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Indoor Air Quality at Nine Large-Hub Airports With and Without Designated Smoking Areas — United States, October–November 2012

Secondhand smoke (SHS) exposure causes death and disease among nonsmoking adults and children (*1*). Adopting policies that completely prohibit smoking in all indoor areas is the only effective way to eliminate involuntary SHS exposure (*1*). Among the 29 large-hub U.S. airports, five currently allow smoking in specifically designated indoor areas accessible to the general public (*2*). In 2011, these five airports had a combined passenger boarding of approximately 110 million (*3*). To assess indoor air quality at the five large-hub U.S. airports with designated indoor smoking areas and compare it with the indoor air quality at four large-hub U.S. airports that prohibit smoking in all indoor areas, CDC measured the levels of respirable suspended particulates (RSPs), a marker for SHS. The results of this assessment determined that the average level of RSPs in the smoking-permitted areas of these five airports was 16 times the average level in nonsmoking areas (boarding gate seating sections) and 23 times the average level of RSPs in the smoke-free airports. The average RSP level in areas adjacent to the smoking-permitted areas was four times the average level in nonsmoking areas of the five airports with designated smoking areas and five times the average level in smoke-free airports. Smoke-free policies at the state, local, or airport authority levels can eliminate involuntary exposure to SHS inside airports and protect employees and travelers of all ages from SHS.

Large-hub airports are defined by the Federal Aviation Administration as airports that accounted for ≥1% of total passenger boarding in the United States during the previous year (*3*). This study included five large-hub U.S. airports with designated smoking areas accessible to the public*: Denver International, Hartsfield-Jackson Atlanta International, McCarran International in Las Vegas, Salt Lake City International, and Washington Dulles International (*2*). Four smoke-free (i.e., smoking prohibited in all indoor areas at all times) large-hub airports with similar passenger boarding totals in 2011 were selected for comparison: Chicago O'Hare International, Fort Lauderdale-Hollywood International, Orlando International, and Phoenix Sky Harbor International.

The specific class of RSPs monitored was particulate matter ≤2.5 microns in diameter ($PM_{2.5}$), a commonly used marker for SHS (*4,5*). Particles of this size are released in substantial amounts from burning cigarettes and easily inhaled deep into the lungs. The final sample consisted of 45 sites in airports with designated smoking areas and four sites in smoke-free airports. Overall, in the five airports with designated smoking areas, $PM_{2.5}$ levels were measured 1) inside 20 smoking-permitted areas, 2) approximately 1 meter (3.3 feet) adjacent to each of the 20 smoking-permitted areas, and 3) in the seating sections at five randomly selected boarding gates where smoking was not allowed. $PM_{2.5}$ levels were measured at one randomly selected gate in each of the four smoke-free airports. Adjacent areas were included in the study to assess whether SHS leaked from smoking-permitted areas. Smoking-permitted areas were subcategorized as smoking rooms, bars, or restaurants and also subcategorized as fully enclosed or partially enclosed.

Data were collected during October 19–November 1, 2012, by one person during 1 day at each airport between the hours of 7 a.m. and 11p.m. The median time spent at each site was 30 minutes (range: 20–90 minutes). An air monitor† was used to log $PM_{2.5}$ at 1-minute intervals, using a calibration factor of 0.32 and a flow rate of 1.7 L/min (*4*). The first and last 1-minute measurements were discarded, and the remaining data points were averaged to compute the mean $PM_{2.5}$ level at each site. Data on 5-minute interval counts of the number of persons and the number of burning cigarettes in each smoking-permitted area also were collected. Sampling

*Two other large-hub airports, Dallas/Fort Worth International and Charlotte Douglas International, have designated smoking areas, but were excluded from this study because those areas are not accessible to the general public.

†The air monitor used was a TSI Sidepak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, Minnesota). The Sidepak was calibrated against a SHS-calibrated nephelometer prior to use.

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was conducted discreetly in order not to alter the occupants' smoking behavior. Smoker density was calculated by dividing the average number of burning cigarettes by the estimated room volume and expressed as the number of burning cigarettes per 100 m^3. Spearman's correlation coefficient (ρ) was calculated to assess the relationship between smoker density and $PM_{2.5}$ ($p<0.05$). A two-sample t-test was conducted to assess the statistical significance of differences between average $PM_{2.5}$ levels ($p<0.05$).

The overall average $PM_{2.5}$ level in smoking-permitted areas was 188.7 $\mu g/m^3$ (range: 29.1–555.3), and the average $PM_{2.5}$ level in areas adjacent to smoking-permitted areas was 43.7 $\mu g/m^3$ (range: 2.1–230.0). The average $PM_{2.5}$ level in nonsmoking areas of airports with designated smoking areas was 11.5$\mu g/m^3$ (range: 2.2–29.0), and the average $PM_{2.5}$ level in smoke-free airports was 8.0 $\mu g/m^3$ (range: 2.0–15.2). The difference between the average level in the nonsmoking areas of airports with designated smoking areas and the average level in smoke-free airports was not statistically significant (Table, Figure 1).

The average $PM_{2.5}$ level in the four smoking-permitted bars and restaurants was 276.9 $\mu g/m^3$ (range: 73.5–555.3), whereas the average $PM_{2.5}$ level in the 16 smoking rooms was 166.6 $\mu g/m^3$ (range: 29.1–382.3). The median of the average number of persons in smoking-permitted areas was 9.3 (range: 2.7–101.7). The median of the average number of burning cigarettes was 7.2 (range: 2.8–56.3) (Table).

The average $PM_{2.5}$ level in areas adjacent to partially enclosed smoking-permitted areas (82.5 $\mu g/m^3$) was higher than the average $PM_{2.5}$ in areas adjacent to fully enclosed smoking-permitted areas (30.8 $\mu g/m^3$) ($p<0.05$). Smoker density was strongly correlated with $PM_{2.5}$ ($\rho=0.81$, $p<0.05$) (Figure 2).

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Editorial Note

The findings in this report indicate that workers and travelers, including children and adults, are at risk for exposure to SHS in airports with designated smoking areas. These findings are consistent with previous research that found elevated $PM_{2.5}$ levels in areas adjacent to enclosed smoking-permitted areas in a medium-hub airport (*6*). There is no risk-free level of SHS exposure; even brief exposures can have immediate adverse effects on the cardiovascular and respiratory systems (*1,7*).

What is already known on this topic?

Exposure to secondhand smoke (SHS) causes disease and death among nonsmokers, and there is no risk-free level of SHS exposure. Among the 29 large-hub airports in the United States, five currently have specifically designated indoor smoking areas accessible to the general public.

What is added by this report?

An assessment of air quality at the five large-hub airports with designated indoor smoking areas found that restriction of smoking to designated areas is not effective in eliminating SHS exposure. The average level of particulate matter ≤2.5 microns in diameter ($PM_{2.5}$) in smoking-permitted areas was 188.7 $\mu g/m^3$ (range: 29.1 $\mu g/m^3$ to 555.3 $\mu g/m^3$). The average $PM_{2.5}$ level in areas adjacent to smoking-permitted areas was 43.7 $\mu g/m^3$ (range: 2.1–230.0).

What are the implications for public health practice?

Employees and travelers of all ages face exposure to SHS both inside and adjacent to smoking-permitted rooms, restaurants, and bars in airports. Smoke-free policies that completely eliminate smoking inside airports are the only way to fully protect nonsmoking employees and travelers from SHS exposure.

Although smoking was prohibited on all U.S. domestic and international commercial airline flights through a series of federal laws adopted from 1988 to 2000, no federal law or policy requires airports to be smoke-free. Certain tobacco product manufacturers have promoted and paid for separately enclosed and ventilated smoking areas in airports and have opposed efforts to implement smoke-free policies in airports (*8*). Most airports with designated smoking areas are explicitly exempted from state smoke-free laws or are located in states without comprehensive smoke-free laws. For example, although state laws in Colorado[§] and Utah[¶] prohibit smoking in indoor areas of workplaces and public places, they specifically allow designated smoking areas at airports.

Because the duration of air monitoring in each location was approximately 30 minutes, the observed $PM_{2.5}$ levels cannot be compared directly to current U.S. Environmental Protection Agency average 24-hour and annual $PM_{2.5}$ exposure standards (35 $\mu g/m^3$ and 15 $\mu g/m^3$, respectively) (*9*). However, given that the average $PM_{2.5}$ level in smoking-permitted bars and restaurants was 24 times the average level in nonsmoking areas of the same airports (276.9 $\mu g/m^3$ versus 11.5 $\mu g/m^3$), workers in smoking-permitted areas such as bars and restaurants might be at heightened risk for SHS exposure and related health problems (*9,10*).

[§] Colorado. Rev. Stat. Ann. § 25-14-205 (1) (f).
[¶] Utah Code Ann. § 26-38-3 (2) (c).

TABLE. Levels of $PM_{2.5}$ in nine large-hub airports with and without designated indoor smoking areas,* by sampled area (N = 49) — United States, October–November, 2012

Area	Average no. of persons	Average no. of cigarettes	No. of burning cigarettes per 100 m^3	Mean $PM_{2.5}$ in smoking-permitted areas ($\mu g/m^3$)	Mean $PM_{2.5}$ in areas adjacent to smoking-permitted areas† ($\mu g/m^3$)	Mean $PM_{2.5}$ in nonsmoking areas§ ($\mu g/m^3$)
Five airports with designated smoking areas¶						
Airport A**						
Smoking-permitted areas (n = 3)						
Bar 1	6.2	2.3	0.8	73.5	44.9	n/a
Bar 2	101.7	56.3	7.8	555.3	60.2	n/a
Restaurant	26.5	13.0	9.9	322.0	41.1	n/a
Mean	44.8	23.9	6.2	316.9	48.7	n/a
Nonsmoking area (gate)	49.0	n/a	n/a	n/a	n/a	29.0
Airport B						
Smoking-permitted areas (n = 4)						
Smoking room 1	4.5	3.8	1.9	184.2	3.2	n/a
Smoking room 2	3.5	2.8	1.4	165.9	4.5	n/a
Smoking room 3	8.5	5.7	3.1	215.1	8.2	n/a
Smoking room 4	8.2	5.0	0.8	149.3	3.1	n/a
Mean	6.2	4.3	1.8	178.6	4.8	n/a
Nonsmoking area (gate)	38.7	n/a	n/a	n/a	n/a	3.0
Airport C						
Smoking-permitted areas (n = 3)						
Smoking room 1	4.5	1.8	0.3	29.1	2.1	n/a
Smoking room 2	5.0	2.5	0.3	38.2	2.8	n/a
Smoking room 3	6.7	4.0	0.8	79.4	7.3	n/a
Mean	5.4	2.8	0.5	48.9	4.1	n/a
Nonsmoking area (gate)	4.8	n/a	n/a	n/a	n/a	2.2
Airport D						
Smoking-permitted areas (n = 5)						
Smoking room 1††	10.0	7.3	1.9	171.7	81.1	n/a
Smoking room 2††	16.2	12.7	3.5	148.9	107.2	n/a
Smoking room 3††	9.5	6.7	2.0	103.4	70.1	n/a
Smoking room 4††	2.7	2.5	1.7	95.4	112.5	n/a
Smoking room 5	9.3	7.0	4.9	161.5	43.3	n/a
Mean	9.5	7.2	2.8	136.2	82.8	n/a
Nonsmoking area (gate)	18.3	n/a	n/a	n/a	n/a	19.2
Airport E						
Smoking-permitted areas (n = 5)						
Smoking room 1	4.8	3.9	1.4	224.0	5.0	n/a
Smoking room 2	17.1	9.3	3.4	245.3	2.3	n/a
Smoking room 3	19.3	14.7	5.4	271.6	3.2	n/a
Smoking room 4††	21.0	15.3	5.6	382.3	230.0	n/a
Bar 1	73.5	31.2	2.8	156.9	41.6	n/a
Mean	27.1	14.9	3.7	256.0	56.4	n/a
Nonsmoking area (gate)	37.0	n/a	n/a	n/a	n/a	4.2
Overall mean (all smoking-permitted areas, n = 20)	**17.9**	**10.4**	**3.0**	**188.7**	**43.7**	**n/a**
Overall mean (all nonsmoking areas [gates], n = 5)	**29.6**	**n/a**	**n/a**	**n/a**	**n/a**	**11.5**
Four smoke-free airports						
Airport F (gate)	52.0	n/a	n/a	n/a	n/a	15.2
Airport G (gate)	23.1	n/a	n/a	n/a	n/a	4.9
Airport H (gate)	6.0	n/a	n/a	n/a	n/a	2.0
Airport I (gate)	41.0	n/a	n/a	n/a	n/a	10.0
Overall mean (all smoke-free airports, n = 4)	**30.5**	**n/a**	**n/a**	**n/a**	**n/a**	**8.0**

Abbreviations: $PM_{2.5}$ = particulate matter ≤2.5 microns in diameter; n/a = not applicable; n = number of areas sampled.

* The five airports with smoking areas were Denver International, Hartsfield-Jackson Atlanta International, McCarran International in Las Vegas, Salt Lake City International, and Washington Dulles International. Four smoke-free airports were matched to the airports with designated smoking areas based on similar passenger boarding reported by the Federal Aviation Administration for 2011: Chicago O'Hare International, Fort Lauderdale-Hollywood International, Orlando International, and Phoenix Sky Harbor International.

† $PM_{2.5}$ in adjacent smoking-permitted areas was measured at approximately 1 meter (3.3 feet) from the entrance of the smoking permitted areas with the air monitor positioned around the breathing zone.

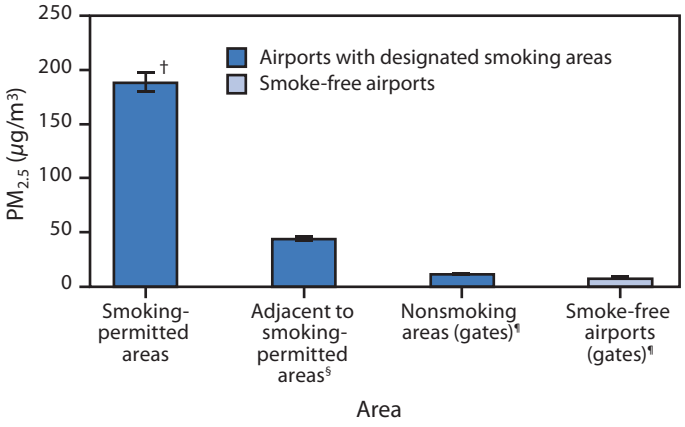
§ One gate was sampled for each of the nine airports. Gate measurements were taken in the seating section of a randomly selected boarding gate.

¶ Because one airport had a large number of designated smoking areas, a random sample of smoking areas was used. In the other four airports with designated smoking areas, data were collected in all smoking-permitted areas.

** Letters represent de-identified airports.

†† Partially enclosed smoking rooms (open entrances with no doors). All other smoking-permitted areas were fully enclosed.

FIGURE 1. Mean levels of $PM_{2.5}$ in nine large-hub airports with and without designated indoor smoking areas,* by area type — United States, October–November, 2012



Abbreviation: $PM_{2.5}$ = particulate matter ≤2.5 microns in diameter.

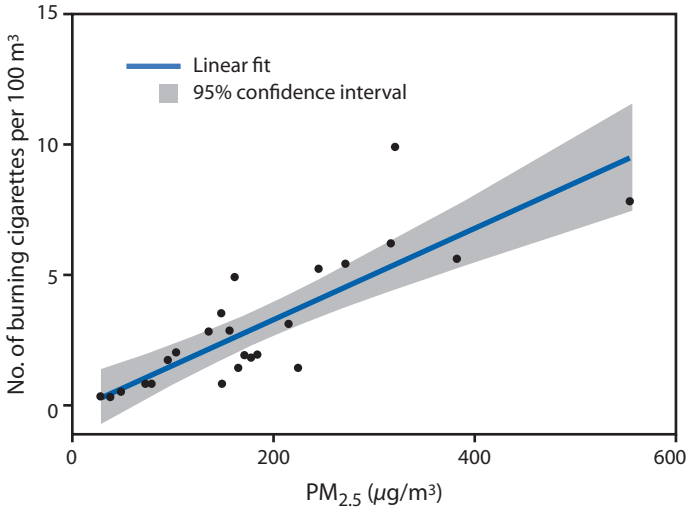
* The five airports with smoking areas were Denver International, Hartsfield-Jackson Atlanta International, McCarran International in Las Vegas, Salt Lake City International, and Washington Dulles International. Four smoke-free airports were matched to the airports with designated smoking areas based on similar passenger boarding reported by the Federal Aviation Administration for 2011: Chicago O'Hare International, Fort Lauderdale-Hollywood International, Orlando International, and Phoenix Sky Harbor International.

† 95% confidence interval.

§ $PM_{2.5}$ levels in adjacent smoking-permitted areas were measured at approximately 1 meter (3.3 feet) from the entrances of the smoking permitted areas with the air monitor positioned around the breathing zone.

¶ Measurements were taken in the seating sections of randomly selected boarding gates.

FIGURE 2. Correlation between mean $PM_{2.5}$ and smoker density* in five U.S. large-hub airports† with designated indoor smoking areas, October–November 2012



Abbreviation: $PM_{2.5}$ = particulate matter ≤2.5 microns in diameter.

* Smoker density was calculated by dividing the average number of cigarettes by the estimated volume of the smoking-permitted area. $PM_{2.5}$ concentration correlated with smoker density ($\rho = 0.81$, $p<0.05$). The average smoker density was 2.8 burning cigarettes per 100 m^3 (range = 0.3–9.9).

† The five airports with smoking areas were Denver International, Hartsfield-Jackson Atlanta International, McCarran International in Las Vegas, Salt Lake City International, and Washington Dulles International.

The findings in this report are subject to at least three limitations. First, SHS is not the only source of $PM_{2.5}$, and $PM_{2.5}$ levels can vary from airport to airport because of differences in elevation above sea level. However, although ambient particle concentrations and cooking are additional sources of $PM_{2.5}$, SHS is the largest contributor to $PM_{2.5}$ levels in indoor settings where smoking is allowed (*5*). Second, $PM_{2.5}$ levels inside and adjacent to the smoking-permitted areas were not measured simultaneously, so it was not possible to assess SHS leakage into smoking-restricted areas in real time. Finally, in very large smoking-permitted areas, the inability to count the exact numbers of occupants and burning cigarettes might have resulted in imprecise estimates.

Both employees and travelers at airports with designated smoking areas could be at risk for SHS exposure. For example, travelers who do not enter smoking-permitted areas can be exposed to SHS in adjacent areas. Employees who work in smoking-permitted restaurants and bars, or who are required to enter smoking-permitted areas for cleaning, maintenance, or other reasons, also are at risk for SHS exposure. In addition, children who are allowed to enter or wait near smoking-permitted areas might be at risk for SHS exposure. Completely eliminating smoking inside airports is the only way to eliminate SHS exposure for nonsmoking workers and travelers of all ages (*1*).

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