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Exposure to Environmental Tobacco Smoke among Infants in Southern Thailand: A Study of Urinary Cotinine

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Abstract We performed a survey to assess the exposure to environmental tobacco smoke (ETS) in 1-year-old infants in Thailand. Of the 725 infants, it was reported that 73.3% had household smoking and 40.7% had detectable urinary cotinine. Twenty-five infants (3.4%) had urinary cotinine in the range of adult heavy smokers. The prevalence of ETS exposure was significantly higher in infants with a father whose education was ≤ grade 6 than in those with father's education >6 years (44.0% vs. 36.0%, $p = 0.039$). Data on the exposure to ETS among infants will provide prevalence information and identify population subgroups at increased risk for exposure.

Keywords Environmental tobacco smoke · Cotinine

Exposure of infants to environmental tobacco smoke (ETS) is associated with an increased risk of several respiratory illnesses (Margolis et al. 1997). Previous studies have demonstrated that ETS exposure can begin as early as the first year of life (Greenberg et al. 1989, 1991; Mascola et al. 1998). This observation, however, was from a western population, in which prevalence of maternal smoking is generally much higher than in Asian countries. In Thailand, for instance, the prevalences of smoking among males and females over 15 years of age were 48.5% and 2.9%, respectively (National Statistics Organization of Thailand 2001). There has been no previous study attempting to assign some reliable figures for ETS exposure among infants in Thailand, however, so this study was undertaken to assess the extent of exposure to ETS in infants in southern Thailand by both interviewing the mothers and studying the infants' urinary cotinine, a metabolite of nicotine.

Materials and Methods

The data for this study were collected as part of the larger "Prospective Cohort Study of Thai Children (PCTC)". The PCTC is an ongoing, observational community-based study begun in the year 2000. The birth cohort, born over a 1-year period in five selected sites in different regions of Thailand, will be observed and followed up longitudinally until they reach the age of 24 years. In this specific paper, because of the very high cost of cotinine analysis, we decided to perform the cotinine survey only in The-pa district in Songkhla province, a rural area. This area is demographically representative of southern Thailand, and also close to Prince of Songkla University where cotinine assays could be performed. Eligible infants were all infants who were born over the 1-year period of the study, from November 2000 to October 2001. The typical ETS exposure situation is that the parents who smoke usually smoke in the same room as the infants due to limitations of space in the home, however, the normal rural home style in Thailand is a single dwelling separate from other homes

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and well ventilated with many windows, which would tend to modify exposure to ETS.

Well-trained data collectors made visits and interviewed the primary care takers of all eligible infants at their homes when the infants were approximately 1-year of age. The information obtained included parental age, religion, education, occupation, household income, household smoking in the same room as the infant in the preceding week. Urine samples for cotinine and creatinine were collected from all infants within 2 weeks following the interview. The samples were transported in an ice chest to the study office, where they were immediately stored at −20°C until being further transported to the laboratory of the Department of Pharmaceutical Chemistry, Faculty of Pharmaceutical Sciences, Prince of Songkla University, Songkhla, Thailand. Concentrations of urine cotinine were measured by high performance liquid chromatography (LC-10A Shimadza, Japan) according to methods reported previously (Ceppa et al. 2000). The detection limit was 0.5 ng/mL. The cotinine assay methods produce comparable results with the methods as described by Ceppa et al. Urinary creatinine was also measured to correct for dilution of the urine.

Statistical analysis was carried out using Intercooled Stata 8 software (Stata Corporation). We evaluated the urinary cotinine as a biomarker of either ETS exposure or non-exposure. The association between several potential predictors of detectable urinary cotinine was investigated. The Chi square test was used to compare the percentage of infants who had been exposed and not exposed to ETS across various categories and logistic regression was used to evaluate the net effect of the variable on ETS exposure while adjusting for the other factors. The continuous variables, paternal age and household income were compared with the Wilcoxon rank sum test.

This study was approved by the National Ethics Committee of the Ministry of Public Health of Thailand, as part of the larger PCTC. All families were clearly informed of all study procedures and possible risks before signing the informed consent form.

Results and Discussion

From the 1,076 infants eligible to participate in the study, urine samples were obtained from 725 (67.4%). Of these, 54.2% were boys. The missing group had no significantly different characteristics (sex, father smoked, parental education, occupation, religion and income) from the subjects who provided a urine sample. The average age of the fathers was 31.9 ± 7.5, range 18–64 years and the average age of the mothers was 27.7 ± 6.4, range 15–46 years. The paternal religions were Buddhist (34.2%) and Muslim (65.8%). Thirty-six percent of the fathers and 33.9% of the mothers had greater than 6 years education. The paternal occupations were agriculture 20.0%, business 8.3%, professional 4.0%, labor 66.0% and not employed 1.7%. Mean household income per year was US$ 2,149.9 ± 1716.4, range 0–12,950.

A total of 532 (532/725; 73.3%) of the infants were reported to have household smoking in the same room as the infant during the week before the data collection. The number of smokers in the households ranged from 1 to 7 persons. Prevalences of father and mother smoking with the infant present were 63.6% and 0.41% respectively. The prevalence of father smoking was significantly higher in infants with a father whose education was grade 6 or under when compared to those with father's education greater than 6 years, 67.9% vs. 57.4%, $p = 0.006$.

Of the 725 infants, 295 (40.7%) had detectable urinary cotinine which ranged from 1.1 to 4,293 with a mean value of 55.1 ± 260.3 and median of 11.9 ng/mL. Twenty-five infants (25/725; 3.4%) had urinary cotinine in the range of adult heavy smokers (>100 ng/mL). When cotinine values were adjusted with creatinine, the mean value was 236.9 ± 556.2, median of 60.0 and range of 2.2–6431.1 ng/mg. The prevalence of ETS exposure, as determined by detectable urinary cotinine, was significantly higher in infants with a father whose education was grade 6 or under than in those with father's education greater than 6 years (44.0 vs. 36.0%, $p = 0.039$). This remained significant after adjustment with parental age and income, (odds ratio1.3, 95% CI 1.1–1.9). There was no significant association between ETS exposure and history of household or father smoking, father's age, religion, occupation or household income (Table 1).

This study was performed to examine ETS exposure in a sample of infants in southern Thailand. We found that the prevalence of reported household smoking in the same room as the infant in the preceding week was very high. The prevalence of father smoking was 63.6%, which is higher than an earlier study covering all of Thailand performed in 2001, which found the prevalence of smoking among males over 15 years was 48.5%, while maternal smoking in our study (0.41%) was lower than in that report (2.9%) (National Statistics Organization of Thailand 2001). These differences may be because smoking prevalences vary in different regions of Thailand as well as among different age groups.

Urinary cotinine was used as the objective measurement of ETS, although one limitation was that we obtained a urine sample from only 67.4% of the subjects. We found that 40.7% of the infants had detectable urinary cotinine and 3.4% had urinary cotinine higher than 100 ng/mL, a cut off point that has been previously described as the range of an adult heavy smoker (Dell'Orco et al. 1995).

Table 1 Infant's urinary cotinine in association with smoking in household and paternal characteristics (n = 725)

Variable*	Urinary cotinine		*p***
	Detectable (n = 295)	Not detectable (n = 430)	
Household smoking, n (%)			
Number of smokers in home			
0	83 (28.1)	108 (25.2)	0.34
1	150 (50.8)	240 (56.1)	
>1	62 (21.0)	80 (18.7)	
Father a smoker	188 (63.5)	272 (63.7)	0.96
Paternal characteristics			
Age, median, year	31	31	0.71
Education, n (%)			
≤6 years	196 (68.5)	249 (60.9)	0.039
>6 years	90 (31.5)	160 (39.1)	
Religion, n (%)			
Buddhist	90 (31.6)	149 (36.1)	0.22
Muslim	195 (68.4)	264 (63.9)	
Occupation, n (%)			
Non-professional	273 (95.5)	399 (96.4)	0.54
Professional	13 (4.5)	15 (3.6)	
Household income per year, median, US$	2,147	2,149	0.61

*Totals may vary because of missing values

***p*-values based on the chi-square or Wilcoxon rank sum test

Infant exposure to ETS in our study should not be considered as representative of ETS exposure in Thailand overall without further studies because, as noted above, the prevalence of household smoking as well as the typical residence varies among different regions of Thailand. Our findings have emphasized, at least in one district of Thailand, on biochemical confirmation of ETS exposure among infants as a means to objective measurement of actual ETS exposure.

A previous study by Mascola et al. (1998), who performed a urinary cotinine study in infants, showed a maximum level of cotinine of 15,200 ng/mg. However, they did not show the prevalence of the infants who had urinary cotinine level in the range of an adult heavy smoker. In our study, the maximum level of cotinine was 6431.1 ng/mg which was lower than that of Mascola's study. We cannot conclude the sort of exposure in the infants who had high urinary cotinine level because of limitations in the data regarding amount and duration of smoke exposure and home ventilation. In Mascola's study, they found an association between high cotinine level and maternal smoking.

Greenberg et al. (1989, 1991) performed a study in 3-week-old infants in North Carolina, and found that 53% had detectable urinary cotinine. At 1-year of age, a follow up study was performed in the same children, and a large increase in the prevalence of detectable urinary cotinine was found, 77%. The prevalence of detectable urinary cotinine in our study was lower than those studies in infants in North Carolina, which may be due to the fact that the prevalence of maternal smoking was quite low in our study while in those studies, the prevalence was higher than 20% which may have contributed to a higher prevalence of detectable urinary cotinine.

A study from the United States found that of children aged 2 months to 11 years, 43% lived in a home with at least one smoker, and 87.9% of non-tobacco users had detectable levels of serum cotinine (Pirkle et al. 1996). Our study found a lower prevalence of detectable urinary cotinine (40.7%) in the infants than in that study. The difference in findings may be due to the different age of the study populations, as older children might be exposed to environmental smoke from both within their own household and from non-household sources.

Our result on reported household smoking (73.3%) and father smoking (63.6%) was higher, while the prevalence of detectable urinary cotinine (40.7%) was lower, than a report of the World Health Organization (WHO 1999) which has estimated that almost half of the children in the world are exposed to ETS, mostly in their homes. Although the prevalence of detectable urinary cotinine in our study was lower than might be expected from the rate of reported smoking, this should not be misinterpreted as an indication that it may not be harmful for adults to smoke near infants, as there are several modifying factors that affect a cotinine study.

The determinants of ETS exposure have been studied and it has been found that number of smokers, parental

smoking and the amount of cigarettes smoked were potential predictors. (Mascola et al. 1998; Dell'Orco et al. 1995; Pirkle et al. 1996). We could not evaluate with certainty the correlation between the history of ETS exposure with cotinine because we had a limitation in that the answering of the tobacco questions and the acquiring of the urine sample were not done simultaneously. Since cotinine has a short half-life in the body, only very recent ETS exposure is indicated by the test. Most results from the literature have shown an association between cotinine and reported exposure, however, these studies also involved an extensive questionnaire survey regarding smoking questions, e.g., amount of cigarette smoking, duration of exposure, number of smokers, distance between infants and smokers, home ventilation, etc, and importantly, urine collection and smoking questions were done simultaneously (Mascola et al. 1998; Dell'Orco et al. 1995; Pirkle et al. 1996). Peterson et al. (1997) performed urinary cotinine measurements in a population-based cohort of children every other month from birth to 2 years of age. Using multiple cotinine measurements as the gold standard, they found that when comparing a single cotinine measurement to the average of multiple measurements, there was an error in excess of 100 ng/mg in 33.7% of the infants. The finding in our study which showed no association between reported smoking and cotinine may be due to the error of single point measurement as explained by Peterson's study. To obtain an accurate estimate of the amount of ETS exposure overtime, multiple cotinine measurements would be necessary, however, a single point measurement can be adequate as a simple indicator variable of ETS exposure in epidemiologic study.

We found that the factor significantly associated with ETS exposure in infants was a paternal education of or less than grade 6. This finding was similar to another study in a sample of children and adolescents in Italy (Dell'Orco et al. 1995). One reason that may help explain this finding is that active smoking is more common in parents with low educational background. In our study, we found that the prevalence of father smoking was significantly higher in infants with a father whose education was grade 6 or under than with those with paternal education greater than 6 years.

In conclusion, these results demonstrate infant exposure to ETS, as determined by reported smoking and urinary cotinine levels, in southern Thailand. The finding at least once of detectable urinary cotinine in 40% of the infants should be considered as evidence that future interventions could usefully target infant exposure to ETS. To reduce ETS exposure, health professionals should provide educational sessions for parents about potential adverse health effects on infants exposed to ETS, such as an increased frequency of lower respiratory illnesses (Margolis et al. 1997), and parents should be encouraged to develop methods to reduce their infants' exposure. The development of future research for an intervention program that could reduce the amount of ETS exposure among infants of smoking parents is recommended.

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