because of operational reasons. However, this distribution of samples provided a good estimation of SHS levels in a previous study [5] and prevents an excessive variety of locations that would make comparisons by locations across countries unfeasible. Finally, we failed to obtain outdoor measurements for comparison with in-hospital measurements, although given the low levels obtained indoor, the comparison group would have been almost useless. Last but not least, in the interpretation of the results it must be taken into account that SHS is not the only source of indoor particulate matter, although it is considered its main contributor.

In conclusion, exposure to SHS, as measured by means of $PM_{2.5}$, is very low across this sample of European hospitals. Use of $PM_{2.5}$ as a marker of exposure to SHS appears to be a feasible method to compare the compliance with the smoke-free regulations in hospitals both within countries and across countries. Periodical surveys of SHS

exposure in hospitals, following a common, standard, and easy to implement protocol should be developed and promoted by the European public health authorities.

ACKNOWLEDGMENTS

The authors acknowledge the local coordinators to facilitate data collection. The European Network for Smoke-free Hospitals acknowledges the funds received from the European Commission (contract No. 2005329). EF, MF, JMMS, and CM are funded by the Ministry of Health (RTIC Cancer, RD06/0020/0089), Government of Spain, and the Ministries of Science and Universities (SGR200500646) and Health (GFH 20008) of the Government of Catalonia. MJL and MN are funded by the Instituto de Salud Carlos III (CIBER en Epidemiología y Salud Pública, CIBERESP CB06/02/0032).

CONTRIBUTORS

All the authors participated in the study design and writing of the protocol. CM and AO coordinated data collection in the participating hospitals. MF, MJL and MN supervised and performed quality-control procedures. MF, JMMS, MJL and CM administered and prepared the data base. EF and JMMS analysed the data. All the coauthors contributed to the interpretation of results. EF drafted the manuscript, which was critically revised by all coauthors. All coauthors approved the final version of the manuscript. EF is the guarantor.

COMPETING INTEREST

Not declared.

APPENDIX

Participating hospitals

Austria: Krankenhaus Hietzing mit Neurologischem Zentrum Rosenhügel; Belgium: AZ Sint Lucas, CHU Saint-Pierre, Institut Jules Bordet, Hôpital Erasme, AZ Sint Blasius; France: Hôpital Cochin, Hôtel-Dieu de Paris, Centre Hospitalier Universitaire de Caen; Germany: Kreiskrankenhaus Osterholz, Evangelisches Krankenhaus Köln – Weyertal, Klinikum Dorothea Christiane Erxleben Quedlinburg, Kreiskliniken Aschersleben; Krankenhaus Sangerhausen; Greece: Tzaneio General Hospital, Evagelismos General Hospital, Agia Olga / Konstadopouleio, Geniko Kratiko /Genimatas, IKA Athinon, Children Hospital "Agia Sofia", Laiko General Hospital; Romania: Bucur Maternity Hospital, Universitary Hospital Maternity, Maternity Hospital, National Institute of Pneumology Marius Nasta; Spain: Institut Català d'Oncologia, Hospital de Mollet, Hospital de Badalona, Hospital Clínic i Provincial de Barcelona, Hospital Sant Joan de Déu.

TABLE 1. Prevalence of smoking, type of smoking legislation in health care facilities, and tobacco control activity in 7 European countries.

	Austria	**Belgium**	**France**	**Germany**	**Greece**	**Romania**	**Spain**
Prevalence of smoking*							
In men	48.1%	30.0%	28.2%	33.2%	46.8%	40.0%	34.1%
In women	46.5%	25.0%	21.7%	22.1%	29.0%	19.5%	22.4%
(population)	(≥ 14 years)	(≥ 18 years)	(≥ 12 years)	(≥ 15 years)	(12-64 years)	(≥ 15 years)	(≥ 16 years)
year of survey	2004	2002	2005	2003	2000	2004	2003
Regulation of smoking in health care facilities†	Ban	Ban	Ban	Voluntary agreement	Ban	Ban	Ban
Tobacco Control Scale score (max. 100)†	35	58	59	37	36	50	55

* Source: World Health Organization, Regional Office for Europe. The European tobacco control report 2007. Copenhagen: World Health Organization; 2007.

† Source: Joossens L, Raw M. Progress in tobacco control in 30 European countries, 2005 to 2007. Berne: Swiss Cancer League, Association of European Cancer Leagues, European Network for Smoking Prevention; 2007.

TABLE 2. $PM_{2.5}$ concentrations (in µg/m^3) in 30 European hospitals by country and location of measurement, 2007.

	(No. of measures)	All Countries (199)	Austria (12)	Belgium (36)	France (8)	Germany (30)	Greece (59)	Romania (24)	Spain (30)
All locations	(199)	3.0 (2.0;7.0)	3.0 (3.0;3.8)	3.0 (1.0;3.8)	3.5 (3.0;13.0)	1.5 (0.0;3.0)	4.0 (2.0;7.0)	10.0 (8.3;20.3)	5.0 (2.0;9.5)
Hall (main entrance)	(30)	3.0 (3.0;5.3)	5.0 (4.0;6.0)	3.0 (3.0;4.0)	4.0 (2.0;16.0)	3.0 (1.5;4.0)	3.0 (3.0;6.3)	-	5.0 (1.0;10.0)
Emergency department waiting room	(29)	3.0 (1.5;4.0)	3.0 (2.0;3.0)	2.0 (1.0;2.5)	4.0 (4.0; 4.0)	0.0 (0.0;2.0)	3.5 (1.8;5.5)	-	3.0 (2.5;9.0)
Internal medicine hospitalisation unit	(22)	4.0 (1.8;7.3)	-	3.0 (1.5;5.5)	3.0 (3.0; 3.0)	0.5 (0.0;7.0)	5.0 (2.0;8.0)	-	5.0 (3.5;16.0)
Cafeteria	(27)	3.0 (2.0;7.0)	-	2.5 (1.5;4.0)	3.0 (3.0;3.0)	3.0 (1.0;3.5)	7.0 (3.0;23.5)	-	5.0 (2.0;14.5)
Fire escape	(22)	3.0 (0.8;6.3)	3.0 (3.0; 3.0)	3.0 (0.0;3.0)	17.0 (17.0; 17.0)	0.5 (0.0;1.8)	6.0 (3.0;8.3)	-	6.0 (3.0;11.0)
General surgery hospitalisation unit	(22)	2.0 (0.0;4.0)	-	0.5 (0.0;1.5)	-	0.0 (0.0;2.3)	2.0 (2.0;5.0)	-	4.0 (3.0;5.5)
Smoking area	(8)	18.5 (3.5;59.8)	3.0 (3.0; 3.0)	55.5 (34.3;67.8)	-	2.0 (2.0; 2.0)	6.0 (5.0;7.0)	-	-
Other places	(39)	8.0 (3.0;13.0)	3.0 (3.0;3.5)	-	-	2.0 (2.0; 2.0)	3.0 (0.8;5.0)	10.0 (8.3;20.3)	-

Data are presented as medians (interquartile range).

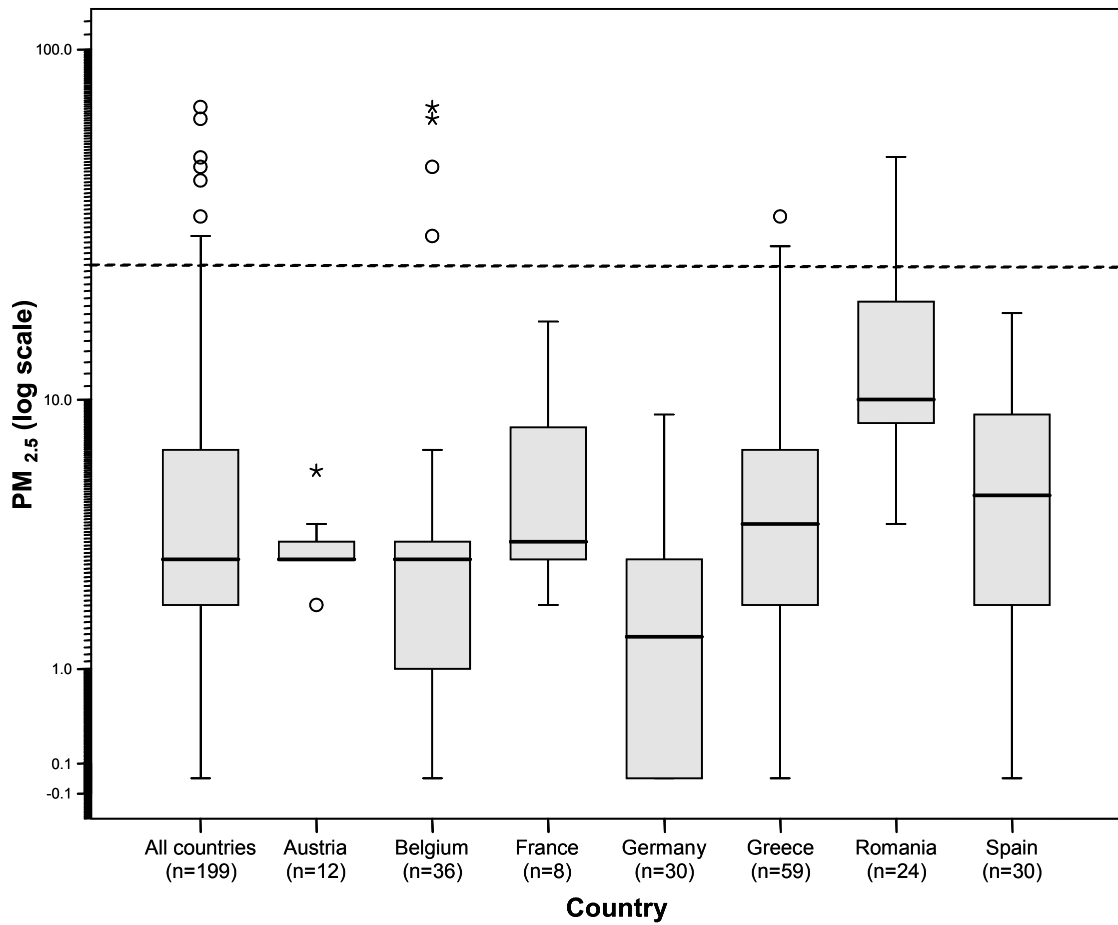

FIGURE 1. Distributions of $PM_{2.5}$ concentrations (in µg/m^3) in 30 European hospitals by country, 2007. Horizontal lines within boxes indicate medians; boxes, interquartile ranges; error bars, values within 1.5 times the interquartile range; circles, outliers; and asterisks, extreme values. n: number of samples in each country. Dashed line indicates 25µg/m^3 24-hour mean value recommended by the WHO indoor air quality guideline. n: number of samples in each country.

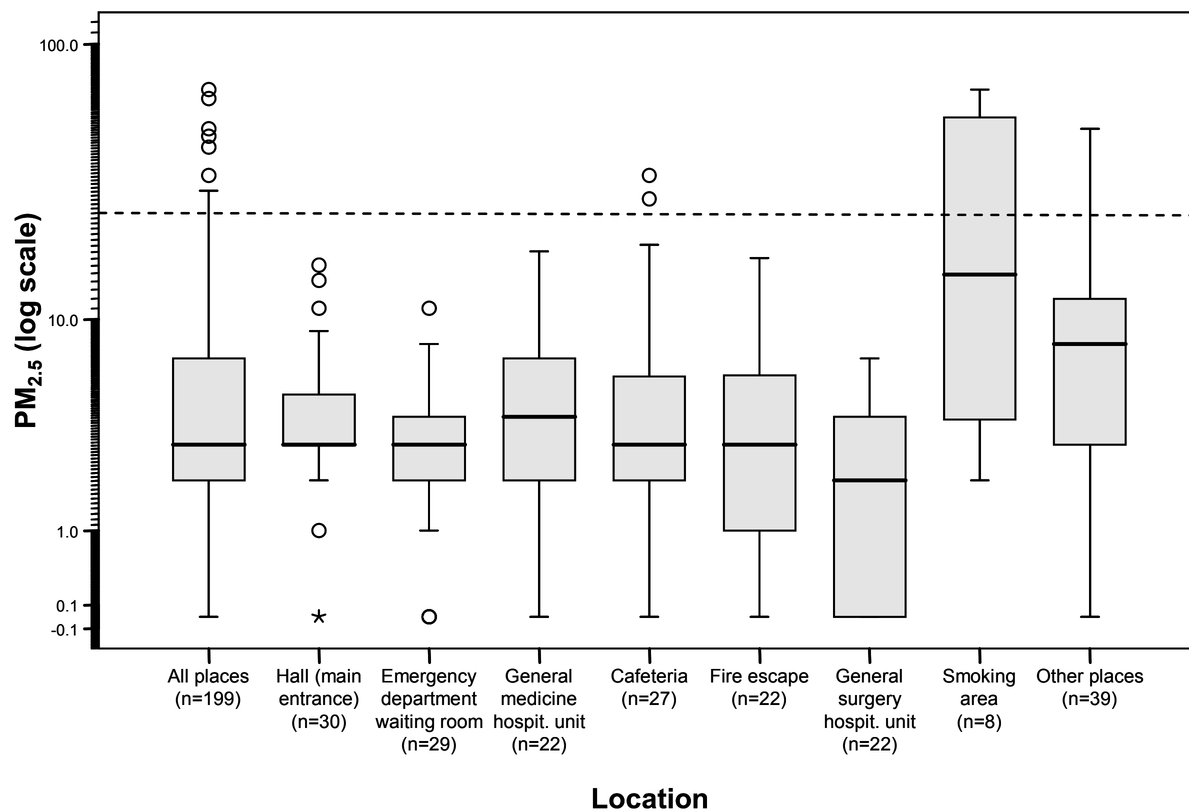

FIGURE 2. Distribution of $PM_{2.5}$ (in µg/m^3) in 30 European hospitals by location of measurement, 2007. Horizontal lines within boxes indicate medians; boxes, interquartile ranges; error bars, values within 1.5 times the interquartile range; circles, outliers; and asterisks, extreme values. n: number of samples in each location. Dashed line indicates 25µg/m^3 24-hour mean value recommended by the WHO indoor air quality guideline. n: number of samples in each location.

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