A Cross-sectional Study of Secondhand Smoke Exposure among Non-smoking Women and Children in Thai Households

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Abstract

Exposure to secondhand smoke (SHS) among women and children indoors is a problem both in urban and rural environments. This study aimed to describe SHS exposure by women and children in Thai households. It is the first study of its kind in Thailand to characterize levels of nicotine in the air of homes with smokers and the extent of personal exposure to nicotine among women and children living in homes with smokers in urban and rural environments. A cross-sectional survey of nicotine exposure of 40 pairs of adult nonsmoking women and children in households with and without smokers was conducted using a questionnaire, passive air monitors, and hair samples of women and children in Bangkok and rural Mukdaharn. Questionnaire data were represented descriptively, while environmental (passive samplers) and metabolic samples (hair nicotine) used established laboratory analysis and statistical measures of association with smoke exposure. Data were analyzed and reported as percentages, means, medians, interquartile ranges, and from skew and $\log^{-10}$ transformed data for Pearson correlation coefficient analysis. Attention was given to results for insight to how exposure results differed between household locations (urban versus rural) and persons exposed (non-smoking adults versus children). Most smokers (81.8%) smoked inside the house and near their children. Hair nicotine level in women and children showed exposure to SHS. Hair nicotine levels among children were significantly higher than the women ($p=0.038$). Exposure to SHS was present with high levels of hair nicotine among women and children in both rural and urban environments when smoking was present. SHS exposure warrants increased attention due to the potential harm to non-smoking women and children reflected in these findings.

Keywords: Secondhand smoke/women and childeren/nicotine in hair and air/urban / rural
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1.Introduction

The exposure to secondhand smoke (SHS) has become a great concern after it was mentioned in the US Surgeon General's report in 1972. The chemical constituents of SHS include nicotine, respirable particles, carbon monoxide, nitrogen dioxide, heavy metals, and many other substances resulting from tobacco smoke. Women and children are most vulnerable to harmful exposures from SHS and are often trapped in situations which make their exposures frequent and extremely high. For example, exposures before, during and after pregnancy are often occasions that are of particular concern since both the woman and her fetus/child often cannot avoid smoke exposure and are unnecessarily exposed in the home. In Asia, where smoking in the home among males is still quite common, substantial research has shown that both women and children suffer and die unnecessarily due to disease caused by these exposures.[1](U.S. Department of Health and Human Services,2016).

Women in countries where males commonly smoke in the home suffer from cancer, respiratory and cardiovascular conditions in higher numbers. In a 2007 study in China, for example, the number of women who died from secondhand smoke related lung cancer actually exceeded the number that died from lung cancer from active smoking.[2](Gan Q,2002). The first major study of lung cancer among women from SHS exposure was the Hirayama study of women in Japan in 1981[3](Hirayama T.,1981). Three decades of studies since then have revealed the dramatic toll women have endured through exposure resulting in cancers, respiratory and cardio-cerebrovascular diseases, but also adverse effects on fertility and reproduction. Children are even more vulnerable because they are involuntarily exposed even before birth and are devastatingly impacted during development, in infancy and their early years, now understood to be associated with many health impacts in later life(Protano C et al.,2012). Recent research shows that these early exposures result in both immediate respiratory effects in children such

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as lower respiratory infections, middle ear disease, cough, phlegm, wheeze, asthma, and later developmental consequences.(U.S. Department of Health and Human Services,2016:5-6).

Several constituents of cigarette smoke have been measured to assess indoor exposure to secondhand smoke (SHS). SHS is commonly defined as the combination of smoke emitted from the burning end of a cigarette or other tobacco products and smoke exhaled by the smoker. For measuring SHS in real time in public facilities like airports, particulate matter is a common indicator of smoke pollution.(Peesing,J.et al.2015) However, nicotine has been most widely used for exposures over time because of its specificity. Nicotine is not present in the air in the absence of tobacco smoking; however, it can be directly measured in human hair. Hair nicotine is a biomarker used for exposure to SHS over a longer duration of time. It is more practical to handle and manage this kind of sample than urine, saliva or serum. In addition, the cost of taking the sample, materials and equipment for storage and transportation is lower for hair nicotine.

Although some research has been done in Asia, few studies have been conducted in Thailand on the circumstances and consequences of home SHS exposures of women and children (Sritippayawan S et,2006;Ostrea,Em Jr,2008).The aim of this study is to describe SHS exposures by women and children documented through a questionnaire, environmental monitoring of air nicotine and a metabolic measure, hair nicotine, a now commonly used measure to assess long term exposure to SHS.

2. Methodology

2.1Participants

A convenience sample of 40 homes was selected, 20 in the Bangkok Metropolitan area and 20 in the rural area of Mukdaharn, a province in northeastern Thailand. Urban homes in Bangkok were located in low-income housing areas while rural homes were in a village. Information about each household including its construction material and ventilation was collected. Each home included had at least one child younger than 10 years of age. "Smoking households" constituted 80% of households and were defined as households with at least 1 smoking male who currently was living in the household with a female adult and child during the study period; with 20% "non-smoking households" as specified by Wipfli et al.(Wipfli H,et al,2008).

2.2 Measures for SHS Exposures

A cross-sectional exposure survey using area monitors and biological samples was performed. The subjects were 40 adult nonsmoking women and 40 children. There were 3 research tools: 1) A questionnaire, adapted from Wipfli et al was translated into Thai, and checked for translation accuracy independently by 3 researchers with final translation agreed by consensus. The information collected was in three areas: smoking status, secondhand smoke exposure, and household and subject characteristics. Household adults were asked about smoking attitudes and behaviors in the household and understanding/support for tobacco control policies; 2) In each household, the area where family members most often congregated was identified. Passive air monitors were then placed at adult height in that area, and left untouched for 7 days to measure air nicotine; air nicotine collection by passive sampler cartridges is an accepted method developed for monitoring secondhand smoke exposure.(Hammond S. & Leaderer B.,1987). The nicotine analysis by gas chromatograph is described in detail elsewhere, (Wipfli et al, 2008) and 3) about 30-50 strands of hair within 3 cm. of the hair root was cut from the head of female and child subjects for hair nicotine analysis; hair samples were then carefully packed and sealed in plastic bags with clear labels and shipped for analysis. Nicotine in hair was extracted using an isotope dilution method modified from that developed by Kintz P.(1992) with analysis by gas chromatography and mass spectrometry as described in detail elsewhere.(Wipfli et al, 2008). Information about chemical treatments of the hair was also recorded and sent with each sample for possible exclusion by the analyst if necessary. Both air and hair samples were transported to be analyzed for nicotine content in the laboratory at the Bloomberg School of Public Health, Johns Hopkins University, USA(Kim S.et al.,1992).

2.3 Statistical Analysis

Household and subject characteristics, smoking status, and exposure to secondhand smoke were analyzed by the Thai researchers, using descriptive statistics such as percentages, means, medians, and interquartile ranges. Hair and air nicotine concentrations were skew and $\log^{-10}$ transformed for statistical analysis. Pearson correlation coefficient was the statistical method employed to examine differences in SHS levels as air nicotine and hair nicotine among women and children; also in smoking versus non-smoking households for women and children. Ethical clearance for all aspects of this study was obtained by the Johns Hopkins research team, H.34.04.11.05.A1.

3. Results

3.1 Household and subject characteristics

There were 40 homes surveyed with an average family size of 4.7 persons (range 3-9). About two-thirds (60.0%) of housing types were single homes, then duplex (35.0%), and shacks (5.0%). As for construction materials, 27.5% are concrete, 17.5% are stone or brick, and 55.0% are wood. Characteristics of adults provided through questionnaire in thisstudy are shown in Table 1.

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Table 1 Characteristics of adult subjects from questionnaire (n=80)

Characteristics	n	Percent
Sex		
Female	40	50.0
Male	40	50.0
	$\bar{x}$± SD = 39.8 ± 11.0	
	min – max = 16 - 78	
Education		
None	2	2.5
Primary School	48	60.0
Secondary School	24	30.0
College and above	6	7.5
Occupation		
Unemployed	12	15.0
Employed	68	85.0
Farmer	30	37.5
Government employees	10	12.5
Wage workers	8	10.0
Others	20	25.0
Smoking status		
Never smoke (M = 8.8%; F = 43.2%)	42	52.5
Current smoke (M = 38.7%; F = 2.5%	33	41.2
Former smoke (M = 2.5 %; F = 3.8%)	5	6.3
Smoker per home		
None	14	17.5
1 Smoker	52	65.0
≥ 2 Smokers	14	17.5
Types of tobacco used		
Filtered cigarette	44	54.6
Hand-rolled tobacco	34	42.4
Pipe tobacco	2	3.0

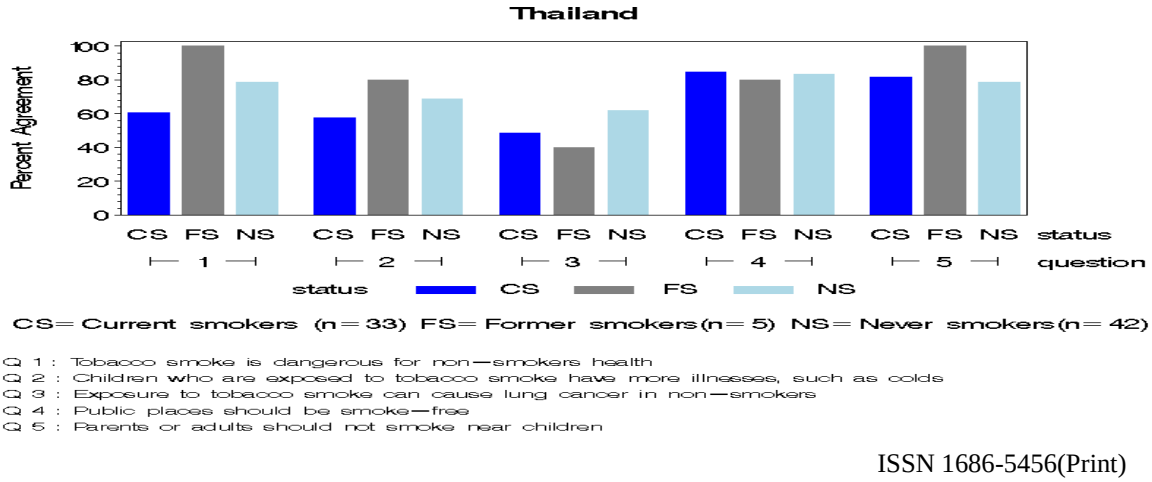
Among smokers, 72.8% reported smoking 1-10 cigarettes/day, 18.1% smoked 11-20 cigarettes/day, and 6.1% smoked >20 cigarettes/day with an average of 9.1 cigarette smoked/day (SD=7.9, range 1-30). In addition, there were 40 children under the age of 10 with an average age of 4.3 years (SD = 2.6, range 3 months-10 years). Approximately 62.5% (25/40) of children were SHS exposed in their home with home exposure of 15.4 hours/day (SD=3.3, range 10-24 hours). Thirty percent of mothers (12/40) reported outdoor exposure averaging 4 hours/day (SD=2.5, range 1.5-10 hours).

3.2 Adult subjects' beliefs, attitudes, and behavior

3.2.1 Beliefs and Attitudes

Figure 1 shows that 60.0% of current smokers perceived that tobacco smoke is dangerous to non-smokers health and that children exposed to SHS have more illnesses. Most of them (85.2%), felt that smoking should not be allowed in public places and parents or adults should not smoke near children. Half of current smokers (50.5%) believed that non-smokers exposed to tobacco smoke can get lung cancer.

Figure 1. Beliefs and Attitudes by Smoking Status



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3.2.2 Behavior

Most smokers (81.8%) smoked inside the house and when their children are present. Some 63.8% of non-smokers reported being exposed to tobacco smoke in their home from their spouses (40.4%), other household members (10.6%), and others (12.8%). As well, non-smokers reported being exposed to tobacco smoke in many other places: government worksites (29.0%), private worksites (24.2%), school/educational facilities (19.4%), transportation vehicles (21.4%), waiting rooms and bus stations (52.9%), restaurants/bars (77.8%), and in the homes of others (70.7%).

3.2.3 Nicotine in the air

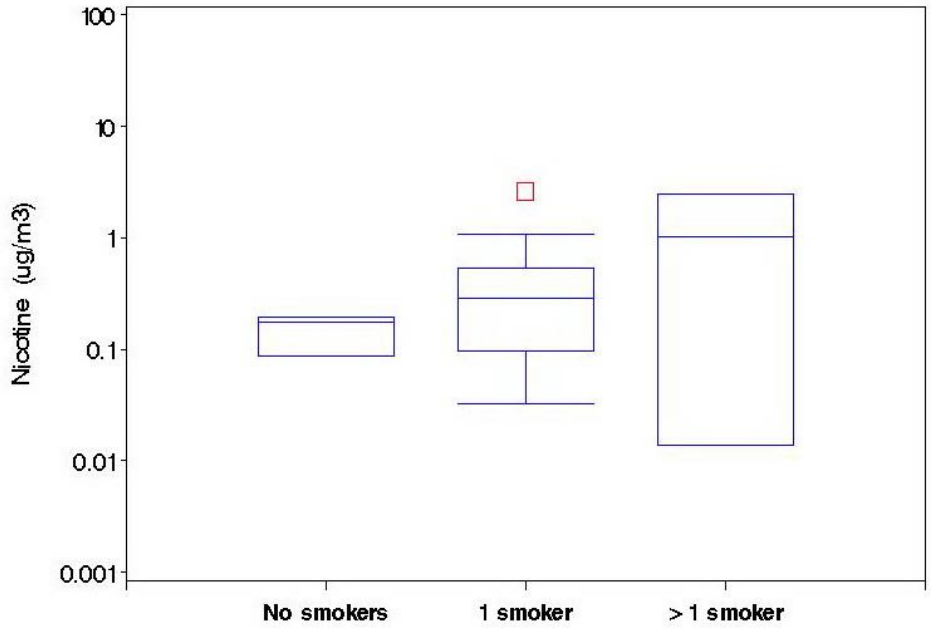
Smoking was permitted in 65.0% of the rooms in the households where the air monitors were placed. About 32.5% of air monitor results (17/40) were below the level of detection (0.005 $\mu g/m^3$) and 13 of them were in households where smoking was allowed in the home. In the remaining homes (23/40: 3 = non-smoking, 20 = smoking), the nicotine levels ranged from 0.0138 to 2.622 $\mu g/m^3$. The distribution of nicotine levels in non-smoking households and households with at least one smoker was not statistically different (p=0.31) and the nicotine levels in the air were not associated with the number of smokers in households (Table 2 and Figure 2). There was no statistically significant difference between rural and urban findings.

Table 2. Levels of nicotine in the air and hair

Air Nicotine ($\mu g/m^3$)	N	*P50	*P75	*P90
All houses	40	0.04	0.29	0.84
Non-smoking household	7	0.002	0.17	0.20
Smoking	33	0.05	0.43	1.03
Hair Nicotine (ng/mg)	N	*P50	*P75	*P90
Women	40	0.55	1.45	5.40
Children	39	1.22	3.48	10.45

*Percentile (P50, P75, P90) indicates the value below which a given percentage of observations in a group of observations fall. For example, the 90th percentile is the value below which 90 percent of the observations may be found. So, 50%, 75%, and 90% are the values below which 50%, 75%, and 90% observations are found.

Figure 2. Levels of Nicotine in the Air: Log 10 Scale



3.2.4 ***Nicotine in the hair***

Hair nicotine levels among children were significantly higher than for women (p=0.038). By comparison, levels of hair nicotine in children of smoking households were higher than in those living in non-smoking households and also higher than in women residing in smoking households. Hair nicotine levels in women residing in houses with one smoker were higher than those in women who lived in non-smoking households. Only one woman and

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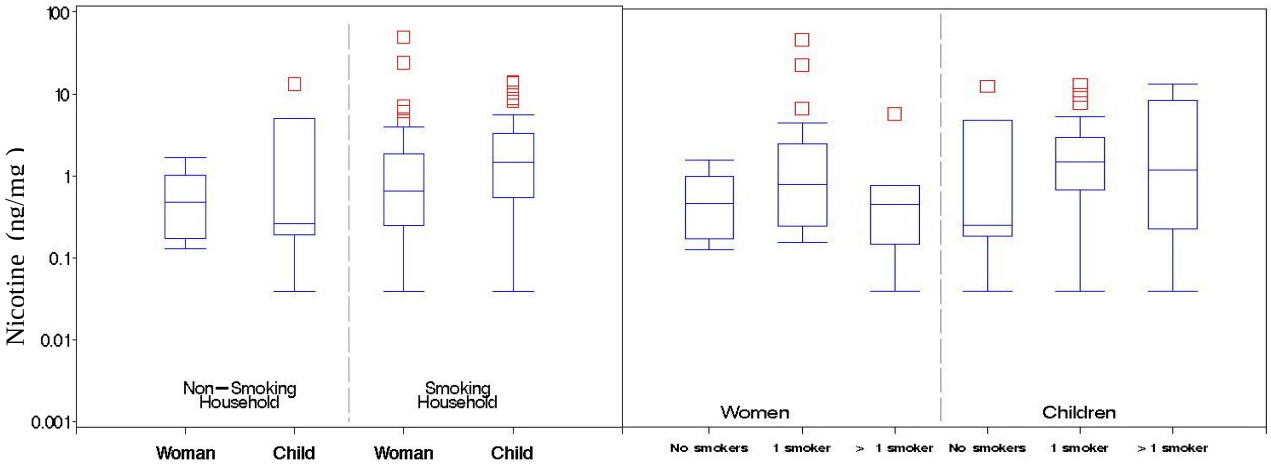
three children had levels of hair nicotine below the limit of detection (0.17 ng/mg) (Figure 3).

There was no statistically significant difference between rural and urban findings.

Figure 3. Range of hair nicotine results for women and children, and in smoking versus non-smoking households



4. Discussion

Our findings show that the children living with smokers have higher levels of hair nicotine compared to those adults living with non-smokers. The presence of hair nicotine can be explained only by their exposure to SHS. This biomarker has the advantages of detecting prolonged exposure, with each centimeter of hair length representing one month of exposure(Kintz P.,1992;Al-Delaimy,2002). Moreover, these children, who lived with smokers, had greater hair nicotine levels compared to the women who were living with smokers as well. The difference was found to be statistically significant with a p-value of 0.038. This may be attributed to a number of factors including lower Body Mass Index (BMI), nicotine uptake, and metabolic differences between children and women.(Wipfli H. et al., 2008; Benowitz,1999). As expected, women living in smoking households had higher levels of hair nicotine than those living in non-smoking households. However, an analysis of the results from the nicotine monitors showed no relation with the number of smokers in the household and the level of nicotine in the air. This may have been due to monitor placement since 13 of the smoking households were below the level of detection. Hence, the difference of air nicotine levels in non-smoking households and households with at least one smoker were not found to be statistically significant (p=0.31).

The variation in the results could be due to a number of confounders. The results show that both women and children living in houses where smoking was permitted had substantial levels of hair nicotine. However, the air nicotine monitors did not record a high enough level to reach the level of detection, in either urban or rural environments. The level of nicotine in the air varies with the number of smokers, intensity of smoking, rate of exchange between the indoor and outdoor air, and the use of air-cleaning devices (Repace JL,1985). However, no data was collected on the use of air-cleaning devices which are not common in Thai households. The type of housing and the construction material of the houses could have played a role in the exchange of indoor and outdoor air. About 55% of the houses were made of wood, 40% in rural and 15% in urban settings, which may have allowed for better ventilation than brick or stone houses (Seong MW et al,2010). Many households kept windows and doors open so smoke could rapidly disperse by natural ventilation. Furthermore, the women and children might have been exposed to SHS outside their homes. Only 22.7% of the workplaces of women had no smoking policy. This might have led to the hair nicotine findings for women. Children could have also been exposed to SHS outside their homes. A father who carries a child while smoking outside the house can expose him or her to SHS (Charoenca N. et al., 2013;IARC,2004).

The major limitation of this study was that it was designed to collect limited situational and SHS data with a small sample of Thai households. Thus, results presented are based on descriptive results from a questionnaire and the analysis from two SHS measures that are related to long-term SHS exposures as in households. Variables considered for association come from smoking households and the environmental and metabolic measures of SHS over long periods, as in households (not real time exposure measures which are monitored over minutes and hours). Although more complex analysis needs to be done, we present these important initial results to show the way for further investigation.

A recent qualitative systematic review of barriers to smoke-free housing notes the complexity of household smoking behavior and

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that many "practical, social, cultural and personal issues" of households must be considered.(Passey, ME et al,2016). Our findings provide initial information of variables and methods that could be important in future investigations leading to interventions for smoke-free homes. For example, investigating which smokers in a household are most important to high exposure levels in the home, and how hair nicotine might be used in future studies given the problems with undetectable levels from passive samplers in Thai households are considerations that arise from our results.

5. Conclusions

This study shows exposure to SHS is very high in smoking households in Thailand (81% of adults smoke indoors) resulting in high levels of hair nicotine in women and children. Although outside air quality is often better in rural settings, there was no statistically significant difference in indoor SHS exposure between urban and rural settings. The route of exposure, whether indoors or outdoors, needs to be monitored closely in order to make the right regulatory and economic policies to minimize exposure to SHS, especially for women and children. These exposures are known to contribute to immediate, short-term effects and cancer and other diseases later in life. Further, biomarker studies should be undertaken to investigate these relationships. Because childhood SHS exposures leading to disease have not received sufficient attention, studies highlighting the economic burden of childhood SHS as completed in other countries are needed to bring greater attention to action for smoke-free homes in Thailand (Wendy M,2014).

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