Tobacco Smoke Pollution from Designated Smoking Rooms in Bangkok's Major International Airport

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Abstract

Levels of fine particulate matter with diameters of less than 2.5 microns ($PM_{2.5}$), an indicator of secondhand smoke, were measured at Bangkok's International Airport in: 1) Designated smoking room(s) (DSR) (2) just outside these smoking rooms ,and (3) in other areas where smoking is prohibited in the main airport building. TSI SidePak AM 510 monitoring equipment was employed to monitor $PM_{2.5}$ for 30 minutes/sample. $PM_{2.5}$ samples were taken inside six selected DSR, just outside the same DSR and at other smoke–free areas inside the building, which included airline lounges, in the walkway to boarding gates, at arrival waiting areas, and at check–in service areas. The level of $PM_{2.5}$ averaged 151.9 μg/m^3 in smoking rooms, 12.0 μg/m^3 just outside DSR, and 9.0 μg/m^3 in areas where smoking is not allowed. $PM_{2.5}$ values inside smoking rooms were fifteen times the WHO annual air quality standard of 10 μg/m^3, whereas the levels outside the DSR were also elevated above the WHO standard. These findings indicate health risks in smoking rooms for travelers visiting the airport with leakage to areas just outside the DSR. Results suggest that smoking rooms at the international airport should be removed.

Keywords: Secondhand Smoke(SHS)/ Designated smoking rooms(DSR)/ Particulate matter/ $PM_{2.5}$

1. Introduction

Many large transportation centers for train, bus, ship and air transport have been smoke-free for many years (Schmidt, 2007). Despite the movement to smoke-free transportation centers, some studies have found lack of action to make and enforce smoke-free transport centers like in airports. A recent review of 34 major international airports in five world regions found that 52.9% have indoor smoking rooms or smoking areas (Stillman et al., 2014). Surprisingly, a US study in 2012 in 5 large-hub airports showed high levels of $PM_{2.5}$, fine particulate air pollution, in designated smoking room(s) (DSR) at these airports. It was concluded that DSR pollution from exposure to secondhand smoke (SHS) in airports poses health risks for workers and travelers (CDC, 2012). The study emphasized that restriction of smoking to DSR is not effective in eliminating SHS. Exposure to SHS causes all kinds of serious health consequences, including lung cancer, heart disease and respiratory infections especially dangerous to children. Newly added in the latest Surgeon General's Report are conclusions of stroke risk from SHS exposure: "The evidence is sufficient to infer a causal relationship between exposure to secondhand smoke and increased risk of stroke. The estimated increase in risk for stroke from exposure to secondhand smoke is about 20–30%. The evidence is sufficient to infer a causal relationship between the implementation of a smoke-free law or policy and a reduction in coronary events…." According to the 2014 US Surgeon General report, there is no risk-free level of SHS; and therefore banning smoking inside is recommended since not even sophisticated air cleaning technologies or ventilation systems in buildings is sufficient. Conventional air cleaning systems cannot remove all the poisons, toxins, gases, and particles found in SHS. The only effective way to protect the health of nonsmoking employees and travelers from SHS exposure is to prohibit indoor smoking even in smoking rooms that are enclosed and ventilated (ASHRAE, 2005; USDHHS, 2006). Recently, the current US Surgeon General, Dr. Vivek Murthy, called on the city of Atlanta, Georgia to make Hartsfield-Jackson International Airport (ATL) completely smoke-free (Burress, 2015), when he visited Atlanta and saw that smoking was allowed in designated smoking lounges in the airport terminals. ATL was one of the five airports studied in 2012; its 13 designated smoking rooms were designed and constructed by Philip Morris front groups with the main objective to promote the social acceptability of smoking (ANR, 2010)(Figure 1).

Thailand has incrementally strengthened its smoke-free law following findings from research evidence (Charoenca et al., 2002). As a result, almost all public places in Thailand are smoke-free. Recent research has even examined fine particulate pollution outdoors. For example, assessment of fine particulate levels in parks in Bangkok found that levels were quite low, but differed somewhat by season (Tantadprasert et al., 2011). The most recent provisions of the Non-smokers' Health Protection Act have been expanded and include parks and outdoor markets as well as domestic airports, but still allow smoking in DSR in international airports (Royal Thai Government, 2010). In a recent review of

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Figure 1: Shocking Difference between this Airport's Smoking and Nonsmoking Rooms. (Source: : http://www.popsugar.com/fitness/Smoking-Room-Washington-Dulles-Airport-37289979)

smoking policies in airports around the world by Stillman et al. (2014), it was noted that airports represent a public and occupational space that is often overlooked in national or subnational smoke-free policies. This study was conducted to assess smoking pollution from airport DSR by measuring levels of $PM_{2.5}$, respirable particles < 2.5 microns in diameter, a commonly used marker for SHS (CDC, 2012). It is important to assess these fine particles since they are usually emitted in large amounts from burning cigarettes and are easily inhaled deep into the lungs.

2. Methodology

Six of 25 designated smoking rooms at Bangkok's major international airport were selected and assessed for particulate air levels, based on their frequency of use. The design of each room was very similar, with a ventilating fan in the ceiling. The room sizes were 4m x 5m x 3m, with some chairs in the center of the room, and one glass door. The sign on the door indicated that no more than 8 persons be allowed at a time (Figure 2).

Indoor air quality was assessed by measuring levels of $PM_{2.5}$, using pre-calibrated aerosol monitors, TSI SidePak model AM510 (TSI Inc., 2006). The SidePak monitors draw air through the built-in pump in the device where particulate matter in the air scatters the light from a laser. An impactor of <2.5 microns was attached to the device to measure the concentrations of $PM_{2.5}$. According to the manufacturer's specifications, the SidePak was zero-calibrated with a high-efficiency particulate air filter, before each use; the air sample flow rate was set at 1.7 L/min and set to record the average of $PM_{2.5}$ concentrations every minute. In addition, the number of persons, number of burning cigarettes, and any activities going on inside DSR were recorded during the 30 minutes of each sample.

To measure $PM_{2.5}$ concentrations inside and just outside the DSR, two aerosol monitors were simultaneously used for recording $PM_{2.5}$ levels for 30 minutes. Following the protocol outlined in a previous study by Lee et al., 2010, one monitor was placed inside the smoking rooms away from the seats; the other was placed outside attaching to the wall about 1 foot from the door and 30 inches from the floor. For comparison, $PM_{2.5}$ samples were collected from other smoke-free areas inside the airport building, such as airline lounges, in the walkway to boarding gates, at arrival waiting areas, airline ticket offices, duty-free shops, and check-in service areas. Data collection occurred on 3 days from 8:00 a.m. to 8:00 p.m.

Figure 2: Typical smoking room in the airport.

3. Results

The 43 samples of respirable particulate matter were collected from six of the eighteen DSR and adjacent areas, all were located in the international zone of the airport. Seven other DSR in the same building have been closed, as the current law does not permit smoking in the domestic section of the airport.

3.1 $PM_{2.5}$ results inside, adjacent to, and distant from DSR

As shown in Figure 3, the mean level of $PM_{2.5}$ inside of the smoking rooms was 151.9 $\mu g/m^3$(range: 29.8 - 488.9). The average $PM_{2.5}$ level in areas adjacent to the smoking rooms was 11.9 $\mu g/m^3$(range: 10.2-13.5). The average $PM_{2.5}$ level in non-smoking areas in the airport building was 9.0 $\mu g/m^3$ (range: 5.9-10.8). The differences of $PM_{2.5}$ levels measured at all sampling sites were analyzed using oneway ANOVA. The findings showed that the average concentration of $PM_{2.5}$ inside the smoking rooms was significantly higher than those of the areas adjacent to smoking rooms and of the smoke-free areas ($p<0.05$). As done in the US 2012 airport study, "smoker density" was also calculated by dividing the average number of burning cigarettes by the volume of the DSR. The association between smoker density and $PM_{2.5}$ concentrations was calculated using Spearman's correlation coefficient and found a significant relationship (rho=0.87; $p<0.05$). The average smoker density was 8.3 burning cigarettes per 100 m^3 (range = 2.2-20.0); while the US study found 2.8 burning cigarettes per 100 m^3 (range = 0.3-9.9).

This result demonstrates that levels of tobacco increased with the number of burning cigarettes. It was observed that the highest $PM_{2.5}$ level (488.8 $\mu g/m^3$) was recorded when the number of burning cigarettes was the highest (12 cigarettes burnt or equivalent to smoker density of 20 burning cigarettes per 100 m^3). This finding is consistent with those of Kaufman et.al. (2011) which found that average increased with the number of lit cigarettes. Also, peak levels of $PM_{2.5}$ were more than 3 times as high (up to 496 $\mu g/m^3$) when smoking was present compared to when smoking was not present. It is important to note that DSR are heavily used and that the levels of $PM_{2.5}$ exposure double at each level from low to high as shown in Table 1. Even the average calculated results in low level densities in DSR per 100 m^3.

Table 1: Level of Smoker Density in DSR with cigarettes being smoked, calculated smoker densities per were higher than the average calculated in DSR in the US study (3.0 versus 2.88).100 m^3 and mean $PM_{2.5}$ exposure levels

Level of Smoker Density	No. of DSR with this level	Range of cigarettes being smoked	Calculated smoker densities per 100 m^3	Mean $PM_{2.5}$ level
Low	4	1.3 - 2.3	3.0	66.55
Medium	14	3.3 – 5.4	7.11	128.16
High	6	7.0 – 12.0	14.7	264.22
Total	24	Ave = 5.00	Ave = 8.3	Ave = 151.9

3.2 $PM_{2.5}$ levels compared to the WHO guideline

When compared to the annual WHO air quality guideline of 10 µg/m^3, all samples taken from inside the DSR and adjacent to DSR were above this level; whereas $PM_{2.5}$ measured from the non-smoking areas were slightly below the guideline as show in Figure 3.

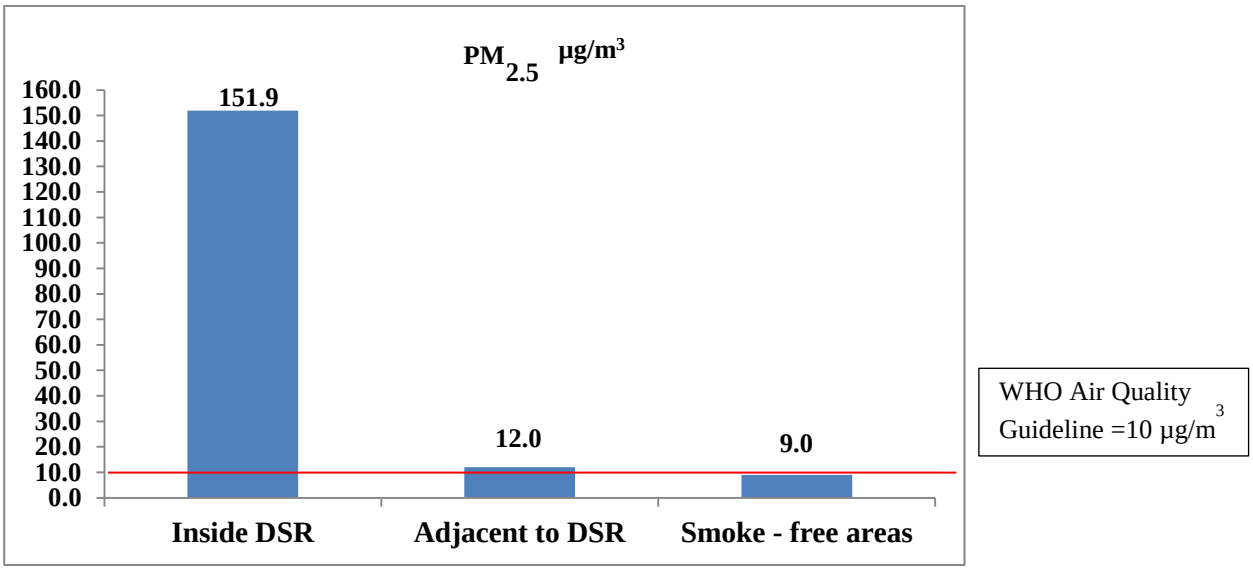

Figure 3:Mean levels of $PM_{2.5}$ in different locations of the airport.

3.3 Difference of $PM_{2.5}$ adjacent to DSR and in smoke-free areas

The results in Figure 4 show the difference of $PM_{2.5}$ concentrations measured just outside the DSR, about 1 foot from the door and 30 inches from the floor (Median = 12.1 µg/m^3) and in various non-smoking areas within the airport building (Median = 9. 5 µg/m^3). The range of exposures in the area adjacent to DSR and in smoke-free areas of the airport are different. The lowest reading of $PM_{2.5}$ from adjacent to DSR (10.2 µg/m^3) is little different from the highest level in relatively smoke-free areas distant from DSR.(Figure 4).

4. Disscussion

This study was developed and designed to This study was developed and designed to determine if levels of $PM_{2.5}$, the most widely used indicator of secondhand smoke pollution from smoking, are at levels that could be dangerous to travelers in Bangkok's largest international airport. $PM_{2.5}$ measurement reflects small particles released from burned materials and cigarette smoke is the primary source in most public places like airport locations where cooking is not present. A comparative study of five large-hub US airports with designated smoking rooms (DSR) against four large-hub airports without four large-hub airports without DSR in 2012 showed very high levels of $PM_{2.5}$ in DSR, elevated $PM_{2.5}$ levels outside DSR, and low levels in the smoke-free airports. Since airport and DSR conditions vary, it was important to measure $PM_{2.5}$ levels in Bangkok's major international airport to see what exposure levels are present. A strong feature of this study was that $PM_{2.5}$ measures were taken simultaneously, so that inside and outside DSR sampling did not differ in time or place since multiple sampling instruments were used.

As reported, the mean level of $PM_{2.5}$ inside six DSR tested was 151.9 µg/m^3, fifteen times the annual WHO guideline for $PM_{2.5}$ exposure. Since there was a great deal of variability in the exposure readings, the median score was somewhat lower (105.7), but still over ten times the annual WHO guideline. These high levels were comparable to the mean levels seen in the US findings inside DSR (151.9 versus 188.7). $PM_{2.5}$ levels outside DSR in this international airport were lower than the means for US airports but still higher than from smoke-free areas inside the airport.

Median levels varied by 3 µg/m^3, but the variation in range for findings showed that levels outside the DSR had little variability with the least level recorded little different than the highest level recorded from the smoke-free areas in the airport (10.2 versus 10.8, See Figure 4). Importantly, $PM_{2.5}$ levels outside the DSR were all above the WHO guideline for annual exposure (10 µg/m^3) which reflects a level important for workers exposed over many working hours throughout the day and over weeks and months.

Professor James Repace, a health physicist who specializes in the measurement of occupational exposure to secondhand smoke (SHS) and the assessment of the health risk to the workforce as a consequence of that exposure has developed analytical models which quantify the

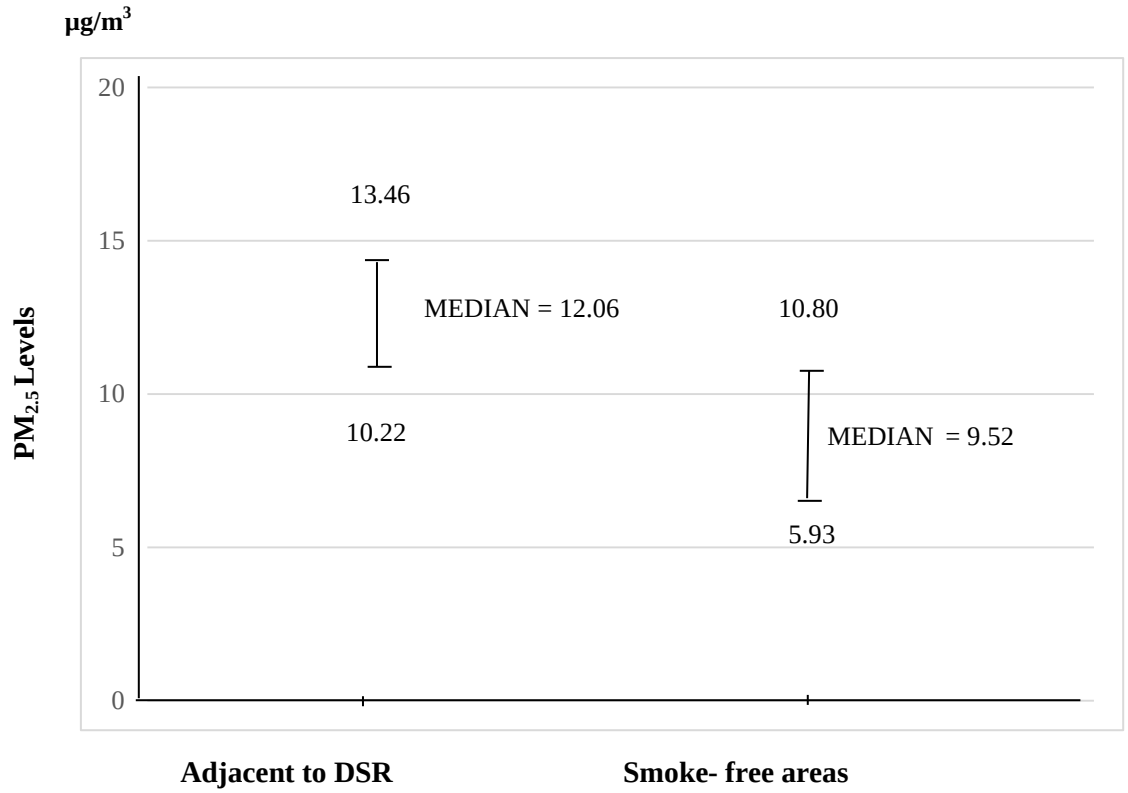

Figure 4: Maximum ,Median and Minimum scores in a range of multiple measure of $PM_{2.5}$ outside DSR and in smoke-free areas in the airport

relationship between exposure to secondhand smoke and mortality. These models have been validated by other studies where the results have been consistent with or lower than those calculated by other health authorities such as the US Occupational Safety and Health Administration.

They show the relationship of SHS exposure during one's work-life to heart disease and lung cancer (Repace JL, 2007). Stroke and other cancers are other conditions not in his calculations, but which are also linked to SHS exposure.Stroke is causally-related to SHS exposure since minor increases of residential $PM_{2.5}$ levels have been associated with clinically relevant reductions in endothelial function which adversely affect circulation to the heart and brain. One study notes, "the change in endothelial function attributed to a 3 microgram/cu. meter increase in annual $PM_{2.5}$ levels is comparable with the effect … of smoking or aging by 5 years." (Krishnan RM et al., 2012).

Our findings indicated leakage of fine particles from airport smoking rooms to the adjacent non-smoking areas. Previous studies have shown that airport smoking rooms expose non-smokers in adjacent non-smoking areas due to leakage of constituents from SHS. Pion and Givel (2004) demonstrated that significant levels of nicotine were detected at 35 feet (10 meters) from an enclosed smoking area that had direct ventilation to the outside of the airport buildings. The study was sponsored by the Missouri Group Against Smoking Pollution Inc. (GASP) to provide evidence to counter tobacco industry's arguments against making Lambert-St. Louis international airport completely non-smoking. There is internal tobacco industry document evidence that the industry promotes the construction of DSR and ventilated smoking areas in airports and has opposed efforts to implement smoke-free policies in airports (Pion and Givel, 2004; Legacy Tobacco Documents Library, 1990; Glantz, 2013).

Researchers have concluded that designated smoking rooms are not able to prevent tobacco smoke from migrating into the adjacent non-smoking areas of airport terminals. In another study conducted at a US medium-sized commercial airport, it was found that fine particles from secondhand smoke leaked from smoking rooms to the surrounding smoke-free areas in the airport (Lee et al., 2010). In addition, Liu et al. (2001) reported the leakage of nicotine as measured from an enclosed smoking area to adjacent non-smoking areas of California office buildings. Several studies have provided evidence that tobacco smoke particles and pollutants drift from tobacco sources to smoke-free environments (Brennan et al., 2010; Cameron et al., 2010; Kaufman et al., 2011; Sureda et al., 2012).

Air contaminants, such as SHS and particulate matter cannot be removed from enclosed smoking rooms, even when equipped with ventilation and air filtration technology.

Even if the room is separately ventilated, the pumping action of swing doors when they are opened and closed further enhances tobacco pollutants leakage from smoking rooms; as much as 10% of air can leak out to non-smoking areas at each door movement (Wagner et al., 2004). The US Surgeon General does not recommend enclosed smoking rooms at all, but recommends complete non-smoking in indoor areas to reduce exposure to SHS, as all poisons, toxins, and particles found in SHS cannot be removed by any air cleaning technologies (USDHHS, 2006; ASHRAE, 2005).

Our findings support other studies that DSR at the airport is a major source of SHS exposure for non-smokers in adjacent non-smoking areas. If airport buildings are not smoke-free, workers and travelers of all ages are at risk for SHS exposure. Impact of high $PM_{2.5}$ levels can affect not only smokers who visit DSR, but cleaning and maintenance staff can have occupational exposure to SHS (Lee et al., 2010; Zellers et al., 2007).

Furthermore, children travelling with adults may be taken inside DSR, or left outside the smoking rooms. Findings suggest that actions such as separation of smoking into areas where smokers are exposed to high levels of particulate material can be very dangerous to smokers since the pollutant levels are concentrated to produce an extremely potent mix of environmental toxicants that could have sudden and life-threatening impacts on travelers whose cardiovascular systems have already become compromised by long travel. Both extreme high-level exposure for smokers and lower-level exposure for nonsmokers working in and around DSR over a working lifetime may be of concern.

These concerns should foster further study of both populations since secondhand smoke can be an added health threat to both smokers and nonsmoker depending on concentration and duration of exposure. Study in environments where exposures are both short- and long-term could be useful in further characterizing lifetime threats among various populations and sub-populations. Smoke-free policies that completely eliminate smoking inside airports are recognized as the only way to fully protect the non-smoking public from SHS exposure (CDC, 2012).

5. Conclusions

In summary, study results point to a measurable and statistically significant increase in $PM_{2.5}$ levels outside DSR, with dangerously high levels of $PM_{2.5}$ inside the DSR. These levels near DSR may not be obvious to travelers, but contribute to health damaging exposures above the WHO annual standard for particulate matter in ambient air.

Results of this study should lead to review of present Thai legislation so that international airports are included as smoke-free as with domestic airports. Further studies of tobacco smoke exposure may benefit from using other indicators of SHS to characterize cigarette smoke exposure using nicotine samplers to complement $PM_{2.5}$ measures.

6. Acknowledgements

Funding and support for this study was provided by the Tobacco Control Research and Knowledge Management Center. Cooperation from airport authorities is also acknowledged and was crucial in locating and monitoring designated smoking rooms in use in the airport at the time of this research.

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