Air Nicotine Monitoring for Second Hand Smoke Exposure in Public Places in India

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ABSTRACT

Background: Air nicotine monitoring is an established method of measuring exposure to second hand smoke (SHS). Not much research has been done in India to measure air nicotine for the purpose of studying exposure to SHS. It is a risk factor and many diseases are known to occur among non smokers if they are exposed to second hand smoke. Objective: To conduct monitoring of air nicotine for second hand smoke exposure in public places across major cities in India. Materials and Methods: A cross sectional survey was conducted across four cities across the country, using passive air monitoring. The buildings included hospitals, secondary schools, Governmental offices, bars and restaurants. The buildings were selected through convenience sampling method keeping in view specific sentinel locations of interest. Result: The presence of air nicotine was recorded in most of the buildings under the study, which included government buildings, hospitals, schools, restaurants and entertainment venues (bars) in all four cities under the study. The highest median levels of air nicotine were found in entertainment venues and restaurants in cities. Conclusion: The presence of air nicotine in indoor public places indicates weak implementation of existing smoke free law in India. The findings of this study provide a baseline characterization of exposure to SHS in public places in India, which could be used to promote clean indoor air policies and programs and monitor and evaluate the progress and future smoke-free initiatives in India.

Keywords: Air nicotine, passive air monitoring, second hand smoke (SHS), smoking, tobacco smoke

Introduction

Second hand smoke (SHS) or environment tobacco smoke (ETS), a complex mixture of gases and particles that contain many carcinogenic and toxic compounds, results from indoor tobacco smoking. There is no safe level of exposure to second hand smoke. Over the last 30 years, a substantial body of evidence has accumulated demonstrating adverse effects to children and adults from prolonged exposure to SHS. Numerous epidemiological studies have documented the link between SHS exposure and increased morbidity and mortality. It is a cause of cardiovascular disease, respiratory illness, and lung cancer.

As a result of the causal link between SHS exposure and chronic health effects, policies aimed at eliminating SHS exposure indoors will have direct benefits to public health. Creation of smoke-free environments has been shown to reduce smoking prevalence and frequency among employees and as part of comprehensive tobacco control strategy, has been shown to reduce overall smoking prevalence.

India is the second largest consumer of tobacco in the world. 57% of men and 10.8% of women consume tobacco, out of which 32.7% men and 1.4% of women are smokers. Bidi is the most common smoking form of tobacco in use, which is made by wrapping sun or air cured tobacco in the leaf of plant Diospyros elanoxylon, locally called “Tendu.” Other smoking forms of tobacco in use are cigarettes, hookah, cigars,
pipes and locally produced tobacco products, e.g., hukli, chutta, chillum, etc.\(^{(12)}\)

India enacted a comprehensive legislation to control the menace of tobacco, namely, cigarettes and other tobacco products (Prohibition of Advertisement and Regulation of Trade and Commerce, Production, Supply and Distribution) Act, (COTPA) in 2003,\(^{(15)}\) followed by ratification of WHO FCTC (Framework Convention on Tobacco Control) in 2004. Article 8 of WHO FCTC provides for smoke-free environments to protect the health of nonsmokers from SHS.\(^{(16)}\) As per the Indian law, smoking is prohibited in all public places. The implementation of this law remained largely ineffective in the initial years. The Government of India reviewed the situation and revised the law, with effect from 2\textsuperscript{nd} October 2008, making additional provisions to improve implementation of smoke-free law. The provision to allow designated smoking rooms/area exists, but is limited to the airports, restaurants with seating capacity of 30 or more and hotels with rooms 30 or more. Smoking is completely banned in all other public places including educational and health institutions, entertainment and hospitality places, public transport, and workplaces.\(^{(15)}\)

The existing surveillance system in the country has no mechanism for routinely measuring exposure to SHS. There have been very few studies or research to look at exposure to SHS in different environments. In the current study, environmental measurements were used to characterize SHS exposure in key indoor public places in cities in India.

**Materials and Methods**

SHS exposure can be characterized by several approaches, including the use of questionnaire or direct observation, personal and area air monitoring, or biomarkers. Questionnaires are relatively easy to implement but do not provide quantitative estimates of SHS exposure, specifically in public places where there may be many people smoking at the same time and with deferring patterns over time.

Airborne nicotine has commonly been used to monitor SHS exposure because (a) it is specific to tobacco smoke (and can be considered a surrogate for exposure to the mixture of chemicals found in SHS and (b) it requires a relatively simple and inexpensive passive filter sampler.

For the current study, a cross sectional survey was conducted across four cities (June-July 2008 in Ahmedabad, Chandigarh, and Chennai and March 2009 in Delhi), using passive air nicotine monitoring. The buildings included hospitals, secondary schools, government offices, bars, and restaurants. The buildings were selected through convenience sampling method keeping in view specific sentinel locations of interest.

Second hand smoke was estimated by passive sampling of vapor-phase nicotine using a filter badge treated with sodium bisulfate coated filters.\(^{(17)}\)

Sampling locations were selected to represent the areas where people frequently work or occupy. For consistency, sampling locations within a building were pre specified. All monitoring for a particular building was done over a 5-7 day period (5 days for office environments). Within each selected building, monitors were placed in areas which people frequently occupy.

Sampling sheets were used to collect information corresponding to each monitor (including the location of the monitor, total amount of time, location characteristics, occupancy, and number of smokers in the room. Building questionnaires were used to collect information from the building manager or other responsible authority.

**Data collection timeline**

**Day 1**
- Place air nicotine monitors
- Administer building questionnaire
- Fill out observations on sampling sheet

**Day 3-4**
- Visit building to ensure monitors are in place
- Fill out observations on sampling sheet

**Day 7**
- Retrieve air nicotine monitors
- Fill out observations on sampling sheet

All the buildings were visited once by the field worker during the monitoring period, preferably on a day and time of maximum frequency.

For quality assurance and control purposes, a fixed random sampling procedure was used to collect one blank sample for each of the 10 samples. The blank samples were handled and analyzed in the same way as the rest of the samples, although these were not placed in the buildings under study. The blanks were used to determine blank-corrected nicotine concentrations and to calculate the method limit of detection. Blanks, duplicates, erroneous, and ripped monitors were excluded from the study.

The samples collected in all four cities were assayed for time-weighted-average airborne nicotine at the Exposure Assessment Facility at Johns Hopkins School of Public Health, USA. In the laboratory, filters were removed
from the cassette, and the nicotine and bisulfate were
desorbed in water. The nicotine was then extracted
and concentrated into a heptanes solution, which was
then injected into a gas chromatograph, with nitrogen
selection to increase the sensitivity. The airborne
concentration of nicotine was calculated by dividing the
amount of nicotine collected by each filter (µg) by the
volume of air sampled (m³).

Data were analyzed using descriptive statistics,
characterizing SHS exposure in the indoor environments
(selected buildings) in selected four cities.

Data limitations
These air nicotine concentrations underestimate actual
exposure in buildings which are unoccupied for a portion
of the day as air concentrations represent 24-h integrated
exposure over a 7 or 10 days period.

These data provide a 1-week snapshot generated from
a small sample of buildings and, therefore, do not
represent indoor air concentrations for the whole city.

Monitors may have been placed in locations where
people tend to congregate, not necessarily where the
majority of smoking is occurring.

The study was carried out in late 2008/early 2009, close to
the amendment carried out in the Smoke Free Legislation
on 2nd October 2008. The impact of the new legislation
may not have been fully captured in this study.

Results
Air nicotine levels are presented city wise in Tables 1-4.

Air nicotine concentrations (µg/m³) in different types
of buildings are also presented city wise in Figures 1-4.

In Ahmedabad, all buildings recorded detectable levels
of air nicotine. The highest median levels of air nicotine
were found in entertainment venues, followed by
restaurants [Table 1 and Figure 1]. Forty-four percent
monitors in schools recorded detectable levels of air
nicotine. Measurable levels of air nicotine were found
in government buildings and hospitals, these levels

Table 1: Air nicotine levels-Ahmedabad

| Building type | Number of buildings | Number of monitors | Median concentration (µg/m³) | Low (µg/m³) | High (µg/m³) |
|---------------|---------------------|--------------------|-----------------------------|-------------|--------------|
| Entertainment | 10                  | 19                 | 0.63                        | 0.01        | 7.54         |
| Smoking       | 16                  |                    | 0.74                        | 0.04        | 7.54         |
| Nonsmoking*   | 3                   |                    | 0.08                        | 0.01        | 0.18         |
| Government    | 6                   | 23                 | 0.05                        | 0.01        | 0.76         |
| Hospitals     | 5                   | 25                 | 0.04                        | 0.01        | 0.23         |
| Restaurants   | 10                  | 20                 | 0.13                        | 0.04        | 0.85         |
| Smoking       | -                   |                    | -                           | -           | -            |
| Nonsmoking*   | -                   | 20                 | 0.13                        | 0.04        | 0.85         |
| Schools       | 5                   | 18                 | <LOD**                      | <LOD**      | 0.09         |

*Or main area if no smoking policy. **Concentration below limit of detection (LOD). Note: One outlying value of 13.85 µg/m³, measured in a hospital, was dropped from the analysis.

Table 2: Air nicotine levels-Chandigarh

| Building type | Number of buildings | Number of monitors | Median concentration (µg/m³) | Low (µg/m³) | High (µg/m³) |
|---------------|---------------------|--------------------|-----------------------------|-------------|--------------|
| Entertainment | 10                  | 20                 | 0.31                        | <LOD**      | 4.63         |
| Smoking       | 4                   |                    | 3.27                        | <LOD**      | 4.37         |
| Nonsmoking*   | 16                  |                    | 0.26                        | 0.08        | 4.63         |
| Government    | 5                   | 28                 | 0.05                        | <LOD**      | 0.71         |
| Hospitals     | 5                   | 27                 | 0.02                        | <LOD**      | 0.47         |
| Restaurants   | 10                  | 20                 | 0.09                        | 0.03        | 0.36         |
| Smoking       | -                   |                    | -                           | -           | -            |
| Nonsmoking*   | -                   | 20                 | 0.09                        | 0.03        | 0.36         |
| Schools       | 5                   | 27                 | <LOD**                      | <LOD**      | 0.11         |

*Or main area if no smoking policy. **Concentration below limit of detection (LOD)

Table 3: Air nicotine levels-Chennai

| Building type | Number of buildings | Number of monitors | Median concentration (µg/m³) | Low (µg/m³) | High (µg/m³) |
|---------------|---------------------|--------------------|-----------------------------|-------------|--------------|
| Entertainment | 4                   | 5                  | 0.15                        | <LOD**      | 0.97         |
| Government    | 5                   | 27                 | 0.16                        | <LOD**      | 0.77         |
| Hospitals     | 5                   | 16                 | 0.19                        | <LOD**      | 0.60         |
| Restaurants   | 6                   | 6                  | 0.60                        | 0.39        | 8.47         |
| Smoking*      | 2                   |                    | 4.53                        | 0.61        | 8.47         |
| Schools       | 5                   | 17                 | 0.22                        | 0.03        | 0.61         |

*Or main area if no smoking policy. **Concentration below limit of detection (LOD)
Table 4: Air nicotine levels—Delhi

| Building type      | Number of buildings | Number of monitors | Percent of monitors that detected nicotine | Median concentration (µg/m³) | Low (µg/m³) | High (µg/m³) |
|--------------------|---------------------|--------------------|-------------------------------------------|----------------------------|-------------|--------------|
| Entertainment      | 10                  | 18                 | 100                                       | 0.28                       | 0.02        | 1.92         |
| Smoking (1)        | -                   | 1                  | -                                         | 1.43                       | 1.43        | 1.43         |
| Nonsmoking (1,2)   | -                   | 14                 | -                                         | 0.27                       | 0.02        | 1.92         |
| Government         | 6                   | 31                 | 90.3                                      | 0.12                       | <LOD³       | 0.94         |
| Hospitals          | 5                   | 24                 | 83.3                                      | 0.11                       | <LOD³       | 1.39         |
| Restaurants        | 8                   | 15                 | 100                                       | 0.11                       | 0.01        | 0.77         |
| Schools            | 4                   | 23                 | 91.3                                      | 0.10                       | <LOD³       | 1.53         |

were generally not as high as those in restaurants and entertainment venues.

In Chandigarh, all monitors recorded detectable levels of air nicotine in restaurants and in entertainment venues, all but one monitor recorded detectable levels of air nicotine. The highest levels of air nicotine were found in entertainment venues, followed by restaurants [Table 2 and Figure 2]. Measurable levels of air nicotine were found in government buildings and hospitals, these levels were generally not as high as levels found in restaurants and entertainment venues.

All monitors in restaurants and schools in Chennai recorded detectable levels of air nicotine. The highest median levels of air nicotine were found in restaurants [Table 3 and Figure 3]. Similar air nicotine concentrations were observed in entertainment venues, schools, hospitals, and government offices of Chennai.

Detectable levels of air nicotine were recorded in all buildings of Delhi under the study. The highest levels of air nicotine were found in entertainment venues, followed by hospitals and schools [Table 4 and Figure 4]. The median levels in restaurants, government buildings,
hospitals, and schools were found to be similar.

Thus the presence of air nicotine was recorded in most of the buildings under the study, which included government buildings, hospitals, schools, restaurants and entertainment venues (bars). However, the concentration of air nicotine levels varied in different types of buildings under the study. The highest median levels of air nicotine were found in entertainment venues and restaurants in all cities. The measurable and median levels of air nicotine were also found in hospital and school buildings. In Ahmedabad and Chandigarh, the concentration of air nicotine in schools was found to be below the limit of detection.

**Discussion**

Although there is some variability between cities, this study recorded detectable levels of air nicotine in buildings in a number of public places.

The levels of air nicotine detected in government buildings, hospitals, schools, bars and restaurants in three (Ahmedabad, Chandigarh, Delhi) out of four cities under study were comparable to a similar study in the cities of Brazil (Rio de Janeiro), Peru (Lima), and Costa Rica (San Jose). In one of the cities (Chennai), air nicotine levels were higher as compared to Latin American cities. Median air nicotine concentrations in schools were substantially higher in Chennai and higher in Delhi as compared to Latin America study. The median air nicotine concentration found in entertainment venues in Ahmedabad (0.63 μg/m³) and Delhi (0.28 μg/m³) exceeded the median nicotine level found in an earlier study of air nicotine in smoking households in India (0.15 μg/m³).

Presence of detectable levels of air nicotine in buildings in public places in cities in India, and those of Latin American countries clearly indicates weak or ineffective implementation of smoke-free policies or laws.

Earlier studies on smoke-free environments have indicated that smoke-free policies not only protect nonsmokers from second hand smoke, but they also create an environment that makes it easier for smokers to stop smoking. Well-implemented smoke-free policies are necessary to eliminate exposure to tobacco smoke in public areas. Complementary efforts are required to increase social awareness of the health effects of smoking to decrease the exposure to SHS, as well as to prompt improvements in legislation about smoke-free places and their implementation. Comprehensive smoke-free legislation in New Zealand seems to have reduced exposure of bar patrons to SHS by about 90%. There is evidence to suggest that comprehensive and properly enforced smoke-free laws can be an effective means of reducing indoor air pollution.

The Indian law bans smoking in all public places, including work places. The poor and weak implementation of smoke-free law over the years is reflected in the findings of this study, whereas detectable levels of air nicotine were found in most of the indoor public places. The Government has revised the law to include more places in the list of public places, where the smoking is prohibited. This includes workplaces also. More emphases are also placed on the effective enforcement of smoke free policies at the State and sub state levels. The onus of implementing the law has also been vested on those who are responsible for their respective public places. Any violation found in the public places makes these responsible entities liable to penalty too. To create enabling environment, the Government of India under the aegis of National Tobacco Control Programme, launched intensive mass media campaign(s) and advocacy measures to raise awareness regarding harmful effects of SHS. Capacity building initiatives to sensitize and equip law enforcers for effective implementation of smoke free law were also undertaken by the Government of India with the support of State Governments, civil society and community based organizations.

The findings of this study provide a baseline characterization of exposure to SHS in public places in India, which could be used to promote clean indoor air policies and programs and monitor and evaluate the progress and future smoke-free initiatives in India.

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**References**

1. Jaakola MS, Jaakola JI. Assessment of exposure to Environmental Tobacco Smoke. Eur Respir J 1997;10:2384-97.
2. Jenkins RA, Guerin MR, Tomkins BA. The chemistry of environmental tobacco smoke: Composition and measurement. Washington DC: Lewis Publishers; 2000.
3. Centers for Disease Control and Prevention Coordinating Centre for Health Promotion, National Centre for Chronic Disease Prevention and Health Promotion, Office on smoking and Health. The health consequences of involuntary exposure to tobacco smoke: A report of the Surgeon General. Atlanta, GA: 2006.
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4. Kraev TA, Adamkiewicz G, Hammond SK, Spengler JD. Indoor concentrations of nicotine in low-income, multi-unit housing: Associations with smoking behaviors and housing characteristics. Tob Control 2009;18:438-44.

5. He J, Vuppaturi S, Allen K, Prerost MR, Hughes J, Whelton PK. Passive smoking and the risk of coronary heart disease, a Meta analysis of epidemiological studies. N Engl J Med 1999;10:2384-91.

6. Otsuka R, Watanabe H, Hirata K, Tokai K, Muro T, Yoshiyama M, et al. Acute effects of passive smoking on the coronary circulation in healthy young adults. JAMA 2001;286:436-41.

7. Pitsavos C, Panagiotakos DB, Chrysohoou C, Skoumas J, Tzioumis K, Stefanadis C, et al. Association between exposure to environmental tobacco smoke and the development of acute coronary syndromes. The CARDIO 2000 case control study. Tob Control 2002;11:220-5.

8. Das SK. Harmful effects of cigarette smoking. Mol Cell Biochem 2003;253:159-65.

9. Brennan P, Buffler PA, Reynolds P, Wu AH, Wichmann HE, Agudo A, et al. Second hand smoke exposure in adulthood and risk of lung cancer among never smokers: A pooled analysis of two large studies. Int J Cancer 2004;109:125-31.

10. Fichtenberg CM, Glantz SA. Effects of smoke free workplaces on smoking behavior: Systematic review. Br Med J 2002;325:188.

11. Centers for Disease Control and Prevention (CDC). Decline in smoking prevalence – New York City, 2002-2006. MMWR Morb Mortal Wkly Rep 2007;56:604-8.

12. Tobacco use in India: Prevalence of tobacco use. In Reddy KS, Gupta PC, editors. Report on Tobacco Control in India. Government of India, Ministry of Health and Family Welfare. 2004. p. 49-56.

13. National Family Health Survey (NFHS 3), India. International Institute of Population Sciences (IIIPS), Mumbai and Macro International. 2005-06;2:426-9.

14. John S. History and culture of Bidis in India: Production, Employment, marketing and Regulations. In Gupta PC, Asma S eds. Bid Smoking and Public Health. Government of India, Ministry of Health and Family Welfare. 2006. p. 1-12.

15. Cigarettes and other Tobacco Products (Prohibition of Advertisement and Regulation of Trade and Commerce, Production, Supply and Distribution) Act, 2003: Government of India.

16. World health Organization. Framework Convention on Tobacco Control. 2004.

17. Hammond SK, Leaderer BP. A diffusion Monitor to Measure Exposure to Passive Smoking. Environ Sci Technol 1987;21:494-7.

18. Navas-Acien A, Peruga A, Breysse P, Zavaleta A, Blanco-Marquizo A, Pilarque R, et al. Second hand tobacco smoke in public places in Latin America, 2002-2003. JAMA 2004;291:2741-5.

19. Wipfli H, Avila-Tang E, Navas-Acien A, Kim S, Onicescu G, Yuan J, et al. Secondhand smoke exposure among women and children: Evidence from 31 countries. Am J Public Health 2008;98:672-9.

20. Jané M, Nebot M, Rojano X, Artazcoz L, Sunyer J, Fernández E, et al. Exposure to environmental tobacco smoke in public places in Barcelona, Spain. Tob Control 2002;11:83-4.

21. Nebot M, López MJ, Gorini G, Neuberger M, Axelsson S, Pilali M, et al. Environmental tobacco smoke exposure in public places of European cities. Tob Control 2005;14:60-3.

22. Nebot M, López MJ, Tomás Z, Ariza C, Borrell C, Villalbi JR. Exposure to environmental tobacco smoke at work and at home: A population based survey. Tob Control 2004;13:95.

23. Fernando D, Rowlles J, Woodward A, Christophersen A, Dickson S, Hosking M, et al. Legislation reduces exposure to second-hand tobacco smoke in New Zealand bars by about 90%. Tob Control 2007;16:235-8.

24. Rothberg M, Heloma A, Svinhufvud J, Kähkönen E, Reijula K. Measurement and Analysis of nicotine and other VOCs in indoor air as an indicator of passive smoking. Ann Occup Hyg 1998;42:129-34.

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