

# Secondhand Tobacco Smoke in Public Places in Latin America, 2002-2003

Ana Navas-Acien, MD, MPH

Armando Peruga, MD, DrPH

Patrick Breyse, PhD

Alfonso Zavaleta, MD

Adriana Blanco-Marquizo, MD

Raul Pitarque, MD

Marisol Acuña, MD

Katya Jiménez-Reyes, MD

Vera L. Colombo, MD

Graciela Gamarra, MD

Frances A. Stillman, EdD

Jonathan Samet, MD, MS

**P**ASSIVE SMOKING IS A SIGNIFICANT but avoidable cause of premature death and disease worldwide.<sup>1,2</sup> While many municipalities and countries are controlling exposures of the population to secondhand smoke, the tobacco industry has vigorously attempted to counter the growing call for smoke-free indoor environments.<sup>3-5</sup> To address these industry tactics and to provide an impetus for reducing exposure to secondhand smoke, data on nicotine concentrations in public places could help by documenting the extent and locations of exposure and identifying the most critical targets for control. Vapor-phase nicotine is a specific tracer for surveillance and quantitation of exposure to secondhand smoke, and the measurement methods are particularly useful because they are relatively simple, accurate, and inexpensive.<sup>6</sup> While concentrations do not directly translate to health risk, the finding of nicotine indicates the presence of a carcinogenic and toxic mixture.<sup>2,7</sup>

As part of the Smoke-Free Americas Initiative, launched by the Pan Ameri-

**Context** The success of measures to restrict smoking in indoor environments and the intensity of enforcement vary among countries around the world. In 2001, the Pan American Health Organization (PAHO) launched the Smoke-Free Americas Initiative to build capacity to achieve smoke-free environments in Latin America and the Caribbean.

**Objective** To assess secondhand smoke concentrations in public places in the capital cities of Argentina, Brazil, Chile, Costa Rica, Paraguay, Peru, and Uruguay in conjunction with the Smoke-Free Americas Initiative.

**Design and Setting** Multicountry assessment of vapor-phase nicotine concentrations using a common protocol in all 7 Latin American countries. A total of 633 sampling devices were placed for 7 to 14 days in 1 hospital, 2 secondary schools, 1 city government building, 1 airport (2 in Argentina), and restaurants and bars in each country.

**Main Outcome Measure** Concentrations of airborne nicotine.

**Results** Airborne nicotine was detected in most (94%) of the locations surveyed. By country, Argentina and Uruguay had the highest median concentrations in most environments (eg, in hospitals: 1.33 [interquartile range {IQR}, 0.51-3.12]  $\mu\text{g}/\text{m}^3$  and 0.8 [IQR, 0.30-1.69]  $\mu\text{g}/\text{m}^3$ , respectively). Overall, bars and restaurants had the highest median concentrations (3.65 [IQR, 1.55-5.12]  $\mu\text{g}/\text{m}^3$  and 1.24 [IQR, 0.41-2.48]  $\mu\text{g}/\text{m}^3$ , respectively). Nicotine concentrations were also found in a number of key, sentinel buildings, including 95% (155/163) of hospital samples (in the physicians' and nurses' stations the median was 0.27 [IQR, 0.02-1.94]  $\mu\text{g}/\text{m}^3$ ), schools, government buildings, and/or airports in most countries.

**Conclusions** The finding of airborne nicotine in critical locations in Latin America provides a basis for enforcing smoke-free initiatives and for strengthening the protection of the public from unwanted exposure to secondhand smoke.

JAMA. 2004;291:2741-2745

www.jama.com

can Health Organization (PAHO) in 2001, we are assessing concentrations of secondhand smoke in public places in Latin America, using nicotine as an indicator. The project started in Argentina, Brazil, Chile, Costa Rica, Paraguay, Peru, and Uruguay in 2002, and in 2003 was extended to 7 additional

countries. We present the results for the 7 initial countries.

## METHODS

### Design and Population

This survey involved a multicountry assessment of nicotine concentration in public places, using a common proto-

**Author Affiliations:** Institute for Global Tobacco Control and the Department of Epidemiology (Drs Navas-Acien, Stillman, and Samet) and Department of Environmental Health Sciences (Dr Breyse), Johns Hopkins University Bloomberg School of Public Health, Baltimore, Md; Pan American Health Organization, Washington, DC (Dr Peruga); Department of Biochemistry, Molecular Biology and Pharmacology, Universidad Peruana Cayetano Heredia and CEDRO, Lima, Perú (Dr Zavaleta); Intendencia Municipal, Montevideo, Uruguay (Dr Blanco-Marquizo); Ministry of

Health at the moment of the study, presently, UATA, Buenos Aires, Argentina (Dr Pitarque); Tobacco Unit, Ministry of Health, Santiago, Chile (Dr Acuña); IAFA, San Jose, Costa Rica (Dr Jiménez-Reyes); INCA, Rio de Janeiro, Brazil (Dr Colombo); Tobacco Unit, Ministry of Health, Asunción, Paraguay (Dr Gamarra).

**Corresponding Author:** Ana Navas-Acien, MD, MPH, Institute for Global Tobacco Control, Johns Hopkins Bloomberg School of Public Health, 615 N Wolfe St, Room W6027, Baltimore, MD 21205 (anavasac@jhsph.edu).

col. The public places selected in capital cities of each country included a tertiary hospital, 2 secondary schools in low-middle-class neighborhoods, a city government building, restaurants and bars, and an airport (2 in Argentina, 1 elsewhere). Permission to place sampling devices in each location was obtained from the responsible authorities. The study was approved by the institutional review board of the Johns Hopkins Bloomberg School of Public Health.

Sampling locations were selected on a convenience basis, without knowledge of the extent of smoking taking place in each, to represent areas where people frequently work or spend time. Of 683 locations sampled, the sampling devices were lost in 50 (7.3%), leaving 633 devices for analysis. The losses most frequently occurred in schools and hospitals. The TABLE presents information on the field work in each country, as well as general characteristics from the Global Youth Tobacco Survey<sup>8,9</sup> and the Tobacco Control Country Profiles.<sup>10</sup>

### Nicotine Monitoring

Time-weighted average concentration of secondhand smoke was estimated by

passive sampling of vapor-phase nicotine using a filter badge treated with sodium bisulfate.<sup>11</sup> The sampling devices were left in each location over either a 1-week period (for restaurants and bars) or a 2-week period (for other locations). These durations were based on anticipated concentrations.

The collected nicotine was extracted from the filter and analyzed by gas chromatography with nitrogen-selective detection. The concentration of airborne nicotine was calculated by dividing the amount of nicotine collected by the filter ( $\mu\text{g}$ ) by the effective volume of air sampled ( $\text{m}^3$ ). For quality control purposes, 10% of the sampling devices had accompanying duplicates and blanks. The intraclass correlation coefficient between duplicates was 0.85. Blanks were used to determine blank-corrected nicotine concentrations and to calculate the method limit of detection. The limit of detection ranged between  $0.001 \mu\text{g}/\text{m}^3$  in Argentina to  $0.007 \mu\text{g}/\text{m}^3$  in Brazil. Forty-one samples had concentrations of nicotine below the detection limit (21 in schools, 12 in government buildings, and 8 in hospitals). For these samples, a value of one half of the detection limit was assigned.

### Statistical Analysis

Medians and interquartile ranges (IQRs) were used to describe the data, and box plots in logarithmic scale were used to graphically present the distribution of nicotine concentrations by country for each type of institution. Analyses were performed using Stata version 7.0 (Stata Corp, College Station, Tex).

## RESULTS

Airborne nicotine was detected in most (94%) locations surveyed. Nicotine was detected in 155 of the 163 hospital samples (95%). Nicotine concentrations ranged widely within each hospital and across hospitals (FIGURE). Median concentrations were highest in Argentina and Uruguay ( $1.33$  [IQR,  $0.51$ - $3.12$ ]  $\mu\text{g}/\text{m}^3$  and  $0.8$  [IQR,  $0.30$ - $1.69$ ]  $\mu\text{g}/\text{m}^3$ , respectively), followed by Chile ( $0.13$  [IQR,  $0.03$ - $0.47$ ]  $\mu\text{g}/\text{m}^3$ ), and lower in the other countries. In the physicians' and nurses' stations ( $n=67$ ) across all countries, the median nicotine concentration was  $0.27$  (IQR,  $0.02$ - $1.94$ )  $\mu\text{g}/\text{m}^3$ . The median concentration was low in secondary schools compared with other places, although nicotine was detected in 73 of 94 samples (78%), some with a substantial amount of nicotine. Among city

**Table.** Country Information and Field Work Sample Data From Study of 7 Latin American Countries, 2002-2003

Country (Capital City)	General Country Information			Field Work Information			
	Students Exposed to Secondhand Smoke in Public Places, %*	Smoking Prevalence, %†	National Smoking Regulations in Public Places‡	Time of Sampling	Final No. of Samples	No. of Lost Sampling Devices	No. of Samples With Nicotine Concentrations Below Limit of Detection
Argentina (Buenos Aires)	87.6	39.8	Not regulated at the national level	November 2002	89	11	0
Brazil (Rio de Janeiro)	Not yet available	31.0	Banned in government buildings; restricted in others	December 2002	90	6	15
Chile (Santiago)	71.9	40.0	Restricted	October 2002	93	6	3
Costa Rica (San José)	51.5	19.4	Banned	December 2002§	83	9	8
Paraguay (Asunción)	64.3	24.0	Banned	February 2003	90	8	12
Peru (Lima)	45.2	33.8	Restricted	July 2002	88	9	3
Uruguay (Montevideo)	80.0	49.5	Banned in schools, restricted elsewhere	November 2002	100	1	0

\*Percentage of students (grades 7-9) in the Global Youth Tobacco Survey<sup>8,9</sup> who answered that someone had smoked in their presence outside their home on at least 1 day in the past 7 days.

†Smoking prevalence was based on national surveys in all countries except Brazil. Age ranges varied between  $\geq 15$  years (Brazil, Chile) and 20-40 years (Peru).<sup>10</sup>

‡From Shafey et al,<sup>10</sup> updated from the Pan American Health Organization (PAHO) database.

§Schools in Costa Rica were monitored during May 2003.

||Measured as any tobacco use during lifetime.

government buildings the nicotine concentrations were highest in Argentina and Uruguay.

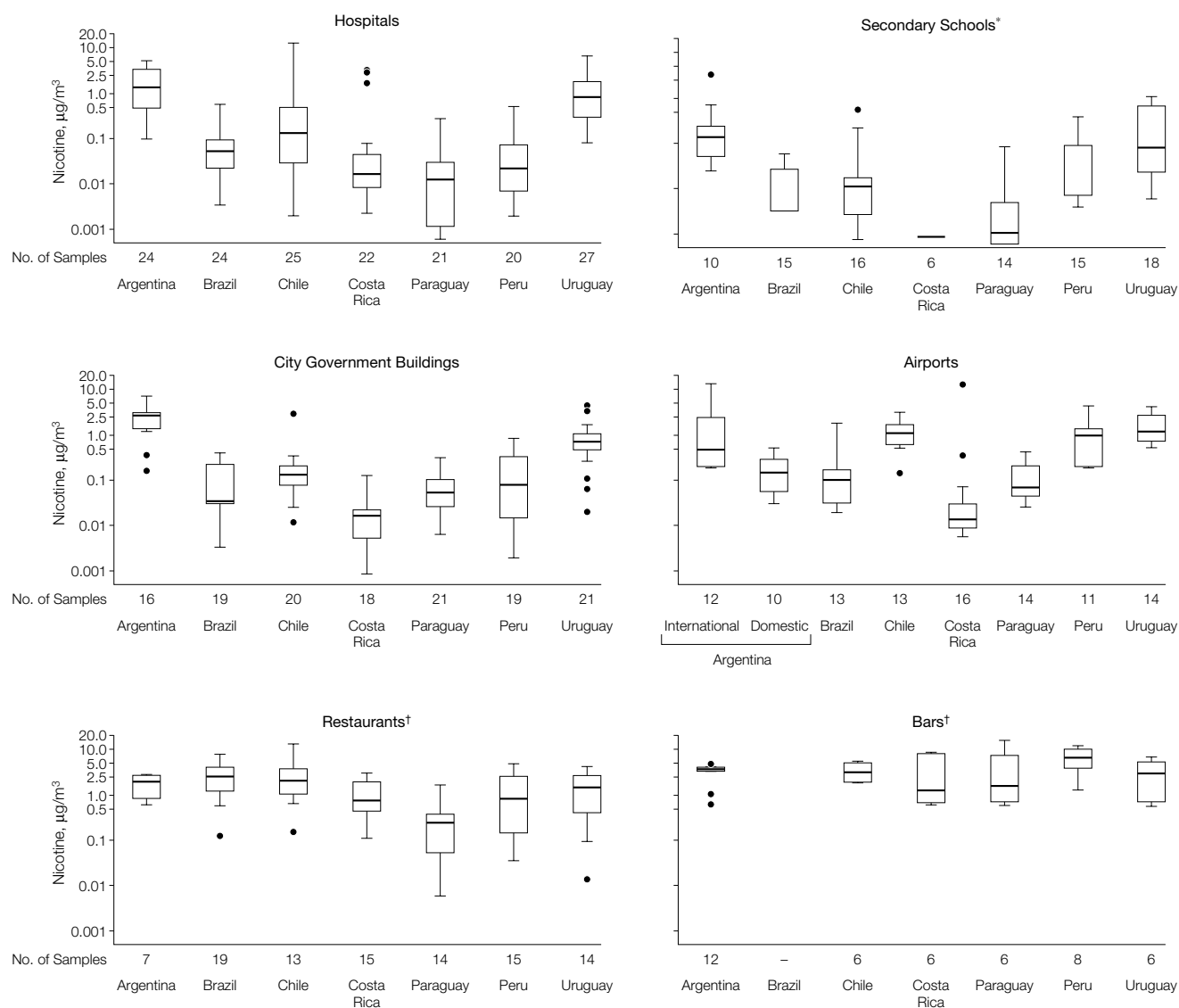
High concentrations of nicotine were found in the international airport in Argentina, and in airports in Chile, Uruguay, and Peru (Figure). Other airports, including the mostly domestic airport in Argentina, had substantially lower concentrations. The highest concentration found in 1 airport sample

in Costa Rica ( $12.5 \mu\text{g}/\text{m}^3$ ) corresponded to the smokers' cafeteria, whereas the rest of the airport was mostly smoke-free (median,  $0.01$  [IQR,  $0.01$ - $0.03$ ]  $\mu\text{g}/\text{m}^3$ ).

Nicotine concentrations in restaurants and bars were relatively high in all countries (Figure). Overall, the median concentration in restaurants was  $1.24$  (IQR,  $0.41$ - $2.48$ )  $\mu\text{g}/\text{m}^3$ . Paraguay showed the lowest concentra-

tions (median,  $0.24$  [IQR,  $0.05$ - $0.36$ ]  $\mu\text{g}/\text{m}^3$ ), compared with other countries (median,  $1.44$  [IQR,  $0.64$ - $2.61$ ]  $\mu\text{g}/\text{m}^3$ ). Measurements in nonsmoking areas in restaurants clearly showed the presence of tobacco smoke (median,  $0.60$  [IQR,  $0.11$ - $0.95$ ]  $\mu\text{g}/\text{m}^3$ ) but in general, less than in smoking areas (median,  $1.24$  [IQR,  $0.34$ - $2.45$ ]  $\mu\text{g}/\text{m}^3$ ). However, some nonsmoking areas showed higher concentrations than did

**Figure.** Concentrations of Airborne Nicotine in Public Places in Capital Cities in Latin America, 2002-2003



\*In Costa Rica, all concentrations were below the limit of detection; in Brazil and Peru, the median and the 25th percentile values represent the same level of nicotine concentration.

†In Brazil, restaurant samples and bar samples could not be distinguished from one another and their data are presented together in the "restaurants" panel. Horizontal lines within boxes indicate medians; boxes, interquartile ranges; error bars, values within 1.5 times the interquartile range; solid circles, outlying data points.

adjacent smoking areas. Indeed, the highest nicotine concentration in the restaurants ( $13.3 \mu\text{g}/\text{m}^3$ ) was found in a nonsmoking area located in a second floor above a smoking area, with a stairway connecting the floors. Bars had the highest nicotine concentrations (median,  $3.65$  [IQR,  $1.55$ - $5.12$ ]  $\mu\text{g}/\text{m}^3$ ), with small differences among countries.

## COMMENT

Using a common protocol in the capital cities of 7 Latin American countries, we measured concentrations of airborne nicotine in key target locations for programs to control secondhand smoke. Nicotine was detected in most places that were surveyed, and nonsmoking areas did not always effectively protect nonsmokers from exposure to secondhand smoke. Moreover, high concentrations of nicotine were found in a number of key, sentinel buildings. In general, and particularly for hospitals and schools, the concentration of nicotine tended to be higher in countries with higher prevalences of smoking<sup>10</sup> and with higher percentages of students reporting exposure to secondhand smoke in public places.<sup>8,9</sup>

Our findings are limited by selecting sampling locations on a convenience basis and by the numbers of samplers placed. These design features were determined by feasibility and by resources available. However, our purpose was not to estimate national exposures by selecting a representative sample; rather, we intended to develop policy-relevant monitoring data that would document whether nicotine was present in key locations and to assess whether control measures appeared to be effective. Although comparability of results across countries cannot be completely assured, a standardized protocol was in place and lead investigators in each country had common training. The locations were characterized to a limited extent, but we could not fully assess some aspects of the buildings, nor could we explore building characteristics as determinants of concentration. Finally, for fea-

sibility, we made measurements on a continuous basis and not during time of occupancy only. Consequently, the concentrations reported herein tend to be underestimates of those occurring during the time of occupancy.

Studies of nicotine concentrations in public places have been carried out primarily in developed countries.<sup>12</sup> Data on nicotine concentrations in Latin America have not been reported. Overall in public workplaces in our study, excluding restaurants and bars, we found lower concentrations than those reported in the 1990s by Hammond et al<sup>13,14</sup> for measurements taken in open offices at a time when passive smoking was more ubiquitous in the United States. In hospitals, government buildings, and airports of some Latin American countries, where smoking is usually restricted, concentrations were similar to those found by Hammond et al in open offices in the United States where smoking was restricted (median,  $1.3 \mu\text{g}/\text{m}^3$ ). A limited number of samples in Argentina, Uruguay, and Chile had values closer to those found in offices in the United States where smoking was unrestricted (median,  $8.6 \mu\text{g}/\text{m}^3$ ).<sup>13</sup> The differences in nicotine levels in Latin America as compared with those reported in the earlier studies in the United States likely reflect a lighter pattern of smoking in Latin America, as well as generally low prevalences of smoking among women in most countries in this study.<sup>10</sup> In the United States today, there are fewer workplaces with unrestricted smoking<sup>12</sup>; however, this is not the case in Latin America, as shown by the high frequency of nicotine detection. Instituting smoke-free environments in government buildings may be useful as a model and an impetus to expanding smoke-free policies to other workplaces.<sup>2</sup>

Hospitals and schools are critical places to be smoke-free, given the importance of professionals in health care and education serving as role models.<sup>15</sup> Instituting a policy to ban smoking in medical centers can control exposure to secondhand smoke.<sup>16</sup> Nicotine was detected in most hospitals in our study, and samples with high con-

centrations were found in Argentina, Uruguay, Chile, and Costa Rica. Similar or higher concentrations have been found in hospitals in other countries (eg, Spain<sup>17</sup> and the United States<sup>16</sup> before the introduction of smoke-free policies). We detected nicotine in the hospitals even though smoking was restricted or banned by national or local regulations in all countries, indicating a lack of enforcement and unfortunate noncompliance by health care professionals. Maintaining hospitals as smoke-free environments should be required as a component of any accreditation process for health care facilities. Nicotine was also detected in many schools in our study, although smoking in schools was banned in most countries. Given the importance of protecting children from the effects of passive smoking<sup>18</sup> and of preventing the initiation of tobacco consumption, smoking should be eliminated in educational settings.

Nicotine concentrations found in restaurants were lower than concentrations reported in restaurants in Europe (median,  $6.07 \mu\text{g}/\text{m}^3$ ), Asia (median,  $4.90 \mu\text{g}/\text{m}^3$ ), and North America (median,  $3.10 \mu\text{g}/\text{m}^3$ ).<sup>19</sup> These differences may reflect generally lower prevalences of smoking in Latin America, but differences in climate, architecture, and use of mechanical systems may also contribute to the lower levels detected. High concentrations of nicotine in many nonsmoking areas in our study corroborate previous evidence indicating that nonsmoking areas are ineffective in controlling exposure to secondhand smoke.<sup>20,21</sup> Moreover, continuous exposure in restaurants and bars to the concentrations found in this study poses a health risk for workers and strengthens the need to promote smoke-free initiatives in all occupational settings.<sup>22</sup>

These data for Latin America have immediate relevance for public health and medical professionals and for the governmental entities responsible for protecting the public from unwanted exposure to secondhand smoke. Compliance with smoking bans in medical facilities is incomplete, and data from

this study support a call to action for authorities who regulate and manage hospitals and for organizations of health care professionals to improve smoke-free regulations and ensure enforcement. Recently, the government of Uruguay cited our study in a decree that aims at creating smoke-free health care facilities.<sup>23</sup> Our data also indicate incomplete compliance with bans in government buildings and airports. The study offers some indication that effectively enforcing smoke-free policies can play a role in decreasing indoor levels of secondhand smoke. For instance, the mostly domestic airport in Argentina and the Costa Rica airport had smoke-free initiatives in place prior to the study and showed very low levels of airborne nicotine. Finally, in Latin America as elsewhere, nonsmoking

sections in restaurants and bars provide little protection against inhaling secondhand smoke, consistent with the main conclusion of the 1986 report of the US surgeon general.<sup>2</sup> If protection is to be complete, banning smoking is a requisite.

**Author Contributions:** Dr Navas-Acien had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analyses.

**Study concept and design:** Navas-Acien, Peruga, Breyse, Stillman, Samet.

**Acquisition of data; administrative, technical, or material support:** Navas-Acien, Peruga, Zavaleta, Blanco-Marquizo, Pitarque, Acuña, Jiménez-Reyes, Colombo, Gamarra.

**Analysis and interpretation of data:** Navas-Acien, Peruga, Breyse, Pitarque, Samet.

**Drafting of the manuscript:** Navas-Acien, Jiménez-Reyes, Stillman, Samet.

**Critical revision of the manuscript for important intellectual content:** Navas-Acien, Peruga, Breyse, Zavaleta, Blanco-Marquizo, Pitarque, Acuña, Colombo, Gamarra, Stillman, Samet.

**Statistical expertise:** Navas-Acien, Breyse, Samet.

**Obtained funding:** Peruga, Samet.

**Study supervision:** Navas-Acien, Peruga, Breyse, Zavaleta, Blanco-Marquizo, Acuña, Jiménez-Reyes, Colombo, Gamarra, Stillman, Samet.

**Funding/Support:** This work was supported by the Pan American Health Organization and the Institute for Global Tobacco Control, Johns Hopkins Bloomberg School of Public Health.

**Role of the Sponsors:** Only the authors, and not the organizations to which they belong, are responsible for the design and conduct of the study; the collection, analysis, and interpretation of the data; the preparation of the data; and the preparation, review, or approval of the manuscript.

**Previous Presentations:** Presented in part at the 12th World Conference on Tobacco or Health; August 2003; Helsinki, Finland, and the XXI Meeting of the Spanish Society for Epidemiology; October 2003; Toledo, Spain.

**Acknowledgment:** We thank Carmen Barco (CEDRO, Peru) for her collaboration in the pilot study and the training workshop, and the contribution to the field work of Marta Angueira (UATA, Argentina) and of the following persons in the local PAHO offices: Rosa María Borrell (Argentina), Miguel Malo (Brazil), Branka Legetic (Chile), Miryan Cruz (Costa Rica), Clovis Lombardi (Paraguay), Fernando Rocabado (Peru), and Julio González (Uruguay). We also thank D'Ann Williams and Jie Yuan for assistance in assembling and analyzing the air samples and Maria Jose López for her contribution to the quality control analyses.

## REFERENCES

- World Health Organization. *The World Health Report 2002*. Geneva, Switzerland: World Health Organization; 2002.
- Centers for Disease Control and Prevention. *The Health Consequences of Involuntary Smoking: A Report of the Surgeon General*. Atlanta, Ga: US Dept of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention; 1986.
- Muggli ME, Hurt RD, Blanke DD. Science for hire: a tobacco industry strategy to influence public opinion on secondhand smoke. *Nicotine Tob Res*. 2003; 5:303-314.
- Ong EK, Glantz SA. Constructing "sound science" and "good epidemiology": tobacco, lawyers, and public relations firms. *Am J Public Health*. 2001; 91:1749-1757.
- Aguinaga-Bialous S, Shatenstein S. *Profits Over People: Tobacco Industry Activities to Market Cigarettes and Undermine Public Health in Latin America and the Caribbean*. Washington, DC: Pan American Health Organization; 2002.
- Hammond SK. Evaluating exposure to environmental tobacco smoke. In: Winegar ED, Keith LH, eds. *Sampling and Analysis of Airborne Pollutants*. Boca Raton, Fla: Lewis Publishers; 1993:319-338.
- Samet JM, Wang SS. Environmental tobacco smoke. In: Lippmann M, ed. *Environmental Toxicants: Human Exposures and Their Health Effects*. New York, NY: Van Nostrand Reinhold Co Inc; 2000:319-375.
- Centers for Disease Control and Prevention, World Health Organization. Global Youth Tobacco Survey. Available at: <http://www.cdc.gov/tobacco/global/GYTS.htm>. Accessed April 19, 2004.
- Global Youth Tobacco Survey Collaborative Group. Tobacco use among youth: a cross country comparison. *Tob Control*. 2002;11:252-270.
- Shafey O, Dolwick S, Guindon GE, eds. *Tobacco Control Country Profiles*. 2nd ed. Atlanta, Ga: American Cancer Society Inc; World Health Organization; International Union Against Cancer; 2003.
- Hammond SK, Leaderer BP. A diffusion monitor to measure exposure to passive smoking. *Environ Sci Technol*. 1987;21:494-497.
- Jenkins RA, Guerin MR, Tomkins BA. *The Chemistry of Environmental Tobacco Smoke: Composition and Measurement*. 2nd ed. Washington, DC: Lewis Publishers; 2000.
- Hammond SK, Sorensen G, Youngstrom R, Ockene JK. Occupational exposure to environmental tobacco smoke. *JAMA*. 1995;274:956-960.
- Hammond SK. Exposure of US workers to environmental tobacco smoke. *Environ Health Perspect*. 1999;107(suppl 2):329-340.
- Oei TP, Baldwin AR. Smoking education and prevention: a developmental model. *J Drug Educ*. 1992; 22:155-181.
- Stillman FA, Becker DM, Swank RT, et al. Ending smoking at the Johns Hopkins Medical Institutions: an evaluation of smoking prevalence and indoor air pollution. *JAMA*. 1990;264:1565-1569.
- Jane M, Nebot M, Rojano X, et al. Exposure to environmental tobacco smoke in public places in Barcelona, Spain. *Tob Control*. 2002;11:83-84.
- Cook DG, Strachan DP. Health effects of passive smoking-10: summary of effects of parental smoking on the respiratory health of children and implications for research. *Thorax*. 1999;54:357-366.
- Schorp MK, Leyden DE. Distribution analysis of airborne nicotine concentrations in hospitality facilities. *Environ Int*. 2002;27:567-578.
- Lambert WE, Samet JM, Spengler JD. Environmental tobacco smoke concentrations in nonsmoking and smoking sections of restaurants. *Am J Public Health*. 1993;83:1339-1341.
- Akbar-Khanzadeh F. Exposure to environmental tobacco smoke in restaurants without separate ventilation systems for smoking and nonsmoking dining areas. *Arch Environ Health*. 2003;58:97-103.
- Siegel M. Involuntary smoking in the restaurant workplace: a review of employee exposure and health effects. *JAMA*. 1993;270:490-493.
- Decreto 98/004. [Establishing that all health facilities in the country, both public and private, are considered 100% tobacco smoke-free environments]. *Diario Oficial de Uruguay*. March 29, 2004.