Taylor & Francis
Taylor & Francis Group

Inhalation Toxicology

International Forum for Respiratory Research

ISSN: 0895-8378 (Print) 1091-7691 (Online) Journal homepage: https://www.tandfonline.com/loi/iiht20

Environmental Tobacco Smoke Exposure and Respiratory Morbidity in Children

Nazan Cobanoglu, Nural Kiper, Embiya Dilber, Nermin Gurcan, Ayhan Gocmen, Ugur Ozcelik, Deniz Dogru, Ebru Yalcin, Sevgi Pekcan & Mehmet Kose

To cite this article: Nazan Cobanoglu, Nural Kiper, Embiya Dilber, Nermin Gurcan, Ayhan Gocmen, Ugur Ozcelik, Deniz Dogru, Ebru Yalcin, Sevgi Pekcan & Mehmet Kose (2007) Environmental Tobacco Smoke Exposure and Respiratory Morbidity in Children, Inhalation Toxicology, 19:9, 779-785, DOI: 10.1080/08958370701402085

To link to this article: https://doi.org/10.1080/08958370701402085

Published online: 06 Oct 2008.

Inhalation Toxicology, 19:779–785, 2007

ISSN: 0895-8378 print / 1091-7691 online
DOI: 10.1080/08958370701402085

informa
healthcare

Environmental Tobacco Smoke Exposure and Respiratory Morbidity in Children

Nazan Cobanoglu,[1] Nural Kiper,[1] Embiya Dilber,[2] Nermin Gurcan,[1] Ayhan Gocmen,[1] Ugur Ozcelik, [1] Deniz Dogru,[1] Ebru Yalcin,[1] Sevgi Pekcan,[1] Mehmet Kose[1]

[1]*Hacettepe University Pediatric Pulmonary Diseases Unit, Ankara*
[2]*Karadeniz Technical University Department of Pediatrics, Trabzon, Turkey*

Environmental tobacco smoke (ETS) contains carcinogenic and toxic agents. Smoking might have a more serious effect on children than adults. We aimed to examine the effects of passive smoking on pulmonary function and respiratory health in children and to assess the concordance between parental self-reported smoking habits and urinary cotinine levels in their children. This cross-sectional study was conducted in the winter with the participation of 131 children (9–12 yr old). The procedure for each subject consisted of administration of a questionnaire to the parents, and collection of a urine sample and measurement of lung function in each child. Cotinine level excreted into urine was analyzed with respect to parental self-reported smoking behavior. Working mothers and mothers with higher level of education tended to smoke more at home (p values, respectively, .002 and .005). There was a statistical difference between the urinary cotinine levels of children when divided into two groups according to their fathers' smoking behavior at home ($p = .0001$). No statistically significant difference was determined in the mean episodes of respiratory infections treated during the last 12 mo among the groups formed according to daily number of cigarettes smoked by the parents at home (1: not exposed; 2: <5 cigarettes; 3: 5–10 cigarettes; 4: >10 cigarettes), or among the groups formed according to urinary cotinine levels (1: <10 ng/ml; 2: ≥10 ng/ml). No significant difference was demonstrated in any of the respiratory function parameters investigated between the groups considered. The reliability of the declarations of the parents in the estimation of ETS exposure of children was low. Children are unable to remove themselves from ETS exposure. It is better to reduce the percentage of parents who smoke rather than to isolate smokers or increase ventilation.

Environmental tobacco smoke (ETS), including both expired and sidestream smoke, contains many of the same carcinogenic and toxic agents as mainstream smoke inhaled by active smokers. ETS has recently been classified as a class I carcinogen by the Internal Agency for Research on Cancer (2004). It increases the risk both of certain respiratory-tract infections and of invasive diseases in adults (Fischer et al., 1997; Nuorti et al., 2000). As children show a higher internal exposure compared with adults, the health hazards associated with passive smoking might have a more serious effect in children. ETS is associated with an increased risk of lower respiratory tract infections, middle ear effusion, increased episodes and severity of asthma, and reduced level of pulmonary function in children (U.S. EPA, 1992; Ugnat et al., 1990; Jinot & Bayard, 1996; Chen et al., 1998). Furthermore, ETS exposure in childhood is associated with the development of dental caries and behaviorial problems (Aligne et al., 2003; Weitzman et al., 1992).

Children's ETS exposure primarily occurs at home and the main source is parental smoking. Numerous studies have reported on parental smoking and their children's ETS exposure (Cook et al., 1994; Dell'Orco et al., 1995; Jarvis et al., 1992, 2000; Jordaan et al., 1999). Most of these studies have been based on questionnaires for the estimation of the children's ETS exposure in the home. A few studies, such as the National

Received 6 January 2007; accepted 6 April 2007.

We thank Munir Ozcelik for performing the spirometry, and all the parents and children for their participation in this study.

Address correspondence to Nazan Cobanoglu, MD, Hacettepe University Faculty of Medicine, Pediatric Pulmonary Diseases Unit, Ankara, Turkey. E-mail: nazanc@hacettepe.edu.tr

Health and Nutrition Examination Survey (NHANES) III, have published data on biomarkers for ETS exposure in a large random population sample in the United States (Mannino et al., 2001).

Cotinine is the major metabolite of nicotine found in biological fluids and is considered to be the best marker of ETS exposure because its biologic half-life in body fluids is much longer than that of nicotine (approximately 20 h compared with 2 h) (Benowitz et al., 1982, 1983). Numerous studies have measured cotinine in the blood, urine, saliva, cervical exudate, semen, meconium, and hair in order to estimate the exposure to passive smoke (Henderson et al., 1989; Pattishall et al., 1985; Chilmonczyk et al., 1990; Wall et al., 1988; Poppe et al., 1995; Vine et al., 1993; Derauf et al., 2003; Woodruff et al., 2003).

The purpose of this study was to examine the effects of passive smoking on pulmonary function and respiratory health in children with adjustment for potentially confounding social factors. Passive smoking exposure was evaluated by questionnaire and by measurement of urinary cotinine levels. We also aimed to assess the concordance between parental self-reported tobacco use and the concentration of cotinine measured in their children's urine.

METHODS

This study was conducted in the winter in Hacettepe University Faculty of Medicine, Pediatric Pulmonary Diseases Unit, Ankara, Turkey. It was designed as a cross-sectional study, and 131 children attending primary or middle school (9–12 yr old) were included.

The procedure for each subject consisted of administration of a questionnaire to the parent, and collection of a urine sample and measurement of lung function in each child.

The questionnaire contained items, administered by the same interviewer, about personal, familial, and environmental characteristics (sex, age, and anthropometric measurements of children, smoking habits of each family member at home [yes or no], number of cigarettes smoked at home [<5 cigarettes; 5–10 cigarettes; >10 cigarettes], age and education [no education, primary school, middle school, high school, or university], and occupational status [for mothers as working or not working; for fathers as self-employed or farmer, bureaucrat, or worker] of parents). Respiratory morbidity was investigated by the number of upper (tonsillitis, sinusitis, otitis media) and lower (pneumonia) respiratory infections during the last 12 mo. Four categories were formed with respect to the children's daily exposure at home according to number of cigarettes smoked, as (1) not exposed, (2) <5 cigarettes, (3) 5–10 cigarettes, and (4) >10 cigarettes.

Lung function was measured with a spirometer (AS-600 Minato, Autospiro). After calibration of the machine and demonstration of its use, each child had at least three acceptable maneuvers with a noseclip. The best test was considered for statistical analysis. Parameters were expressed as vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), and 25–75% of forced expiratory flow (FEF_{25-75}).

A morning urine sample was obtained from each child and stored at –70°C until analysis. Cotinine excreted into urine was analyzed with the high-performance liquid chromatography method (Pirkle et al., 1996). Children exposed to ETS were distinguished from nonexposed children using a cutoff value of 10 ng/ml urinary cotinine, as recommended previously (Chilmonczyk et al., 1993). A comparison was made between parental reports of tobacco use and urinary cotinine level.

The data were analyzed using Statistical Package for the Social Sciences 11.5 (SPSS, Inc., Chicago). The Kruskal–Wallis test was used for comparisons of the mean episodes of upper and lower respiratory infections occurring during the last 12 mo and of the mean values of respiratory function tests between the four groups formed according to the number of cigarettes smoked by the parents at home (daily). The Mann–Whitney U-test was used for comparisons of the mean episodes of upper and lower respiratory infections during the last 12 mo and of the mean values of respiratory function tests between the 2 groups formed according to the urinary cotinine levels of children and according to parental smoking behavior at home. To analyze the association between education and occupational status of parents and their smoking habits at home, and between the urinary cotinine levels of children and smoking habits of their parents at home, the χ^2 test was performed. Differences were considered significant at $p < .05$.

RESULTS

Of 131 children, 68 (51.9%) were male. The mean age of all children was 10.48 yr (range: 9–12, SD: ±0.59).

Working mothers and mothers with higher level of education tended to smoke more at home (p values, respectively, .002 and .005) (Figure 1). Although the smoking tendency of the fathers decreased as the level of education increased, it was not statistically significant ($p = .312$). We found no statistical difference when we compared the occupational status of the fathers and their smoking behavior at home ($p = .801$) (Figure 2).

There was no statistical difference between the urinary cotinine levels of children when divided into two groups according to their mothers' smoking behavior at home ($p = .544$), but the difference was significant for their fathers' smoking behavior at home ($p = .0001$) (Table 1).

As shown in Figure 3, there was no statistically significant difference in the mean episodes of otitis media, tonsillitis, pneumonia and sinusitis treated during the last 12 mo between the 4 groups formed according to the daily number of cigarettes smoked by the parents at home (p values, respectively, .389, .295, .686, and .955). The difference was also not significant when we compared the mean episodes of respiratory infections of the two groups formed according to the urinary cotinine levels of children (Figure 4).

Figure 5 shows the mean values of respiratory function tests of children in the groups divided with respect to daily exposure at home according to the number of cigarettes smoked, to parental

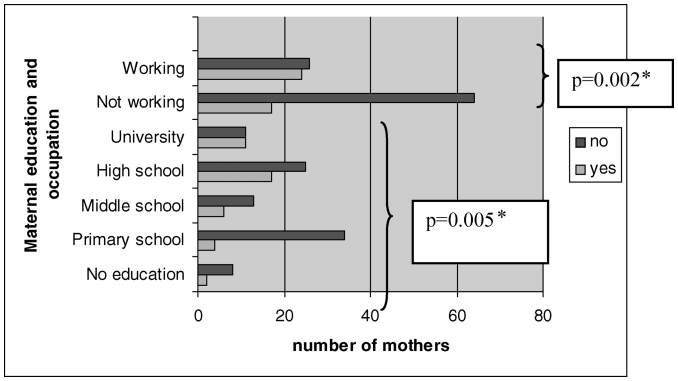


FIG. 1. The association between smoking behavior at home and maternal education and occupation. No: not smoking at home; yes: smoking at home. Asterisk indicates differences were considered significant at $p < .05$.

smoking behavior at home, and to urinary cotinine levels. No significant difference was demonstrated in any of the respiratory function parameters between the groups considered.

Validity and agreement of the parental reports are shown in Table 2. It was observed that the reliability of the declarations of the parents in the estimation of ETS exposure of the children was low. Although 41.7% of parents declared that they were not smoking at home, the urinary cotinine levels of their children were $\geq$10 ng/ml.

DISCUSSION

Most people are inclined to believe that parents with a low educational level tend to smoke relatively more in the presence of their children than parents with middle or high educational levels. Different results have been reported in different countries in the studies investigating the relation between the level of education and smoking habits. In a study conducted in the United States, it was reported that the use of cigarettes decreased as the level of education increased, whereas a study carried out in France indicated that the rate of smoking grew with the increase in the level of education (Wadenknecht at al., 1990; Kauffmann et al., 1989). However, a recent study reported from Turkey detected no relation between ETS measured with urinary cotinine level and the education level of the parents (Boyaci et al., 2006). We found different results between the mothers and fathers in our study. The mothers with a higher level of education tended to smoke more at home. Although the smoking tendency of the fathers decreased as the level of education increased, the difference was not statistically significant.

Several studies have reported that maternal smoking had a stronger influence than paternal smoking on children's exposure (Cook et al., 1994; Henschen et al., 1997; Willers et al., 1992; Wong et al., 2002). One of the reasons may be that mothers spend more time with their children or that they smoke around their children more frequently. The best predictor of urinary cotinine level among children in our study was paternal smoking (Table 1). This is incompatible with all except one of the previous results (Bek et al., 1999). Among the possible explanations is (1) incorrect declarations of some mothers. Discrepancies between self-reported smoking habits and urinary biomarker levels were reported in several studies for children and adolescents (Caraballo et al., 2004; Heller et al., 1998; Patrick et al., 1994). There are many concerns associated with questionnaire assessment, including lack of a gold standard with which to validate questionnaires, lack of commonly accepted standardized questionnaires, and the possibility of misclassification of exposure for several reasons(U.S. EPA, 1992). Our study showed that the assessment of ETS exposure in children by means of questionnaire results had a low validity and reliability, which is in agreement with previous studies (Boyaci et al., 2006; Willers et al., 2000, 2004; Nafstad et al., 1995). Another possible explanation is (2) that children might have been exposed to ETS from sources other than parental smoking, such as friends and occasional visitors, or exposure to ETS might have occurred in social settings and in public places. Another is that (3) misclassification may be extensive due to factors not covered by the questionnaire, such as proximity to the smoker.

TABLE 1
Comparison of the mean urinary cotinine levels of children according to parental smoking behavior at home

		Urinary cotinine level (ng/mL)		
		N	Mean	
Smoking behavior of mother at home	Yes	42	66.93	p = 0.544
	No	89	62.66	
Smoking behavior of father at home	Yes	87	72.21	p = 0.0001*
	No	44	47.39	

Note. Asterisk indicates differences were considered significant at $p < .05$.

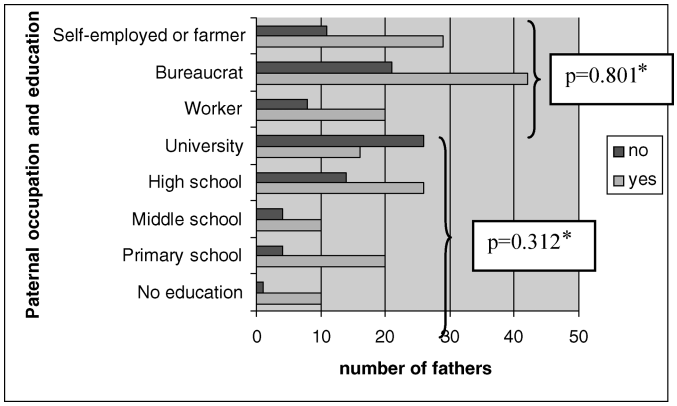


FIG. 2. The association between smoking behavior at home and paternal education and occupation. No: not smoking at home; yes: smoking at home. Asterisk indicates differences were considered significant at $p < .05$.

TABLE 2
Validity and agreement of the parental reports

		U- cotinine level (ng/mL)		
		<10	≥10	Total
Smoking behavior of parents at home (n, %)	Yes	22 (23.2%)	73 (76.8%)	95 (100%)
	No	21 (58.3%)	15 (41.7%)	36 (36%)
	Total	43	88	131

Note. U-cotinine: urinary cotinine; sensitivity 82.9%, specificity 48.8%.

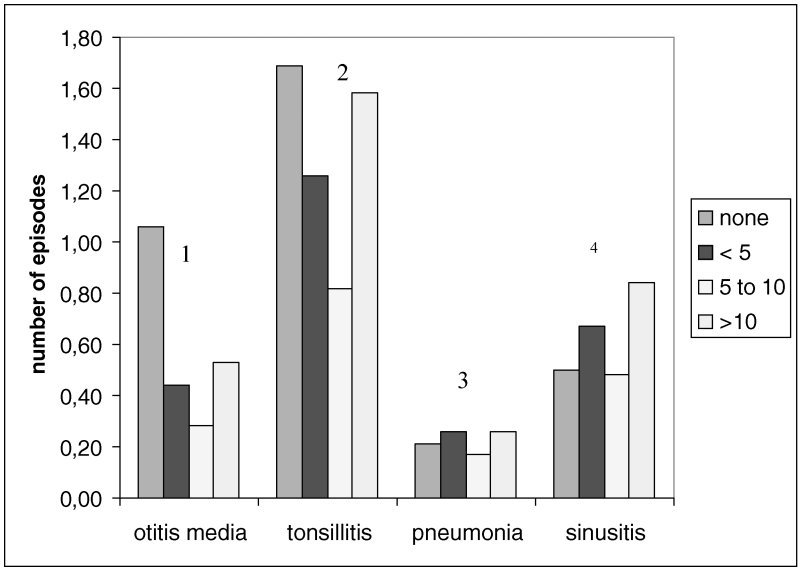


FIG. 3. Comparison of the mean episodes of respiratory tract infections of the groups subdivided according to the number of cigarettes smoked at home (none, <5 cigarettes, 5 to 10 cigarettes, >10 cigarettes). Asterisk indicates differences were considered significant at $p < .05$.

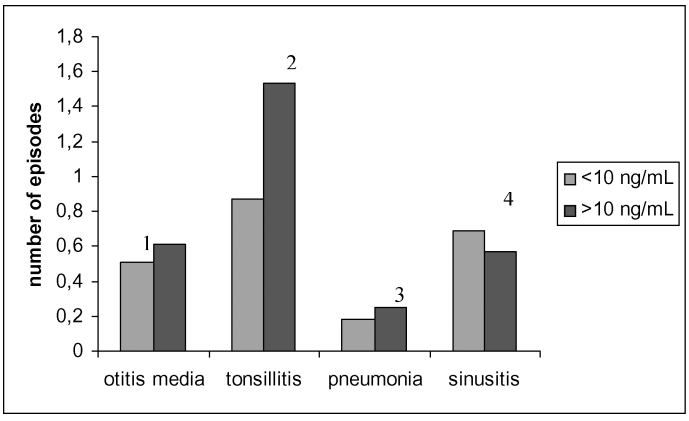
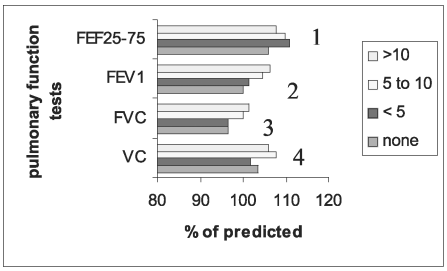
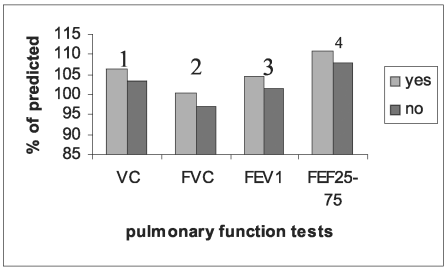


FIG. 4. Comparison of the mean episodes of respiratory infections of the groups subdivided according to urinary cotinine level of children (<10 ng/ml and >10 ng/ml). Asterisk indicates differences were considered significant at $p < .05$.



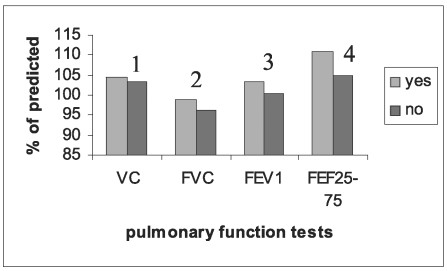
1. p=0.795
2. p=0.149
3. p=0.258
4. p=0.073

A. Comparison of pulmonary function tests of children subdivided according to the number of cigarettes smoked at home (none, <5 cigarettes, 5 to 10 cigarettes, >10 cigarettes).



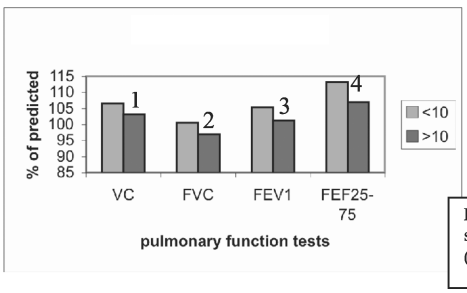
1. p=0.146
2. p=0.112
3. p=0.143
4. p=0.587

B. Comparison of pulmonary function tests of children subdivided according to maternal smoking behavior at home. **no:** Not smoking at home, **yes:** Smoking at home



1. p=0.264
2. p=0.284
3. p=0.137
4. p=0.160

C. Comparison of pulmonary function tests of children subdivided according to paternal smoking behavior at home. **no:** Not smoking at home, **yes:** Smoking at home



1. p=0.142
2. p=0.101
3. p=0.051
4. p=0.123

D. Comparison of pulmonary function tests of children subdivided according to the urinary cotinine levels of children (<10 ng/mL and >10 ng/mL).

FIG. 5. Comparison of pulmonary function tests of children subdivided according to the number of cigarettes smoked at home (A), parental smoking behavior at home (B and C), and urinary cotinine levels of children (D). Asterisk indicates differences were considered significant at $p < .05$.

The effects of passive tobacco smoke on lung function and its possible association with subsequent development of lung diseases have become major health issues. The nonsignificant differences observed in this cross-sectional study between the spirometric measurements of the groups, divided as exposed and nonexposed to ETS according to parental reports and urinary cotinine levels, raise an important question: What kind of exposure can the cross-sectional studies assess, the recent or long-term exposure? The effect of long-term exposure may be cumulative or the recent exposure may have a more prominent effect on pulmonary function. It is difficult for cross-sectional studies to address such a question. The small number of subjects participating in our study compared with other more extensive studies might also have been insufficient for assessing the effect of ETS on pulmonary function.

Both smoking and exposure to tobacco smoke in the household are associated with carriage of bacteria, such as *Neisseria meningitis* and *Streptococcus pneumoniae* (Stuart et al., 1989; Greenberg et al., 2006). Although the association between ETS exposure and respiratory diseases was shown in many studies (Corbo et al., 2003; Tutka et al., 2002; Cook & Strachan, 1999; Saraclar et al., 1998; Al-Dawood, 2001), the respiratory symptoms were not regarded as associated with ETS exposure in this study. However, we assessed the number of episodes of respiratory infections using parental declarations and not physician reports, which may present a susceptibility to information bias.

Although the cotinine level measured in the urine is an evident indicator of ETS exposure, there is no cutoff point that has been accepted worldwide for determining ETS exposure. We used 10 ng/ml as the cutoff point in our study. As the prevalence of passive smoking in developing countries such as Turkey is very high, this cutoff level might have been unable to indicate the causative effect of ETS in lower respiratory tract infections.

In conclusion, multicentric comprehensive studies are necessary for assessing the effect of ETS on the respiratory health of children living in Turkey. As children are unable to complain or to remove themselves from ETS exposure, parents should make sure that their children live in a smoke-free environment. It seems better to reduce the percentage of parents who smoke rather than to isolate smokers or increase ventilation. Each country should take all legislative measures to forbid adults to smoke not only in public places but also in the home environment, in an effort to protect children from exposure to ETS.

REFERENCES

Al-Dawood, K. 2001. Parental smoking and the risk of respiratory symptoms among schoolboys in Al-Khobar City, Saudi Arabia. *J. Asthma* 38:149–154.

Aligne, C. A., Moss, M. E., Auinger, P., and Weitzman, M. 2003. Association of pediatric dental caries with passive smoking. *J. Am. Med. Assoc.* 289:1258–1264.

Bek, K., Tomaç, N., Delibas, A., Tuna, F., Teziç, H. T., and Sungur, M. 1999. The effect of passive smoking on pulmonary function during childhood. *Postgrad. Med. J.* 75:339–341.

Benowitz, N. L., Jacob, P., Jones, R. T., and Rosenberg, J. 1982. Interindividual variability in the metabolism and cardiovascular effects of nicotine in man. *J. Pharmacol. Exp. Ther.* 221:368–372.

Benowitz, N. L., Kuyt, F., Jacob, P., Jones, R. T., and Osman, A.-L. 1983. Cotinine disposition and effects. *Clin. Pharmacol. Ther.* 34:604–611.

Boyacı, H., Etiler, N., Duman, C., Basyigit, I., and Pala, A. 2006. Environmental tobacco smoke exposure in school children: Parent report and urine cotinine measures. *Pediatr. Int.* 48:382–389.

Caraballo, R. S., Giovino, G. A., and Pechacek, T. F. 2004. Self-reported cigarette smoking vs serum cotinine among U.S. adolescents. *Nicotine Tobacco Res.* 6:19–25.

Chen, Y., Rennie, D. C., Lockinger, L. A., and Dosman, J. A. 1998. Effect of environmental tobacco smoke on cough in children with a history of tonsillectomy and adenoidectomy. *Eur. Respir. J.* 11:1319–1323.

Chilmonczyk, B. A., Knight, G. J., Palomaki, G. E., Pulkkinen, A. J., Williams, J., and Haddow, J. E. 1990. Environmental tobacco smoke exposure during infancy. *Am. J. Public Health* 80:1205–1208.

Chilmonczyk, B. A., Salmun, L. M., Megathlin, K. N., Neveux, L. M., Palomaki, G. E., Knight, G. J., Pulkkinen, A. J., and Haddow, J. E. 1993. Association between exposure to environmental tobacco smoke and exacerbations of asthma in children. *N. Engl. J. Med.* 328:1665–1669.

Cook, D. G., and Strachan, D. P. 1999. Health effects of passive smoking-10: Summary of effects of parental smoking on the respiratory health of children and implications for research. *Thorax* 54:357–366.

Cook, D. G., Whincup, P. H., Jarvis, M. J., Strachan, D. P., Papacosta, O., and Bryant, A. 1994. Passive exposure to tobacco smoke in children aged 5–7 years: Individual, family and community factors. *Br. Med. J.* 308:384–389.

Corbo, G. M., Forastiere, F., Agabiti, N., Dell'Orco, V., Pistelli, R., Massi, G., Perucci, C. A., and Valente, S. 2003. Passive smoking and lung function in alpha (1)-antitrypsin heterozygote schoolchildren. *Thorax* 58:237–241.

Dell'Orco, V., Forastiere, F., Agabiti, N., Corbo, G. M., Pistelli, R., Pacifici, R., Zuccoro, P., Pizzabiocca, A., Rosa, M., and Altieri, I. 1995. Household and community determinants of exposure to involuntary smoking: A study of urinary cotinine in children and adolescents. *Am. J. Epidemiol.* 142:419–427.

Derauf, C., Katz, A. R., and Easa, D. 2003. Agreement between maternal self-reported ethanol intake and tobacco use during pregnancy and meconium assays for fatty acid ethyl esters and cotinine. *Am. J. Epidemiol.* 158:705–709.

Fischer, M., Hedberg, K., Cardosi, P., Plikaytis, B. D., Hoesly, F. C., Steingart, K. R., Bell, T. A., Fleming, D. W., Wenger, J. D., and Perkins, B. A. 1997. Tobacco smoke as a risk factor for meningococcal disease. *Pediatr. Infect. Dis. J.* 16:979–983.

Greenberg, D., Givon-Lavi, N., Broides, A., Blancovich, I., Peled, N., and Dagan, R. 2006. The contribution of smoking and exposure to tobacco smoke to *Streptococcus pneumoniae* and *Haemophilus influenzae* carriage in children and their mothers. *Clin. Infect. Dis.* 42:897–903.

Heller, W. D., Scherer, G., Sennewald, E., and Adlkofer, F. 1998. Misclassification of smoking in a follow-up population study in southern Germany. *J. Clin. Epidemiol.* 51:211–218.

Henderson, F. W., Reid, H. F., Morris, R., Wang, O. L., Hu, P. C., Helms, R. W., Forehand, L., Mumford, J., Lewtas, J., and Haley, N. J. 1989. Home air cotinine levels and urinary cotinine excretion in preschool children. *Am. Rev. Respir. Dis.* 140:197–201.

Henschen, M., Frischer, T., Pracht, T., Spiekerkotter, E., Karmaus, W., Meinert, R., Lehnert, W., Wehrle, E., and Kuehr, J. 1997. The internal dose of passive smoking at home depends on the size of the dwelling. *Environ. Res.* 72:65–71.

International Agency for Research on Cancer. 2004. Tobacco smoke and involuntary smoking. *IARC Monogr. Eval. Carcinogen. Risks Hum.* 83.

Jarvis, M. J., Strachan, D. P., and Feyerabend, C. 1992. Determinants of passive smoking in children in Edinburgh, Scotland. *Am. J. Public Health* 82:1225–1229.

Jarvis, M. J., Goddard, E., Higgins, V., Feyerabend, C., Bryant, A., and Cook, D. G. 2000. Children's exposure to passive smoking in England since the 1980s: Cotinine evidence from population surveys. *Br. Med. J.* 321:343–345.

Jinot, J., and Bayard, S. 1996. Respiratory health effects of exposure to environmental tobacco smoke. *Rev. Environ. Health* 11:89–100.

Jordaan, E. R., Ehrlich, R. I., and Potter, P. 1999. Environmental tobacco smoke exposure in children: Household and community determinants. *Arch. Environ. Health* 54(5):319–327.

Kauffmann, F., Tager, I. B., Munoz, A., and Speizer, F. E. 1989. Familial factors related to lung function in children aged 6–10 years. Results from the PAARC epidemiologic study. *Am. J. Epidemiol.* 129:1289–1299.

Mannino, D. M., Caraballo, R., Berowitz, N., and Repace, J. 2001. Predictors of cotinine levels in US children—Data from the Third

National Health and Nutrition Examination Survey. *Chest* 120:718–724.

Nafstad, P., Botten, G., Hagen, J. A., Zahlsen, K., Nilsen, O. G., Silsand, T., and Kongerud, J. 1995. Comparison of three methods for estimating environmental tobacco smoke exposure among children aged between 12 and 36 months. *Int. J. Epidemiol.* 24:88–94.

Nuorti, J. P., Butler, J. C., Farley, M. M., Harrison, L. H., McGeer, A., Kolczak, M. S., and Breiman, R. F. 2000. Cigarette smoking and invasive pneumococcal disease. Active Bacterial Core Surveillance Team. *N. Engl. J. Med.* 342:681–689.

Patrick, D. L., Cheadle, A., Thompson, D. C., Diehr, P., Koepsell, T., and Kinne, S. 1994. The validity of self-reported smoking: A review and meta-analysis. *Am. J. Public Health* 84:1086–1093.

Pattishall, E. N., Strope, G. L., Etzel, R. A., Helms, R. W., Haley, N. J., and Denny, F. W. 1985. Serum cotinine as a measure of tobacco smoke exposure in children. *Am. J. Dis. Child.* 139:1101–1104.

Pirkle, J. L., Flegal, K. M., Bernert, J. T., Brody, D. J., Etzel, R. A., and Maurer, K. R. 1996. Exposure of the US population to environmental tobacco smoke. The Third National Health and Nutrition Examination Survey, 1988 to 1991. *J. Am. Med. Assoc.* 275:1233–1240.

Poppe, W. A., Peeters, R., Daenens, P., Ide, P. S., and Van Assche, F. A. 1995. Tobacco smoking and the uterine cervix: Cotinine in blood, urine and cervical fluid. *Gynecol. Obstet. Invest.* 39:110–114.

Saraclar, Y., Sekerel, B. E., Kalayci, O., Cetinkaya, F., Adalioglu, G., Tuncer, A., and Tezcan, S. 1998. Prevalence of asthma symptoms in school children in Ankara, Turkey. *Respir. Med.* 92:203–207.

Stuart, J. M., Cartwright, K. A., Robinson, P. M., and Noah, N. D. 1989. Effect of smoking on meningococcal carriage. *Lancet* 2:723–725.

Tutka, P., Wielosz, M., and Zatonski, W. 2002. Exposure to environmental tobacco smoke and children health. *Int. J. Occup. Med. Environ. Health* 15:325–335.

Ugnat, A. M., Mao, Y., Miller, A. B., and Wigle, D. T. 1990. Effects of residential exposure to environmental tobacco smoke on Canadian children. *Can. J. Public Health* 81:345–349.

U.S. Environmental Protection Agency. 1992. *Respiratory health effects of passive smoking: Lung cancer and other disorders*. Office of Health and Environmental Assessment. Washington, DC: Office of Research and Development. EPA/600/6-90/006F.

Vine, M. F., Hulka, B. S., Margolin, B. H., Truong, Y. K., Hu, P. C., Schramm, M. M., Griffith, J. D., McCann, M., and Everson, R. B. 1993. Cotinine concentrations in semen, urine, and blood of smokers and nonsmokers. *Am. J. Public Helath* 83:1335–1338.

Wagenknecht, L. E., Perkins, L. L., Cutter, G. R., Sidney, S., Burke, G. L., Manolio, T. A., Jacobs, D. R., Jr., Liu, K. A., Friedman, G. D., and Hughes, G. H. 1990. Cigarette smoking behavior is strongly related to educational status: The CARDIA study. *Prev. Med.* 19:158–169.

Wall, M. A., Johnson, J., Jacob, P., and Benowitz, N. L. 1988. Cotinine in the serum, saliva, and urine of nonsmokers, passive smokers, and active smokers. *Am. J. Public Health* 1988;78:699–701.

Weitzman, M., Gortmaker, S., and Sobol, A. 1992. Maternal smoking and behaviour problems of children. *Pediatrics* 90:342–349.

Willers, S., Attewell, R., Bensryd, I., Schutz, A., Skarping, G., and Vahter, M. 1992. Exposure to environmental tobacco smoke in the household and urinary cotinine excretion, heavy metals retention, and lung function. *Arch. Environ. Health* 47:357–363.

Willers, S., Feyerabend, C., Nielsen, J., Skarping, G., and Skenfving, S. 2000. Assessment of environmental tobacco smoke exposure in children with asthmatic symptoms by questionnaire and cotinine concentrations in plasma, saliva and urine. *J. Clin. Epidemiol.* 53:715–721.

Willers, S., Hein, H. O., and Jansson, L. 2004. Assessment of environmental tobacco smoke exposure: Urinary cotinine concentrations in children are strongly associated with the house dust concentrations of nicotine at home. *Indoor Air* 14:83–86.

Wong, G. C., Berman, B. A., Hoang, T., Bernaards, C., Jones, C., and Bernert, J. T. 2002. Children's exposure to environmental tobacco smoke in the home: comparison of urine cotinine and parental reports. *Arch. Environ. Health* 57:584–590.

Woodruff, S. I., Conway, T. L., Edwards, C. C., and Hovell, M. F. 2003. Acceptability and validity of hair collection from Latino children to assess exposure to environmental tobacco smoke. *Nicotine Tobacco Res.* 5:375–385.