



Impact of tobacco control policies in hospitals: Evaluation of a national smoke-free campus ban in Spain

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ABSTRACT

Introduction. On January 2, 2011, the Spanish government passed a new smoking law that banned smoking in hospital campuses. The objective of this study was to evaluate the implementation of smoke-free campuses in the hospitals of Catalonia based on both airborne particulate matter and observational data.

Methods. This cross-sectional study included the hospitals registered in the Catalan Network of Smoke-free Hospitals. We measured the concentration of particulate matter < 2.5 µm in µg/m³ at different locations, both indoors and outdoors before (2009) and after (2011) the implementation of the tobacco law. During 2011, we also assessed smoke-free zone signage and indications of smoking in the outdoor areas of hospital campuses.

Results. The overall median particulate matter < 2.5 µm concentration fell from 12.22 µg/m³ (7.80–19.76 µg/m³) in 2009 to 7.80 µg/m³ (4.68–11.96 µg/m³) in 2011. The smoke-free zone signage within the campus was moderately implemented after the legislation in most hospitals, and 55% of hospitals exhibited no indications of tobacco consumption around the grounds.

Conclusions. After the law, particulate matter < 2.5 µm concentrations were much below the values obtained before the law and below the annual guideline value recommended by the World Health Organization for outdoor settings (10 µg/m³). Our data showed the feasibility of implementing a smoke-free campus ban and its positive effects.

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Introduction

The implementation of smoke-free policies in hospitals and health care services became a challenge in the US when, in 1992, the Joint Commission on Accreditation established a compulsory requirement to ban smoking in indoor areas for hospital members. In 2000, the European Network of Smoke-free Hospitals (ENSH) also developed a guideline to establish smoke-free policies in hospitals (www.ensh.eu) (Martinez et al., 2009); however, that was a voluntary requirement in a strategy to become smoke-free and promote smoking prevention

Abbreviations: ENSH, European Network of Smoke-free Hospitals; FCTC, Framework Convention on Tobacco Control; IARC, International Agency of Research on Cancer; IQRs, interquartile ranges; PM, particulate matter; SHS, second-hand smoke; XCHSF, Catalan Network of Smoke-free Hospitals; WHO, World Health Organization.

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and cessation. There is evidence that indoor smoking bans alone promote slight decreases in tobacco consumption, are supported by employees, and elicit satisfaction among patients and visitors (Hopkins et al., 2010; IARC, 2009; Longo et al., 1996, 2001; Martinez et al., 2008). However, some studies suggest that more restrictive smoke-free policies, including outdoor bans, would support employees in attempts to reduce or cease smoking (Fernandez and Martinez, 2010; Gadomski et al., 2010; Williams et al., 2009). Other benefits include the protection of non-smokers, the reduction of smoking opportunities, and the denormalization of smoking (IARC, 2009). Moreover, this policy is expected to promote a cleaner environment, reduce fire hazards, and increase productivity among staff (Fernández et al., 2010).

As a result, a new movement emerged to promote smoke-free hospital campuses, which extended smoking bans to outdoor areas (Fernández et al., 2010; Williams et al., 2009) following the recommendations based on Article 8 of the World Health Organization Framework Convention on Tobacco Control (FCTC) (World Health Organization,

2009). One objective of smoke-free hospital campuses is to set a clear example of good health-promoting practices, by providing a clear message to patients, visitors, and employees that tobacco consumption is a health risk, and therefore, it would not be allowed on the grounds of the institution. This message was expected to encourage patients, visitors, and employees to quit smoking and maintain a clean, neat environment (Fernández et al., 2010).

Recently, some countries, including the US, Japan, and Australia, have implemented smoke-free campuses (Martinez et al., 2014; Nagle et al., 1996). In 2008, over 45% of US hospitals reported that they had extended tobacco-free policies to outdoor places (Williams et al., 2009). In Europe, among the 1400 hospitals that belong to the ENSH, now called the Global Network for Tobacco Free Health Care Services, some have adopted smoke-free hospital campus policies, based on what is considered the GOLD standard for tobacco control in health care services (Fernández et al., 2010). In Spain, however, the implementation of smoke-free campuses became compulsory on January 2, 2011, when law 42/2010 was adopted to reinforce previous legislation (law 28/2005), which banned smoking in indoor places (including workplaces and public places, like hospitals). The new tobacco law prohibited smoking in all health care services, both indoors and outdoors, with the exception of medium- and long-stay psychiatric services and nursing homes, where designated smoking rooms are allowed (Ministerio de Sanidad y Consumo, 2005).

In Catalonia, Spain, in 2000, the Catalan Network of Smoke-free Hospitals (www.xchsf.com) was created with the objective of enforcing smoke-free hospitals and extending other tobacco control activities in the hospitals (Fernández et al., 2010). One of the activities included monitoring and evaluating tobacco control activities to assess the progress of smoke-free policies over the years (Martinez et al., 2009). With the implementation of the new smoke-free law 42/2010, the Catalan Network of Smoke-free Hospitals supported and assisted hospitals in implementing smoke-free campuses. The main aims of the present study were: (1) to describe SHS levels within the hospital after implementing the new tobacco law and, to compare the results obtained in 2009, before the implementation of the law 42/2010; and (2) to evaluate the implementation of smoke-free campuses by measuring outdoor SHS levels, the presence of total smoke-free zone signage, and indications of tobacco consumption on the grounds of hospital campuses.

Methods

Study design and participants

This descriptive, repeated cross-sectional study, included all hospitals registered in the Catalan Network of Smoke-free Hospitals, in Catalonia (Spain). Data were collected before and after the implementation of smoke-free legislation using the same strategy. The pre-legislation data were obtained between February and September 2009 among the 53 hospitals affiliated to the Catalan Network of Smoke-free Hospitals at that time. Post-legislation data were obtained between March and October 2011 including a total of 60 hospitals of the Network by the year 2011. Data collections were performed after contacting the coordinator of the smoke-free hospital committee by telephone or e-mail to arrange an appointment.

Measurements and variables

PM_{2.5} concentrations

We measured PM_{2.5}, a selective airborne tobacco marker commonly used to evaluate SHS levels. We followed a common measurement protocol based on previous studies. We used a hand-held instrument to monitor particle size and mass concentration (TSI SidePak AM510 Personal Aerosol Monitor) (Fernandez et al., 2009; Sureda et al., 2010). The monitor was fitted with a 2.5- μ m impactor to measure the

concentration of particulate matter with a mass-median, aerodynamic diameter $\leq 2.5 \mu\text{m}$. The sample flow rate through the TSI SidePak monitor was set at 1.7 l/min to ensure proper operation of the attached 2.5- μ m impactor. We applied a K factor of 0.52 to all the measurements calculated with our specific instrument. The equipment was set to a one-second sampling interval and was zero-calibrated prior to each use with the attachment of a HEPA filter, according to the manufacturer's specifications. Every location was sampled for a period of 15 min, with the exception of the first location, which was measured for 20 min (the first 5 min was discarded). For each location, we recorded the start and finish times of measurements. All data were recorded with the TSI SidePak monitor and downloaded weekly onto a personal computer for management and statistical analysis. PM_{2.5} concentrations are expressed in $\mu\text{g}/\text{m}^3$.

We measured PM_{2.5} concentrations in eight standard locations within the hospital campus before and after the implementation of the law, including the hall, emergency department (waiting room), general medicine department, cafeteria, fire escape, dressing rooms (surgical and non-surgical), main building entrance (outdoor), and a background measurement performed at least 10 m from the campus main entrance. After the implementation of the smoke-free law, we included main campus entrance (outdoor) to evaluate the implementation of smoke-free campuses and, in some hospitals, we were also asked to measure an outdoor point suspected to be used for smoking ("conflicting points", according to the knowledge of the smoke-free committee coordinator). Measurements started in indoor locations and ended with outdoor locations.

Observational data

We recorded additional information for every PM_{2.5} measurement, including the location area (m^2), location volume (m^3), temperature ($^{\circ}\text{C}$), relative humidity (%), and ventilation. We also recorded the presence of signage that stated smoking was prohibited and different indicators of the presence of tobacco smoking (number of hospital staff smoking, number of patients or visitors smoking, the presence of ashtrays, the presence of cigarette butts, and tobacco odor), based on the criteria used in previous observational studies (Fernandez et al., 2009; Sureda et al., 2010). When appropriate, we also recorded whether the location was completely outdoor or quasi-outdoor. Quasi-outdoor locations were defined as outdoor areas covered by a roof and/or protected with side walls, but not completely enclosed. Finally, we accounted for the traffic density (mean number of cars per min within a 15 min observation) near the hospital.

After the implementation of the new legislation, we selected some common locations around the grounds to evaluate the implementation of outdoor smoke-free zones, that included main building entrances, main campus entrances, other building entrances, gardens, cafeterias, kiosks, and other outdoor areas where smoking was suspected ("conflicting points"), based on information from the smoke-free hospital coordinators. For every outdoor location, we recorded the presence of tobacco-free zone signage; the message on the sign; the same indicators of tobacco consumption mentioned above; the physical characteristics of the area (garden, parking area, paved area); and the weather conditions (sunny, cloudy, or rainy). We established implementation criteria to assess compliance with the outdoor ban, depending on the signage of smoke-free zones and the presence of indicators of tobacco consumption.

We defined a smoke-free signage variable with three possible categories: (1) *fully implemented* was when 100% of the campus was well-delimited and all entrances to the campus and building had posted signs. The signs referred to the new law and/or they displayed the Catalan Network image; (2) *moderately implemented* was when there was poor signage across the campus, and only 50–75% of the entrances were signed. The signs displayed the Catalan Network image and/or mentioned the new law; and (3) *slightly implemented* was when there

Table 1
PM_{2.5} concentrations (µg/m³) in specific locations of 53 hospitals before (2009) and after (2011) the Spanish smoke-free legislation; Catalonia, Spain.

| | n | Median (IQR) 2009 (µg/m ³) | Median (IQR) 2011 (µg/m ³) | p-Value* |
|------------------------------------|-----|--|--|----------|
| Location | | | | |
| All | 362 | 12.22 (7.80–19.76) | 7.80 (4.68–11.96) | <0.001 |
| Hall | 50 | 13.26 (11.44–22.56) | 6.24 (5.07–11.05) | <0.001 |
| Emergency department, waiting room | 45 | 12.48 (7.02–21.32) | 5.72 (3.90–9.10) | <0.001 |
| General medicine | 47 | 10.40 (8.32–13.52) | 8.32 (4.68–11.96) | 0.094 |
| Cafeteria | 47 | 14.56 (9.36–23.40) | 9.36 (5.72–15.08) | 0.013 |
| Fire escape | 39 | 13.00 (8.32–28.08) | 7.28 (4.68–9.88) | 0.007 |
| Dressing room | 46 | 6.50 (2.08–12.09) | 6.76 (2.60–10.40) | 0.472 |
| Main entrance | 47 | 14.04 (10.40–28.08) | 9.88 (6.76–14.04) | 0.005 |
| Outside | 41 | 11.44 (9.10–15.08) | 8.84 (7.02–16.12) | 0.134 |

IQR: interquartile ranges.

* Wilcoxon test for paired samples.

were no signs on the campus, and <50% of the entrances had posted signs.

We also defined a variable based on the presence of indicators of tobacco consumption within the campus with three possible categories: (1) no indicators of tobacco consumption around the grounds of the hospital; (2) indicators of tobacco consumption in 1 or 2 outdoor locations; and (3) indicators of tobacco consumption in 3 or more outdoor locations.

Data analyses

We presented medians and interquartile ranges (IQRs) of PM_{2.5} concentrations (and box-plot graphs) to describe the PM_{2.5} concentrations in each location. We compared PM_{2.5} medians with the non-parametric Wilcoxon test for paired samples by year of the measurements. For outdoor locations (main building entrances and main campus entrances), we described medians and corresponding IQRs of PM_{2.5} concentrations in areas with distinct characteristics; for example, areas with different numbers of lit cigarettes (<10; ≥10); with an outdoor or quasi-outdoor location; with or without indicators of tobacco smoking (yes/no); with or without smoke-free zone signage (yes/no), and with high or low traffic density (≤10 cars/min; >10 cars/min). We used the non-parametric test to compare medians among groups. We calculated the proportion of hospitals with indicators of tobacco

consumption and the percentages of outdoor locations signed. We performed all analyses with SPSS v. 15.00.

Results

Table 1 shows the median PM_{2.5} concentrations and corresponding interquartile ranges of the 362 repeated measures in 53 hospitals before (2009) and after (2011) the implementation of the smoke-free law. The overall median PM_{2.5} concentration fell from 12.22 µg/m³ (7.80–19.76 µg/m³) in 2009 to 7.80 µg/m³ (4.68–11.96 µg/m³) in 2011 (p < 0.001). The reductions in median PM_{2.5} concentrations were statistically significant for hall, emergency department, cafeteria, fire escape, and main entrance. Before the implementation of the law, we observed indicators of tobacco smoking in 73 out of 362 locations, with a median PM_{2.5} concentration of 15.08 µg/m³ (IQR: 10.40–31.46 µg/m³). After the legislation, 25 out of 362 locations had indicators of tobacco smoking with a median PM_{2.5} concentration of 9.88 µg/m³ (IQR: 5.98–16.90 µg/m³).

Among the 60 hospitals after the implementation of the smoke-free law, the highest median PM_{2.5} concentrations were obtained in outdoor locations, including “conflicting points”, with 10.40 µg/m³ (IQR: 8.45–18.72 µg/m³); main building entrances, with 9.88 µg/m³ (IQR: 6.76–14.43 µg/m³); and main campus

Table 2
PM_{2.5} concentrations in outdoor hospital campuses, Catalonia, Spain (2011).

| | n | PM _{2.5} main building entrances (µg/m ³) median (IQR) | n | PM _{2.5} main campus entrances (µg/m ³) median (IQR) |
|---------------------------------------|----|---|----|---|
| <i>Number of lit cigarettes</i> | | | | |
| <10 | 54 | 9.88 (6.37–13.65) | 31 | 8.84 (5.72–16.12) |
| ≥10 | 2 | 23.66 (15.60–31.72) | 7 | 11.44 (8.32–19.24) |
| p-Value* | | 0.073 | | 0.221 |
| <i>Enclosure</i> | | | | |
| Quasi-outdoor | 39 | 10.40 (5.20–17.16) | 1 | 4.68 |
| Outdoor | 17 | 9.36 (6.76–11.70) | 34 | 10.40 (7.15–16.25) |
| p-Value* | | 0.498 | | 0.215 |
| <i>Indications of tobacco smoking</i> | | | | |
| Yes | 23 | 11.44 (7.80–17.68) | 32 | 9.62 (6.76–16.51) |
| No | 33 | 9.36 (5.20–13.00) | 6 | 10.14 (4.29–15.73) |
| p-Value* | | 0.125 | | 0.770 |
| <i>Signage</i> | | | | |
| Yes | 48 | 9.88 (6.76–13.00) | 28 | 9.10 (5.98–16.51) |
| No | 10 | 11.96 (7.54–19.50) | 10 | 10.40 (7.67–15.73) |
| p-Value* | | 0.323 | | 0.829 |
| <i>Traffic density</i> | | | | |
| ≤10 cars/min | 23 | 9.88 (5.20–14.04) | 15 | 8.84 (4.68–15.08) |
| >10 cars/min | 21 | 11.44 (6.76–18.72) | 14 | 9.10 (7.15–17.81) |
| p-Value* | | 0.347 | | 0.406 |

PM_{2.5}: airborne particulate matter <2.5 µm in diameter; IQR: interquartile range.

* Non-parametric test for comparing medians of independent samples.

entrances, with $9.62 \mu\text{g}/\text{m}^3$ (IQR: $6.50\text{--}16.25 \mu\text{g}/\text{m}^3$). The median $\text{PM}_{2.5}$ concentration obtained outside the building (background measurement) in those 60 hospitals was $9.10 \mu\text{g}/\text{m}^3$ (IQR: $7.28\text{--}15.86 \mu\text{g}/\text{m}^3$).

Table 2 shows $\text{PM}_{2.5}$ concentrations after the implementation of smoke-free campuses in outdoor main building entrances and main campus entrances. Median $\text{PM}_{2.5}$ concentrations were similar regardless the number of lit cigarettes, the type of enclosure, the presence of tobacco consumption indicators, the presence of tobacco signage, and traffic density outside the campus.

We did not observe any indicators of tobacco consumption (people smoking, the presence of ashtrays, the presence of cigarette butts, and tobacco odor) around the grounds of 55% of hospital campuses in 2011. In 30% of hospital campuses, we observed indicators of tobacco consumption in 1 or 2 outdoor locations. In 3 out of 60 hospitals, we found indicators of tobacco consumption in 3 or more outdoor locations. In 12 out of 60 hospital campuses, smoke-free signage was fully implemented, with 100% of the campus delimited and all campus and building entrances signed. In most hospital campuses ($n = 45$), smoke-free zone signage was moderately implemented, with 50–75% of entrances signed. Only 3 out of 60 hospitals had signage in less than half the entrances.

We evaluated 212 outdoor locations among the 60 hospital campuses in 2011, with most observations (87.7%) done in entrances. The other outdoor locations included gardens ($n = 7$), cafeterias ($n = 6$), fire escapes ($n = 5$), parking areas ($n = 2$), kiosks ($n = 1$), and other “conflicting” points suggested by the smoke-free hospital committee ($n = 5$). We did not observe any smokers in most of the locations (61.8%). Among the 60 hospital campuses, we found between 1 and 5 smokers in 63 locations (29.7%) and more than 5 smokers in 18 locations (8.5%). We recorded a total of 340 smokers, 63% were visitors or patients, and the remainder comprised of hospital staff. We found indications of tobacco consumption in 95 out of the 212 outdoor locations evaluated, including tobacco odor, the presence of ashtrays combined with cigarette butts, and/or people smoking. Smoke-free zone signage was present in 77% of the observed outdoor locations.

Discussion

In our study, SHS levels, measured in terms of $\text{PM}_{2.5}$ concentrations, decreased in all locations after the implementation of the law 42/2010 despite the already low concentrations due to the previous Spanish tobacco law (law 28/2005) that had already prohibited indoor smoking in health care facilities. The Catalan Network evaluated the previous smoke-free policy before (2005) and after (2006) its implementation in January 2006. Second-hand smoke (SHS) exposure was assessed by measuring airborne nicotine concentrations in public hospitals of Catalonia (Fernandez et al., 2008). The results indicated that median nicotine concentrations had declined considerably after the law was implemented. Another study conducted in Catalan hospitals in 2009 showed good compliance with the tobacco law, based on the low concentrations of small ($\leq 2.5 \mu\text{m}$ in diameter), airborne particulate matter ($\text{PM}_{2.5}$) in most locations, except in outdoor designated smoking areas, cafeterias, and main entrances (outdoors) (Sureda et al., 2010). The results obtained in the present study could be explained by the reinforcement of the tobacco law to outdoor locations in the health care facilities and also by better implementation and development of the Catalan Network program over time (Martinez et al., 2009).

Moreover, $\text{PM}_{2.5}$ levels obtained after the implementation of the new Spanish smoke-free legislation were below the annual outdoor average ($10 \mu\text{g}/\text{m}^3$) recommended by the World Health Organization as the low end of the range associated with significant effects on health (World Health Organization, 2006; World Health Organization, 2000). Only some “conflicting points” identified by the hospital smoke-free

committee showed SHS levels slightly above the World Health Organization guideline value for long term exposures. The highest $\text{PM}_{2.5}$ concentrations obtained in 2011 were found in outdoor locations (“conflicting points”, main building entrances, and main campus entrances). However, those levels were also below the 24 h outdoor average guideline value of $25 \mu\text{g}/\text{m}^3$ recommended by the same guidelines. After the implementation of the new law, we evaluated SHS levels in the main building and campus entrances and analyzed different variables that could modify those levels. $\text{PM}_{2.5}$ concentrations were slightly higher in the few places with 10 or more lit cigarettes compared to areas with less than 10 lit cigarettes, but the differences were not significant, possibly due to the low number of places with 10 or more lit cigarettes. Previous studies had shown that the number of smokers and/or lit cigarettes in an area was predictors of SHS levels in outdoor locations (Brennan et al., 2010; Cameron et al., 2010; CARB, 2005; Edwards and Wilson, 2011; Kaufman et al., 2010; Klepeis et al., 2007; Parry et al., 2011; Repace, 2005; St.Helen et al., 2011; Stafford et al., 2010; Sureda et al., 2011; Sureda et al., 2013; Wilson et al., 2011). While previous studies have considered the degree of enclosure as a factor for predicting outdoor SHS levels (Brennan et al., 2010; Cameron et al., 2010; Parry et al., 2011; Stafford et al., 2010; Sureda et al., 2011; Travers et al., 2007; Wilson et al., 2011), our data did not show any clear pattern.

The presence of other indicators of tobacco smoking, apart from lit cigarettes, was associated with a slight increase in $\text{PM}_{2.5}$ concentrations in main building entrances, but not in main campus entrances. Unlike tobacco odor and the presence of ashtrays and/or cigarette butts, which can be detected in the absence of people smoking, the $\text{PM}_{2.5}$ concentrations can immediately drop to background levels, depending on atmospheric conditions and the density and distribution of smokers (CARB, 2005; Klepeis et al., 2007; Repace, 2005). Finally, $\text{PM}_{2.5}$ concentrations, both in main building and campus entrances, moderately increased with higher traffic densities. However, the increase was not statistically significant. It is known that $\text{PM}_{2.5}$ concentrations derive from tobacco burning and other sources of combustion, like traffic-related air pollution (Gorini et al., 2005).

Smoke-free campuses were highly implemented in most of the hospitals affiliated with the Catalan Network of Smoke-free Hospitals. A majority (55%) of hospital campuses did not show any signs of tobacco consumption. These results suggested that outdoor smoke-free policies for hospitals were well accepted by the general public and hospital staff. A review on public attitudes towards smoke-free outdoor places showed that, in a number of jurisdictions, the majority of the public supported restricted smoking in various outdoor settings, including hospitals (Thomson et al., 2009). Another study conducted in Italy found that 79.9% of the population supported smoke-free policies in outdoor areas surrounding hospitals (Gallus et al., 2012). Nonetheless, 40% of outdoor locations showed people smoking within the grounds of the campus, including hospital staff. A previous study systematically observed smoking behavior in standard outdoor areas; with a reduction in the number of staff and visitors smoking on hospital grounds over a 2-year period (Poder et al., 2012). In the present study, we collected data between 3 and 10 months after the implementation of the smoke-free regulation for hospital campuses. Further monitoring would be needed to evaluate the long term compliance to the new law over time.

Smoke-free zone signage was moderately implemented, with 50–75% of the entrances well-signed. A previous study that evaluated the impact of introducing smoke-free zone signs in outdoor areas of the hospital grounds found that signage may be an effective strategy in reducing, but not eliminating smoking in those settings (Nagle et al., 1996). We recommend that other activities, beyond the implementation of smoke-free zone signage should be undertaken to achieve better compliance with the outdoor smoking ban. These activities might include improved communication, education, and training for hospital staff.

Study limitations

The main limitation of the study is the absence of PM_{2.5} measurements in main campus entrances and observational information around the grounds of the hospitals before the implementation of the law. However, we could compare PM_{2.5} concentrations in most of the indoor locations before and after the law, including the main building entrances.

Another potential limitation of the study is that PM_{2.5} is not a specific marker of SHS, because these particles can originate from other combustion sources, like cooking or traffic-related air pollution (Gorini et al., 2005). Those sources of combustion might explain the higher PM_{2.5} concentrations found in kitchens and some outdoor locations near busy roads. For this reason, we considered traffic density a factor that might contribute to outdoor PM_{2.5} levels. For indoor locations other than kitchens, tobacco smoke is considered the main contributor to PM_{2.5}. In fact, other studies used PM_{2.5} to evaluate SHS in hospitals and found it was a feasible and sensible method for SHS assessments in those settings (Nardini et al., 2004; Sureda et al., 2010; Vardavas et al., 2007). Additionally, we measured background PM_{2.5} levels to control for potentially day-to-day variability that could influence our results and we did not observe statistical significant differences in background levels before and after the implementation of the law suggesting that the differences observed in PM_{2.5} levels within the hospital locations could not be explained by this day-to-day PM_{2.5} level variability.

Study strengths

This was the first study to evaluate the implementation of the smoke-free hospital campus policy after the new Spanish tobacco law (law 42/2010) that banned smoking in all hospital locations, both indoors and outdoors. Moreover, this was a real-life study conducted in real-time. Thus, unlike results from controlled experiments, we provided a realistic view of smoking behavior and the actual SHS exposure in different locations. We used an objective marker of SHS levels (PM_{2.5}), we compared those levels before (2009) and after (2011) the implementation of the law in the same hospitals and locations measured using the same standardized procedures, and we analyzed observational data from different locations around the hospital grounds after the new smoke-free law to evaluate the presence of smoke-free zone signage and indications of tobacco consumption. Finally, we included a large number of locations around the hospital grounds in this study. We observed nearly the entire grounds of hospitals, including nearly all the entrances to the buildings and campuses.

Conclusion

The present study suggests the effectiveness of the new Spanish tobacco law (law 42/2010) in combination with the initiatives of the Catalan Network of Smoke-free Hospitals for implementing smoke-free campuses. We found lower SHS levels for all locations after the implementation of the law compared with the levels obtained in 2009. In addition, we found that nearly all the PM_{2.5} concentrations were lower than the 10 µg/m³ level recommended for outdoor settings by the WHO. Continuous evaluation of tobacco control policies can identify the strengths and weaknesses in each hospital and promote the development of new strategies for improving compliance. These results also show the feasibility of extending smoke-free legislation to outdoor settings and may encourage the full implementation of Article 8 of the WHO FCTC in other jurisdictions.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

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Contributors

XS and EF designed the study to which all the authors contributed. XS, MB, MF, CM and EC collected the data in the participating hospitals. EC and CM performed quality-control procedures. XS prepared the database. XS analyzed the data and revised results with JMMS, MF, MB, CM, ES, and EF. All authors contributed to the interpretation of the results. XS drafted the manuscript, which was critically revised by all authors, who also approved the final version. EF is the guarantor.

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