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Who lives in the same households as smokers? Evidence from a full household survey in Ningbo, China

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B.S.
Sun Yat-sen University
2011

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Abstract

Who lives in the same households as smokers? Evidence from a full household survey in Ningbo, China

By

Wei Xiong

Background. Secondhand smoke (SHS) exposure in the home is a major cause of ill-health, especially among those exposed to SHS due to living with smokers. Evaluations of nicotine concentrations and individual surveys are the two commonly used methods to estimate exposure to SHS at home.

Objective. Conduct a survey to describe the characteristics of all household members of a random sample of households to estimate the prevalence of SHS at home and identify the specific characteristics of households with smokers.

Methods. A sample of 1120 households from Ningbo, China was selected using a multi-stage stratified sampling method. Demographic information and smoking status of all residents in each selected household was obtained and the prevalence of SHS exposure among those who live in these homes was estimated. Conditional logistic regression models were used to examine the association between household characteristics (number of adult males and females, number of children, income level, etc) and SHS exposure status.

Results. Among the 1120 surveyed households, 566 (50.5%) had one current smoker and 72 (6.4%) had two or more current smokers; 706 of the 720 identified smokers (98.1%) were male. Overall, 57.5% of non-smoking women, 64.1% of non-smoking children under 18, and 63.2% of non-smoking children under 7 were exposed to SHS in home. Among the 638 households with current smokers, 569 (89.2%) of them also had non-smoking females, 246 (38.6%) of them had non-smoking children under 18, and 98 (15.4%) of them had non-smoking children under 7. Households with smokers were not different from households without smokers in terms of income and wealth, the presence of children in the home or the mean age of the adults in the home. Smoking households had more male household members than non-smoking households; after controlling for the number of males, non-smoking households had longer mean years of education among adult residents.

Conclusion. SHS exposure in the homes of women and children in urban China is a major public health problem that exists in almost all types of households. It indicates that a comprehensive tobacco control program targeted on household exposure to SHS is urgently needed.

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Chapter 1: Introduction

The presented study is a part of the China Tobacco Control Partnership Program (CTCP) between Emory University and a non-governmental public health consortium (the 'Think Tank') in Beijing. The CTCP Program is an ongoing project that aims to implement comprehensive tobacco control programs in 17 cities in China. The goal of the baseline survey, of which the data used in this thesis is a part, is to document the smoking practices in 17 cities before implementing site-specific tobacco control policies and interventions. Specifically, the data used here were retrieved from the baseline survey conducted in the city of Ningbo (shown in Figure 1), which is a relatively prosperous city located on the east coast of China. The data collection in Ningbo was coordinated and conducted by Professor Michael Phillips and his team from the Shanghai Jiao Tong University in cooperation with the local sponsoring institution (i.e. the Ningbo Center of Disease Control and Prevention). As a fellow from Emory University who joined the research team led by Dr. Phillips, I was authorized by Dr. Phillips to access and use the baseline survey data of Ningbo to conduct a secondary data analysis and to report the findings.

The baseline survey is a comprehensive assessment of Knowledge, Attitudes, and Practices related to tobacco use. As shown in Figure 2, the full household survey was originally used for selecting one adult household member to be the subject of the detailed individual survey. However, since the full household form (shown in Figure 3) collected basic demographic information and smoking behavior of all residents in every

household, it provides a unique opportunity to estimate the exposure to secondhand smoking (SHS) within these households. By looking into the household structure and the tobacco use of each member, we can achieve a better understanding of the sources of smoking in homes and how extensively people, especially children, are exposed to SHS at home.

Therefore, the purpose of this particular data analysis is to assess the prevalence of SHS at home in Ningbo and to explore the use of brief household surveys to understand the household factors that are related to and SHS at home.

Chapter 2: Literature Review

2.1. Secondhand smoking (SHS)

During the smoking of cigarettes, pipes, and other tobacco products, a stream of smoke is released between puffs into the air from the burning cone. Once released, this stream is mixed with exhaled mainstream smoke as well as the air in an indoor environment to form the secondhand smoke (SHS) to which both smokers and nonsmokers are exposed[1]. Thus, secondhand tobacco smoke is composed of aged exhaled mainstream smoke and diluted sidestream smoke. SHS is actually a complex mixture, containing many compounds the concentration of which varies with time and environmental conditions[1]. Cigarette smoking is the main source for SHS exposure[1]. Compared to mainstream smoke, sidestream smoke from cigarettes is released at lower temperatures and at lower dilutions, so it tends to have higher concentrations of many of the toxins[2]. The median particle size of sidestream SHS is subsequently smaller than that of the particles of mainstream smoke[1]. Comparisons between smoking and nonsmoking locations revealed up to a threefold higher concentrations of respirable suspended particles in smoking areas; these are the particles that are small enough to reach the lower airways of the human lung[1]. In those smoking locations, there are also considerably increased levels of nicotine, carbon monoxide (CO), benzene, and other tobacco toxins[1].

2.2. Health effects of SHS

The WHO Framework Convention of Tobacco Control (FCTC) stated 'there is no safe level of exposure to tobacco smoke'[3]. Exposure to SHS places adults and children at increased risk of premature death and a range of other health outcomes, including diverse serious cardiovascular diseases, respiratory diseases, and cancers[4]. The harmful effects of second-hand smoke (SHS) have been recorded since 1928[5]. Evidence about ill health resulting from SHS has accumulated from a number of studies from all around the world. Knowledge about the links between second-hand smoke and specific diseases has been summarized in comprehensive assessments or reviews by the International Agency for Research on Cancer[1], World Health Organization (WHO)[6], Scientific Committee on Tobacco in the United Kingdom[7], US National Research Council[8], US Environmental Protection Agency[9], California Environmental Protection Agency[10], and the US Surgeon General's office[11].

More than 50 carcinogens have been identified in sidestream smoke and SHS. Since 1986, there has been conclusive evidence of the harms of these carcinogens based on evidence from epidemiologic studies and clinical studies. Scientific evidence has unequivocally established that exposure to tobacco smoke causes death, disease, and disability[1]. Exposure to SHS causes a significant increase in urinary levels of metabolites of the tobacco-specific lung carcinogen and increases risk for lung cancer in nonsmokers[1]. The evidence is also sufficient to infer that exposure to SHS has a prothrombotic effect and causes endothelial cell dysfunctions, which leads to atherosclerosis and heart diseases[1].

Tobacco smoking has primarily been a custom and addiction among men, leaving women and children as the majority of the world's passive smokers[12].

2.2.1. Adverse health effects of SHS exposure on women

Exposure of adults to SHS has immediate adverse effects on the cardiovascular system and is associated with higher risk of coronary heart disease and lung cancer. Evidence is sufficient to infer a causal relationship between exposure to SHS and increased risks of coronary heart disease morbidity and mortality among both men and women[13]. Pooled relative risks from meta-analyses indicate a 25-30% increase in the risk of coronary heart disease from exposure to SHS[13].

It's also established that the risk of lung cancer for nonsmoking women with spouses who smoke is higher than that of those whose partners don't smoke[14,15,16,17,18]. Moreover, in some of the studies, the relative risk was found higher with increasing years of exposure[17] and amount of exposure[16], which indicates an exposure-response relationship. For instance, in the study conducted by Cardenas et al., when the husbands smoked 1-19, 20-39 and >39 cigarettes per day, the relative risks of developing lung cancer for women exposed to SHS were 1.1, 1.2 and 1.9 respectively, with a significant trend test ($p=0.03$)[16].

Increased risk of breast cancer was also found associated with husbands' smoking status in several studies[16,19,20] with relative risks rang from 1.2 to 3.1, but the findings are contradictory and inconclusive overall.

2.2.2. Adverse health effects of SHS exposure on children

Exposure to SHS has also been found to be a cause of sudden infant death syndrome (SIDS), slightly reduced birth weight, lower respiratory illnesses such as pneumonia and bronchitis, chronic respiratory symptoms such as coughing and wheezing, middle ear disease, reduced lung function, neurobehavioral impairment, as well as cardiovascular disease in later adulthood[6]. A series of systematic quantitative reviews have summarized and established that children raised in homes with smokers are at much higher risk of health problems related to SHS, predominantly middle ear disease and respiratory illnesses/symptoms[21,22,23]. Moreover, Childhood cancers including brain tumors, leukemia, lymphomas and other cancers have also been investigated among children exposed to SHS. The pooled estimate of the relative risk of any childhood neoplasm from exposure to maternal smoking is 1.11 and that for leukemia is 1.14. Additionally, the odds of these negative health outcomes were usually higher in pre-school than in school aged children and dose-response effects was argued: for children who live with smokers, the prevalence of asthma increased with the number of smokers in the home[24]. Furthermore, the risk ratio for hematopoietic cancers increased from 1.7 when one parent smoked to 4.6 when both parents smoked[25].

2.3. Developmental effects of SHS

It is noteworthy that, in addition to the harmful health effects of SHS at home, parental smoking also plays an important role in influencing smoking behaviors among the younger generation. The WHO FCTC stated that teenagers who live in homes where smoking is allowed are nearly twice as likely to start smoking than those in homes

where smoking is prohibited[26]. Studies have found that parent smoking contributes to the onset of daily smoking in their teenagers even if parents practice good family management, hold norms against teen tobacco use, and do not involve their children in their own tobacco use[27]. In a longitudinal study that followed 3012 children and their parents for nine years, it revealed that having one parent who smokes substantially increase risk that children will become daily smokers, relative to families where neither parent smokes[28]. Moreover, in a study conducted in Taiwan, which has a similar cultural background as China, parental influence, taking as parental behaviors and attitudes together, play a more important role than peer influence in smoking among high school students[29]. A systematic review looking at evidence from the UK found out that living in household significantly increased the risk of future regular smoking in children[30]. However, a systematic review of 87 studies assessing the association between adolescent smoking and parent and sibling smoking behaviors pointed out that the findings across studies show weak and inconsistent associations between parent and adolescent smoking, which may be attributed to methodological issues or confounding[31].

2.4. Measurement of SHS

A micro-environmental model is usually used to investigate the exposure to SHS, in which personal exposures to SHS is the weighted sum of the concentrations of SHS in each micro-environment where time is spent[32]. A microenvironment is a space, such as a room in a residence, with relative uniform concentration of SHS during the time that is spent in that particular microenvironment. Within this model, several useful indicators

of SHS exposure were used, including surrogate indicators to measure prevalence of smoking, indirect report of SHS exposure in home and workplace, and biomarkers that reflect concentration of SHS components[13]. Self-reported SHS exposure is a useful indicator of being exposed, but questionnaire reports of intensity of exposure are usually of uncertain validity[13].

Most population-based estimates of SHS exposure are based on surrogate indicators from self-reports. Questionnaires have been used to ascertain the prevalence of SHS, including self-reported exposure and descriptions of the source of SHS. WHO definition of passive smoking was adopted in many surveys, which defined exposure for at least 15 minutes per day and more than 1 day per week as SHS exposure[13].

Two global surveys of tobacco use were conducted in China nationally: the International Tobacco Control (ITC) and the Global Adult Tobacco Survey (GATS). The ITC policy evaluation project was created in 2002 to measure the effectiveness of national level tobacco control policies in selected countries that have signed and ratified FCTC[33]. It was conducted in six selected cities in China among permanent residents, with 800 smokers and 200 non-smokers in each city. GATS is a component of the Global Tobacco Surveillance System (GTSS) and was developed in 2007 to obtain nationally representative periodic data of parties that have adopted FCTC, and monitor tobacco use and changes due to policy[34]. It was completed in China in 2010, and conducted in 50 urban districts and 50 rural counties among 28 provinces with a total sample size of 13,354 individuals. SHS questions were asked in both surveys.

For children, the micro-environmental model makes clear the dominance of exposures in the home, where children spend the majority of their time. Therefore, exposure to SHS among children is mostly measured by parental smoking. It is generally estimated using household and school-based surveys. In household surveys, both parental smoking and the presence of children can be directly measured. In school-based surveys, children can accurately report whether or not their parents smoke but are less able to give valid reports of quantity of parental cigarette consumption[6]. In most countries, particularly those where people are generally not aware of tobacco smoke's harmful effects on children's health, parental smoking status will reflect children's exposure. However, it would always be better to validate these self-reports by biomarkers of children's actual exposure to offset socially desirable but inaccurate questionnaire responses.

Direct measures of SHS exposure include measurement of concentrations of SHS components in the air and SHS biomarkers levels in biological specimens. The selection of a particular SHS component in air for monitoring is largely based on technological feasibility. The most widely studied components are respirable particles and nicotine. Biomarkers of exposure are compounds that can be measured in biological materials such as blood, urine, or saliva[35]. Cotinine, a metabolite of nicotine, is a highly specific indicator of exposure to SHS in nonsmokers and it can be readily measured in blood, urine, and even saliva with either radioimmunoassay or chromatography[35].

2.5. Global epidemic of SHS

According to the WHO's report on the global tobacco epidemic released in 2011, tobacco use continued to be the leading global cause of preventable diseases and premature deaths[36]. By 2030 or perhaps a little sooner, tobacco is expected to be the single biggest cause of death worldwide by killing one in six adults, accounting for about 10 million deaths per year[37]. The epidemic of chronic disease and premature death is rapidly shifting to the developing world. By 2020, seven of every 10 people killed by smoking will be in low- and middle-income nations[37].

Given the widespread use of tobacco, SHS exposure is common throughout the world but not easy to estimate because few countries routinely collect the relevant data[12]. National estimates based on surveys are available only for a few countries, including the United States and China. 93% of the world's population is living in countries not covered by fully smoke-free public health regulations[38]. In a study estimating the global burden of disease from exposure to SHS using data from 192 countries, 40% of children, 33% of male non-smokers, and 35% of female non-smokers were exposed to SHS in 2004, although the definition and measurement of SHS varies in different countries and regions[39]. The overall prevalence of SHS exposure varies in different regions, from 13% or less in the population of Africa to 50% or more in the population of Western Pacific or Eastern Europe[39].

The study estimated that exposure to SHS caused 379,000 deaths from ischemic heart disease, 165,000 from lower respiratory infections, 36,900 from asthma, and 21,400 from lung cancer in the world in 2004[39]. An estimated 1% of worldwide mortality

was attributed to SHS, among which 47% of deaths occurred in women, 28% in children and 26% in men[39]. Also, an estimated 0.7% of total worldwide burden of diseases (in terms of disability adjusted life years [DALYs]) in 2004 was due to exposure to SHS, which amounted to 10.9 million[39]. The disease burdens were mostly from lower respiratory infections in children younger than 5 years of age, ischemic heart disease in adults, and asthma in adults and children[39]. In particular, 61% of DALYs lost were in children[39].

2.5.1 Global efforts of SHS exposure prevention

The FCTC is an evidence-based treaty negotiated under the auspices of the WHO and it was developed in response to the globalization of the tobacco epidemic[3]. It provides guidelines and a foundation for countries to implement and manage tobacco control. There are 176 countries that are parties of the WHO FCTC. To make the FCTC a reality, WHO introduced the MPOWER measures which correspond to one or more articles of the FCTC to assist in reducing the demand for tobacco products at a country-level[40]. The MPOWER package include six proven policies: Monitor tobacco use and prevention policies; Protect people from tobacco smoke; Offer help to quit tobacco use; Warn about the dangers of tobacco; Enforce bans on tobacco advertising, promotion and sponsorship; and Raise taxes on tobacco[40]. Among these policies, protecting people from tobacco smoke aims at creating smoke-free environments and controlling SHS exposure[40].

2.5.2. Context of SHS control in China

As the world's largest producer and consumer of tobacco, China has approximately 320 million smokers, which is 30% of the total number of smokers globally[41]. The prevalence of tobacco use estimated by the Global Adult Tobacco survey (GATS) was 52.9% among men and 2.4% among women[42]. Although it has been argued that the gender smoking ratio has a strong relation with the level of economic development in many countries[43], the unique smoking pattern in China with substantial gender gap remains attributed to strong and persistent social norms against female smoking despite the economic prosperity[44].

After China became a party of the WHO FCTC in 2006 and adopted the MPOWER package of evidence-based tobacco control measures in 2008, a set of rules have been issued by the Ministry of Health (MOH) of China to ban smoking in public places and control tobacco advertisements[45]. Since China's ratification of the WHO FCTC, it should have enacted a universal protection against SHS before January 9, 2011 by ensuring that all indoor workplaces and public places are free of SHS. However, there is a significant gap between the current state of affairs in China and the requirements of the FCTC[46]. China's endorsement of the FCTC principles has made little difference with regard to China's actual tobacco control efforts. The absence of political wills, incompatibility of institutional arrangements, interest conflicts with tobacco industry, and political and financial restrictions on NGOs are the most important factors that hinder the internalization of FCTC in China[47]. Among these factors, the most prominent barriers to the effective implementation of the FCTC are the State Tobacco Monopoly

Administration (STMA) and other commercial and vested interests of the tobacco industry[48].

2.6. SHS at home

Numerous studies have established that young children's exposure to tobacco smoke comes mainly from smoking within the home, especially by parents. And children are heavily exposed to SHS because they are not able to avoid the main source of exposure, which is mainly from their close relatives.

In a cross-sectional exposure study that measured air nicotine concentrations in households and hair nicotine concentration among nonsmoking women and children in 40 households in 31 countries, median air nicotine concentration was found to be 17 times higher in households with smokers compared with households without smokers[49]. In this study, air nicotine and hair nicotine concentration in women and children increased with the number of smokers in the household, and the dose-response relationship was steeper among children[49]. It has also been found that air nicotine concentrations increased 12.9 times in households allowing smoking inside compared with those prohibiting smoking inside[49]. In an exposure study conducted in Syria, children's hair nicotine level was strongly correlated with ambient household nicotine and number of cigarettes smoked daily in the household, and also was related to having a father who smoked in the children's presence[50]. Evidence from Malaysia using salivary cotinine concentration to measure SHS exposure found that cotinine levels were positively associated with living with one or more smokers, as well as other household

characteristics such as urban residence and education of the father[51].

Evidence from the 2006 and 2007 waves of the International Tobacco Control Four Country Survey (ITC-4) indicated that smokers with high SES had higher odds of both having and introducing a total ban on smoking inside the home compared to low SES smokers, as well as decreased odds of removing a total ban[52]. A nationally representative survey conducted in Hungry also found higher risks of home SHS exposure among younger, lower educated, and poorer people[53].

2.7. SHS at home in China

According the results of GATS in China, about seven in 10 nonsmoking adults are exposed to secondhand smoke in a typical week and four of them are exposed to second-hand smoke on a daily basis[42]. Using a global standardized geographically clustered sample design and based on a nationally representative survey with a sample size of 13,354, GATS estimated that the prevalence of SHS exposure in China was 74.1% among non-institutionalized men aged 15 and older, 71.6% among non-institutionalized women aged 15 and older, 70.5% among urban population, and 74.2% among rural population[54]. In an earlier nationally representative study, the prevalence of SHS exposure at home was estimated as 12.1% among male nonsmokers and 51.3% among female nonsmokers, which means 8, 658,000 Chinese men and 108,402,000 Chinese women were exposed to SHS at home[31].

Another study that was conducted in six counties in China estimated that the SHS exposure rate at home was 48.3%; in 3165 families with smokers, 87.2% of respondents

reported that smokers would smoke in front of them; in 2124 families with smokers and children, 76.5% of respondents reported that smokers would smoke in front of children; only 6.3% of families completely forbade smoking at home[55]. By surveying six rural areas in China, the occurrence of SHS exposure at home was found to be 68.0% among nonsmoking children and 59.3% among nonsmoking adults[56]. The study also identified that children living in households with married, low-education, and low-income heads of household and those who resided in a west province of China were more likely to be exposed to SHS. And adults who were female, aged 19-34, single, low-education, low income, and those who lived in the same west province of China were more like to be exposed to SHS at home.

2.8. Rationale for this study

However, all of the estimations above were based on individual surveys, in which children were not directly asked and the source of SHS at home was not directly identified either. Despite the established harm of SHS and the pervasive occurrence of SHS at home in China shown above, little has been known at the household level about the characteristics of households with smokers, which would have important implications for direct community-based interventions. Therefore, we carried out a full household survey collecting data of all household members to estimate the prevalence of SHS at home, project the source of SHS at home, and analyze specific characteristics associated with the smoking status of households.

Chapter 3: Manuscript

Authors' Contribution

The data was collected by Dr. Phillips and his research team in 2010. The dataset was created and cleaned by Dr. Phillips. Before I (Wei Xiong) joined the research team, preliminary data analysis was conducted by Dr. Phillips and table 1 and table 2 were partly developed.

I took over all the rest of the work later on. With the guidance of Dr. Phillips, I conducted the rest of the secondary data analysis including descriptive analysis and logistic regression, developed and formatted all the tables and figures, reviewed all the literature and developed the draft of the manuscript. The manuscript was revised for multiple times under the directions of Dr. Phillips and my thesis advisor Dr. Ali.

Who lives in the same households as smokers?

Evidence from a full household survey in Ningbo, China

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Abstract

Background. Secondhand smoke (SHS) exposure in the home is a major cause of ill-health, especially among those exposed to SHS due to living with smokers. Evaluations of nicotine concentrations and individual surveys are the two commonly used methods to estimate exposure to SHS at home.

Objective. Conduct a survey to describe the characteristics of all household members of a random sample of households to estimate the prevalence of SHS at home and identify the specific characteristics of households with smokers.

Methods. A sample of 1120 households from Ningbo, China was selected using a multi-stage stratified sampling method. Demographic information and smoking status of all residents in each selected household was obtained and the prevalence of SHS exposure among those who live in these homes was estimated. Conditional logistic regression models were used to examine the association between household characteristics (number of adult males and females, number of children, income level, etc) and SHS exposure status.

Results. Among the 1120 surveyed households, 566 (50.5%) had one current smoker and 72 (6.4%) had two or more current smokers; 706 of the 720 identified smokers (98.1%) were male. Overall, 57.5% of non-smoking women, 64.1% of non-smoking children under 18, and 63.2% of non-smoking children under 7 were exposed to SHS in home. Among the 638 households with current smokers, 569 (89.2%) of them also had non-smoking females, 246 (38.6%) of them had non-smoking children under 18, and 98 (15.4%) of them had non-smoking children under 7. Households with smokers were not different from households without smokers in terms of income and wealth, the presence of children in the home or the mean age of the adults in the home. Smoking households had more male household members than non-smoking households; after controlling for the number of males, non-smoking households had longer mean years of education among adult residents.

Conclusion. SHS exposure in the homes of women and children in urban China is a major public health problem that exists in almost all types of households. It indicates that a comprehensive tobacco control program targeted on household exposure to SHS is urgently needed.

Introduction

Extensive research has established the harmful effects of secondhand smoke (SHS)[1]. It places adults and children at increased risk of premature death and other adverse health outcomes, including cardiovascular and respiratory diseases[2]. The WHO Framework Convention on Tobacco Control (FCTC) states that there is 'no safe level of exposure to tobacco smoke'. In addition, evidence from 31 countries has shown that median air nicotine concentration was 17 times higher in households with smokers compared to households without smokers and that air nicotine and hair nicotine concentrations in women and children increased with the number of smokers in the household[3].

Children and women are known to be particularly susceptible to the negative consequences of SHS. Several systematic reviews have shown that children raised in homes with smokers are at higher risk of various health problems and that the effects are most pronounced among pre-school aged children[4]. There is, moreover, a clear dose-response effect in which the health risk increased with the number of smokers in the home[5,6]. Among women, there is a higher cardiovascular mortality in those who live in households where they are exposed to SHS[7].

Most estimates of SHS exposure in the home are based on the results of surveys of the smoking status of a random selection of adults in the community. The SHS exposure of non-smoking respondents can be estimated using this data if respondents are asked about SHS, but the surveys that ask non-smoking respondents about SHS

exposure do not usually identify the location of the SHS exposure. These surveys do not ask smoking respondents about SHS exposure in family members so it is not possible to identify the source of SHS in persons exposed to SHS. Moreover, these community-based surveys do not include children so they cannot provide information about rates of SHS exposure in this important cohort. To overcome these problems, we identified the smoking status of all household members in a randomly selected sample of households in an urban area of China and used this data to estimate the proportion of households with smokers that have non-smoking household members.

Methods

Sampling design and procedures

The survey was performed in Ningbo, a relatively prosperous municipality in Zhejiang Province that is located on the east coast of China. At the time of the survey in 2010, there were 2,855,000 households in the city with an average of 2.47 members in each household[8]. About one-third of the population was non-permanent residents of the city, most of whom had come to the city from rural communities for work. The sampling procedure is shown in Figure 1. A sample of 1406 households was selected using a multi-stage stratified sampling design with inclusion probabilities proportional to size in each stratum. The household response rate was 76.7%.

Each selected household was visited by a trained interviewer. All 124 interviewers were experienced staff members from the Center of Disease Control in Ningbo and trained by trainers from the Shanghai Mental Health Center following a standardized

protocol. In each selected household, an adult resident (older than 18 years of age) was asked by the interviewer to provide demographic and smoking information about all co-resident family members. Typically, survey responses took less than 5 minutes to complete this brief survey. Altogether, a total of 1120 households completed the family form. The study was approved by the Institutional Review Board of the Shanghai Mental Health Center.

Measures

The family smoking questionnaire was used to collect demographic information and smoking status of all residents (including children) who lived in the household for over 60 days in the past three months. The information for each household member obtained included age, sex, years of schooling, residence status in Ningbo, smoking status and how many days he/she smoked in the past month. Four measures were used to estimate each family's social economic status (SES): 1) self-reported family economic status (choosing from high, medium or low), 2) total monthly family income; 3) per capita monthly income in the family; and 4) number of family assets (i.e., fridge, washing machine, air conditioner, computer, and family car). The first three income measures were highly correlated; we decided to use the reported total monthly family income as the income index. The number of family assets was used as a measure of family wealth.

Statistical analysis

SPSS 17.0 (SPSS inc. Chicago, USA) was used to clean and analyze the data. In order

to compare households rather than individuals, the household was treated as the basic unit of analysis. In each household the number of residents, number of adult males, number of adult females, number of children under 7 years of age, number of children under 18 years of age, number of migrant residents, and number of smokers were computed and treated as continuous variables. Mean age and mean years of schooling of all adults were also calculated as essential demographic characteristics of each household. The monthly family income was skewed to the right so it was converted to a three-level tertile variable – "high" (>4700 CNY), "medium" (2000-4700 CNY) and "low" (<2000 CNY) economic status[*] – with a similar number of households in each category.

In order to compare the above variables between households with and without smokers, t-tests, chi-squared tests, and Mann-Whitney U tests were used depending on the type and distribution of each variable (Table 3). In order to identify the association between household characteristics and smoking status, logistic regression models were used to adjust for the number of adult males in each household. In each model, the smoking status of the household was used as the dependent variable; number of adult males in each household was used as an independent variable together with each household characteristic in interest. In all analyses, statistical significance was defined as p-value <0.05.

This analysis of these data was approved by the Institutional Review Board of Emory University.

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[*] Income was reported in Chinese Yuan (CNY). 1 $int.=3.96 CNY in April, 2010.

Results

The average number of residents in the surveyed households was 2.74. Smoking rates among male residents was 53.6% while that among female residents was 1.1%. Among the 720 identified smokers 706 (98.1%) were male. Among smokers, the median (inter-quartile range) of smoking days was 30 (30-30) days a month, which indicated that over three quarters of the smokers in these households were daily smokers.

As shown in Table 2, among the 1120 surveyed households, 566 (50.5%) had one current smoker and 72 (6.4%) had two or more current smokers. Among the current smokers, 86.3% were daily smokers. Among households with children under 18 years of age, 63.9% had at least one household member that smoked, and 56.6% had someone that smoked on a daily basis. Among households with children under 7 years of age, 63.2% had current smokers, and 60.6% had current daily smokers.

Table 3 shows the demographic characteristics of the 638 households with smokers. In these households, 88.7% had one smoker, 10.5% had two smokers and 0.8% had three or more smokers. The majority of these households (84.8%) had someone that smoked every day in the past month. Among the 638 households with current smokers, 91.7% also had non-smokers living in the household: 89.2% had non-smoking adult women, 38.6% had non-smoking children under 18 years of age, and 15.4% had non-smoking children under 7 years of age. There was also a large gender gap: only 2.0% of the households had female smokers and only 0.8% had both male and female smokers. Teen smoking was not identified as a problem in this region; there was only one

household that reported having a smoker who was under 18 years of age.

As shown in Table 4, by comparing households that did and did not have smokers crudely, there were several significant differences. However, considering that the majority of smokers were males, the number of male residents in each household was controlled as a confounder. After adjusting for the number of adult male household members, all the other significant differences became insignificant. Only the mean years of schooling of adult household members became significant after controlling for the number of adult males, in which the households without smokers had longer average years of education compared to households with smokers.

In conclusion, households with more adult male members are more likely to have someone who smokes (OR=2.34); when the number of adult males in each household is being adjusted, longer average years of education tend to be associated with non-smoking status of the households.

Discussion

China is the world's largest tobacco producer and the world's largest tobacco consumer[9], so it is important to develop multiple methods for estimating the prevalence of SHS exposure, particularly in women (who only rarely smoke in China) and children (who almost never smoke in China). There are some difficulties in estimating SHS exposure using the results of individual-based surveys of smoking; for example, these surveys do not include children, so estimates of SHS exposure in children are usually based on extrapolation from results in adults. We have adopted a different approach to

this problem in the current study – obtaining smoking history of all household members of a representative sample of households – to assess household exposure to SHS. The robust sampling procedure used in the study ensured good representativeness of the target population, a large urban metropolis in eastern China. We have not found any previous studies that use this method.

The average number of residents in each household in our sample is very close to that in the population. The estimated prevalence of SHS exposure we found in women was similar to that reported in a large individual-based survey in China which report an overall prevalence of SHS exposure at home of 51.3% among female non-smokers[10]. Although the general prevalence of smoking (27.3%) was similar to that reported in more conventional individual-based surveys, the male-to-female ratio of smoking in the current study (64:1) was substantially higher than the estimated national ratio (22:1)[11]. It indicates that SHS is even more disproportionally affecting women in the investigated area.

The study highlights a major public health issue for China. We found that two-thirds of all pre-school aged children in Ningbo were living with current smokers and over half of the children under 18 years of age were living with daily smokers. Almost all smokers lived with non-smokers (most of whom were women and children) and about one-tenth of smoking households had more than one smoker. Previous reports have found that the majority of the people who lived with smokers report that smokers usually smoke in front of other family members including children[12]. It's also estimated

that only 6.3% of the families in China forbade smoking at home[12]. Therefore, a large number of children and women are at risk of inhaling SHS at home. A previous study conducted in rural China found that children living in low SES households and female adults with low SES were more likely to be exposed to SHS[13]. However, in our study, smoking status of a household was only found to be moderately associated with average years of education controlling for the number of male residents. Therefore, we can conclude that the problem of SHS at home in the investigated area was pervasive among families with diverse demographic structure and economic statuses, but those with longer average years of education were less likely to have smokers when the number of adult males is being adjusted for.

There are several potential limitations of the study that should be considered when assessing the results. This is a cross-sectional study so we can only provide a single snapshot of smoking behavior in Ningbo; we cannot predict the trends in these values. Also, we cannot make any conclusions about the causality of the relationships identified between household characteristics and the smoking behavior of members of the households. The sample is representative of households in Ningbo but the representativeness of Ningbo to other urban centers in China is unknown. Moreover, about 23.3% of the selected households didn't respond to the survey and the non-responded households could be different from the responded households in number of residents, number of children, social economic status or other variables. In addition, all the information was self-reported and information about the smoking behavior of all

members of the household was usually obtained from a single adult representative of the family, so there is certainly the possibility of biased responses (which typically result in underestimation of the prevalence of smoking behavior). This may be a particular problem in estimating rates of adolescent smoking[14]. The family questionnaire did not obtain information about smoking inside the home, so we cannot be certain that identified smokers actually smoked inside the home; but in China, very few households ban smoking in the home[12], so we expect that this would have only a minor effect on our estimated rates of household exposure to SHS.

Smoking is being restricted in more and more public sites in China, but no community-wide effort has focused on control of SHS at home. Given the magnitude of this problem, particularly for women and children, it is essential to initiate more programs specifically focused on household exposure to SHS. To assess the effectiveness of targeted campaigns about reducing SHS (and to assess the secondary effect on SHS of other tobacco-related interventions) there needs to be regular monitoring of SHS exposure in homes. The method used in this study – based on a five-minute interview with an adult member of a random selection of households – is an easy way to estimate the prevalence of SHS exposure in the home and, thus, to assess the effectiveness of different interventions. The current method could be improved by asking how often the identified smokers in each household actually smoked inside the home. The validity of this approach could be assessed by comparing the results of the survey with more objective measures of household exposure to nicotine (e.g., periodic sampling of

household air) and with nicotine levels in the blood and hair of non-smoking household members.

Figure 1. Flowchart of the data collection

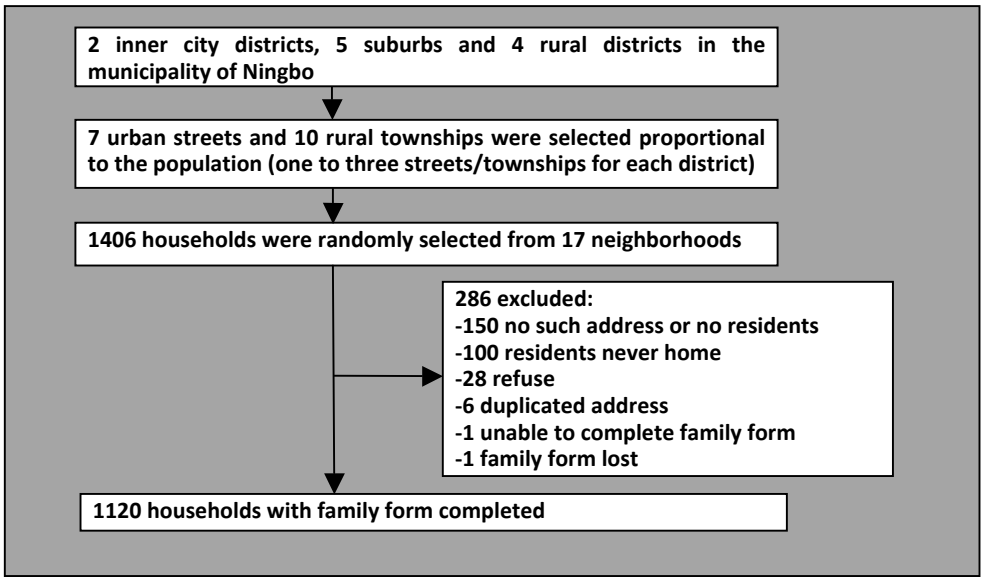

Table 1: Characteristics of the 1120 households surveyed	
Mean (sd) number of residents (range: 1-9)	2.7 (1.2)
Mean (sd) number of adult (18+) residents (range: 1-8)	2.4 (1.0)
Mean (sd) age of adult residents (range: 18-96)	47.5 (14.6)
Mean (sd) years of schooling of adult residents (range: 0-19)	7.4 (3.7)
% (95% CI) of single-person households	12.3% (10.3-14.3%)
% (95% CI) households with children under 18	34.4% (31.7-37.1%)
% (95% CI) households with children under 7	13.8% (11.8-15.8%)
% (95% CI) households with non-permanent residents	23.8% (21.3-26.3%)

Table 2: Smoking status of the 1120 surveyed households		
ALL HOUSEHOLDS (n=1120)	*%*	(95% CI)
% households with current smokers	57.0%	54.1%--59.9%
% households with current daily smokers	49.9%	47.0%--52.8%
% households with 2+ current smokers	6.4%	5.0%--7.8%
% households with 2+ current daily smokers	4.8%	3.6%--6.0%
HOUSEHOLDS WITH CHILDREN <18 (N=385)	*%*	(95% CI)
% households with current smokers	63.9%	59.0%--68.8%
% households with current daily smokers	56.6%	51.7%--61.5%
HOUSEHOLDS WITH CHILDREN <7 (N=155)	*%*	(95% CI)
% households with current smokers	63.2%	55.6%--70.8%
% households with current daily smokers	60.6%	53.0%--68.2%
SINGLE-PERSON HOUSEHOLDS (N=138)	*%*	(95% CI)
% households with current smokers	32.6%	24.8%--40.4%
% households with current daily smokers	30.4%	22.8%--38.0%
HOUSEHOLDS WITH NON-PERMANENT RESIDENTS (N=267)		
% households with current smokers	57.7%	51.8%--63.6%
% households with current daily smokers	49.4%	43.5%--55.3%

Table 3: Characteristics of the 638 households with smokers	
Characteristic	**n (%)**
Have smokers that smoked every day in the past month	541 (84.8%)
Have female smokers	13 (2.0%)
Have children (under 18 years of age) smokers	1 (0.2%)
Have 1 smoker	566 (88.7%)
Have 2 smokers	67 (10.5%)
Have 3+ smokers	5 (0.8%)
Have non-smokers	585 (91.7%)
Have non-smoking females	569 (89.2%)
Have non-smoking children under 18 years of age	246 (38.6%)
Have non-smoking children under 7 years of age	98 (15.4%)

Table 4: Comparison of households that have smokers and those that have no smokers

Characteristics of households	All households (n=1120)	Households with no smokers (n=482)	Households with smoker(s) (n=638)	statistic	p-value	adjusted p-value[d]
Mean (sd) number of residents	2.75 (1.24)	2.43 (1.11)	2.98 (1.27)	z=-7.15	<0.001	0.979
Mean (sd) number of adults	2.35 (0.97)	2.11 (0.85)	2.54 (1.01)	z=-7.50	<0.001	0.103
Mean (sd) number of adult males	1.18 (0.64)	0.96 (0.59)	1.34 (0.62)	z=-10.53	<0.001	--
Mean (sd) number of adult females	1.18 (0.59)	1.15 (0.50)	1.20 (0.65)	z=-1.21	0.225	0.103
Mean (sd) age of adults in household	47.59 (14.41)	49.25 (16.43)	46.16 (12.94)	t=3.41	0.001	0.200
Number (%) with child <18 years of age	370 (34.4%)	139 (28.8%)	246 (38.6%)	χ^2=11.50	0.001	0.113
Number (%) with child <7 years of age	148 (13.7%)	57 (11.8%)	98 (15.4%)	χ^2=2.88	0.090	0.905
Number (%) with non-Ningbo residents	250 (23.2%)	113 (23.4%)	154 (24.1%)	χ^2=0.07	0.787	0.559
Mean (sd) years of schooling among adults in household	7.38 (3.69)	7.48 (4.14)	7.31 (3.36)	t=0.77	0.441	0.030
Mean (sd) number of major possessions in household[a,b]	2.64 (1.58)	2.61 (1.59)	2.65 (1.59)	t=-0.46	0.647	0.102
Number (%) who reported monthly family income in the following ranges[b,c]						
High (>¥4700)	349 (32.3%)	137 (29.1%)	212 (34.8%)	χ^2=13.36	0.001	0.208
Medium (¥2000-4700)	352 (32.6%)	140 (29.7%)	212 (34.8%)			0.412
Low (<¥2000)	380 (35.2%)	194 (41.2%)	186 (30.5%)			0.327

[a] goods considered include fridge, washing machine, air conditioner, computer, and family car

[b] Variables have missing values: for the number of major possessions, N= 1089 (474 households with no smoker, 615 households with smoker); for monthly family income, N=1081 (471 households with no smoker, 610 households with smoker)

[c] Income was reported in CNY (1 $int.=3.96 CNY in April, 2010)

[d] Adjusted for number of adult males in the household (as a continuous variable) in a logistic regression model comparing the two types of households that uses the characteristic of interest and the number of adult males as the independent variables.

References

[1] **World Health Organization**. *WHO Framework Convention on Tobacco Control*. Geneva: World Health Organization, 2003.

[2] **World Health Organization**. *10 facts on second-hand smoke*. Geneva: World Health Organization, 2009.

[3] **Wipfli H**, Avila-Tang E, Navas-Acien A, *et al*. Secondhand smoke exposure among women and children: evidence from 31 countries. *Am J Public Health* 2008;**98**(4):672-679.

[4] **Cook DG**, Strachan DP. Health effects of passive smoking. 10. Summary of parental smoking on the respiratory health of children and implications for research. *Thorax* 1999;**54**:357-366.

[5] **Lewis SA**, Antoniak M, Venn AJ, *et al*. Secondhand smoke, dietary fruit intake, road traffic exposures, and the prevalence of asthma: a cross-sectional study in young children. *Am J Epidemiol* 2005;**161**(5):406-411.

[6] **Sandler DP**, Everson RB, Wilcox AJ, *et al*. Cancer risk in adulthood from early life exposure to parents' smoking. *Am J Public Health* 1985;**75**(5):487-492.

[7] **Hill, SE**, Blakely T, Kawachi I, et al. Mortality among lifelong nonsmokers exposed to secondhand smoke at home: cohort data and sensitivity analyses. *Am J Epidemiol* 2007;**165**(5):530-540.

[8] **Ningbo Municipal Statistics Bereau**. Main findings from the 2010 sixth national population census data (in Chinese). Retrieved from http://www.nbxiaoshi.net:8080/dili/Article/ShowArticle.asp?ArticleID=355. Accessed on January 6, 2013.

[9] **World Health Organization**. *Towards a tobacco-free China.* Geneva: World Health Organization, 2007.

[10] **Gu D**, Wu X, Reynolds K, *et al*. Cigarette smoking and exposure to environmental tobacco smoke in China: the international collaborative study of cardiovascular disease in Asia. *Am J Public Health* 2004;**94**(11):1972-1976.

[11] **U.S. Centers for Disease Control and Prevention**. *Global Adult Tobacco Survey (GATS): Fact Sheet of China, 2010.* Atlanta: United States Centers for Disease Control and Prevention, 2010.

[12] **Wang CP**, Ma SJ, Xu XF, *et al*. The prevalence of household second-hand smoke exposure and its correlated factors in six counties of China. *Tob Control* 2009;**18**(2):121-126.

[13] **Yao T**, Sung HY, Mao Z *et al*. Secondhand smoke exposure at home in rural China. *Cancer Causes Control* 2012;**23**(Suppl 1):109-115.

[14] **Mak YW**, Loke AY, Lam TH, *et al*. Validity of self-reports and reliability of spousal proxy reports on the smoking behavior of Chinese parents with young children. *Addict Behav* 2005;**30**(4):841-845.

Chapter 4: Conclusion and Recommendations

The findings of our study imply that SHS at home is a major public health threat in Ningbo, China. The fact that over two-thirds of all pre-school aged children in Ningbo live with daily smokers and over half of the children under 18 years of age live with daily smokers reveals an urgent need to control SHS exposure at home for the health of the next generation, and as one method of preventing their initiation of smoking. The fact that nine out of 10 households with smokers have non-smoking women living in the same home highlights the need to protect the health of these women. Our findings indicate that this problem is pervasive across all types of households regardless of their socioeconomic status. After controlling the number of males in each household, the mean years of schooling of adult members became significantly related to the smoking status of the household. It means that when the numbers of adult males are equivalent, households with longer average years of education are less likely to have smokers live there. However, the implication of this finding is limited due to the lack of information about the quality and the degree of the education. Nevertheless, the number of adult males remains the dominant determinant of the smoking status of a household and this study clarifies the magnitude of the challenge and the need for comprehensive population-based actions to control SHS in the home.

A smoke-free home is one in which no occupant or visitor smokes indoors or in the family car (if the family owns a car). Smoke-free homes have been shown to reduce exposure to SHS for both non-smoking adults and children[40]. Population-based evidence

from the state of Oregon, United States has shown that most of the households with a full ban in place reported that no individual smoked in the home over the previous month[57]. The proportion was 99% among households without smokers and 91% among households with at least one smoker[57]. A total ban of smoking in the home was also found to be associated with significantly lower urinary cotinine to creatinine ratio levels among children with asthma[58]. Moreover, a literature review about the effect of smoke-free homes on adult smoking behavior summarized the consistent evidence that smokers who had or who newly implemented a smoke-free home were significantly more likely to make a quit attempt and to be abstinent; those who continued to smoke reported reduced the daily number of cigarettes smoked at follow-up[59].

To effectively increase the adoption of home smoking bans and reduce the prevalence of SHS at home in Ningbo, there are a few steps the local and national governments can take.

4.1. Strengthen smoke-free regulations in public places

According to the MPOWER brochure for the FTCT, all people have a fundamental right to breathe clean air. Completely smoke-free indoor environments—with no exceptions—are the only proven way to protect people. However, there hasn't been any national legislation against smoking in indoor public settings[60]. In the city of Ningbo, a local law was enacted in 1996 banning smoking in public venues such as hospitals, museums, schools, etc[61]; smoking bans legislation with larger coverage including shopping malls, internet cafes, bars, and clubs was carried out in 2007[62]. However, the penalty for violation was poorly specified, the definition of "executor" was unclear, and

the entire legislation was poorly enforced. Smoking behaviors remain prevalent in almost all indoor public areas, especially in workplaces[63].

The enactment of strong laws making public places or workplaces smoke-free is highly associated with a broader adoption of voluntary smoke-free home policies. In a study conducted in the United States using population survey data, living in a county fully covered by a 100% clean indoor air law in public places is associated with a 7.8 fold increased likelihood of having a voluntary 100% smoke-free home rule among those who live with smokers and a 4.1 fold increased likelihood among those who don't live with smokers[64]. Another study that measured the prevalence of home smoking bans among smokers in four European countries also found that the proportion of smokers with total home smoking bans increased significantly after implementation of national smoke-free legislation[65].

In fact, the public support in China for comprehensive smoke-free policies is quite high. As shown in the ITC China survey in six other cities[66], the majority of residents support total smoking bans in most public settings, especially in schools, public transportation vehicles, hospitals, and conference rooms. However, support for a total ban in workplaces, restaurants and bars was relatively lower, so this may be a major barrier for policy implementation.

4.2. Support community-based interventions in achieving smoke-free homes

Some community-based approaches have been studied and have been found to be effective in building smoke-free homes. In a community-based intervention study conducted in the metro Atlanta area in the United States, a four-component

intervention significantly increased home smoking restrictions[67]. The first component was a "tool-kit" for creating a smoke-free home including a "five-step guide to a smoke-free home", which describes the steps, tips, and strategies to plan for, make, and keep a smoke-free home. The second component was a coaching call, which incorporated the five steps in the guideline. It asked about the progress of making the home smoke-free, benefits of a smoke-free home, and challenges and barriers to setting a smoke-free home rule, as well as providing messages based on the stage of change each household was in. The third component included additional educational information on SHS and its dangers, tips on having a conversation with the smoker in the home, ways to make smoking outside easier, and ways to celebrate being smoke-free. The fourth component included a newsletter with testimonials and success stories portraying families and their reasons for having a smoke-free home. Formal assessment of this brief intervention has shown that it is effective in promoting smoke-free home policies among low-income households.

Another study of the smoke-free home initiative launched in Rotherham, England using similar materials was also found to be successful in creating smoke-free homes[68]. A more recent study further validated the effectiveness of delivering written materials in increasing totally smoke-free homes, but it failed to prove the usefulness of adding a brief counseling session on SHS exposure protection[69].

Despite the positive results, the samples in all three studies were small and not representative of the community at large. No control group families were used in the first two studies. Thus, this booklet-based intervention appears to be generalizable, but

the methods should be revised before being used in China. Surveys or focus groups should be conducted before implementing the intervention to help adapt the method of communicating these health messages to the very different cultural setting that exists in China.

4.3. Improve smoking cessation services

Although more difficult, a more direct and effective way to control SHS exposure at home other than smoke-free homes is to encourage more people to quit smoking. Quitting smoking combined with complete home smoking bans will afford children the best protection from SHS exposure[70].

Effective treatment can significantly increase rates of long-term abstinence[71]. Numerous effective medications are available for tobacco dependence and the combination of medication, practical counseling and social support, produce the best outcomes. A review of smoking cessation studies show that pharmacotherapy alone or in combination with counseling is effective in China. Some studies suggest that the use of traditional Chinese medicines yield an even higher abstinence rate than the combination of western medications and counseling, but these findings are inconclusive[72].

However, the use of formal treatment alternatives for smoking cessation is very low in China. The ITC China survey found that approximately 26% of smokers had attempted to quit but only 6% were abstinent at 18-month follow up; only 5.8% of those attempting to quit reported using Nitotine Replacement Treatment (NRT)[73]. Population-

wide data on the usage of other cessation treatments were limited. Furthermore, although the Chinese Clinical Smoking Cessation Guidelines have been released and more and more smoking cessation clinics are being established, several major socio-contextual obstacles to smoking cessation remain: family and social influences, the myth that quitting smoking is dangerous to health, and misinformation from health professionals[74]. The challenge that local and national governments face is how to increase community demand for cessation services through social marketing and public education and how to improve access to high-quality cessation services.

4.4. Monitor and evaluate new policies

The implementation of SHS control policies, if there will be any, should be monitored and evaluated at the local and the national levels. The enforcement and effectiveness of these policies need to be carefully documented over time. The method used in this study is an easy to use way to monitor the changes in the prevalence of SHS exposure at home and, thus, also assess the effectiveness of different interventions.

SHS has lead to substantial but avoidable mortality and loss of active life-years among non-smokers, especially children. The challenges of SHS in China are considerable, but not insurmountable. The health and wellbeing of China's residents, especially women and children, can be greatly improved by acting to reduce these completely avoidable risks related to SHS.

Appendix

Figure 1: Geographical location of Ningbo, Zhejiang, China.

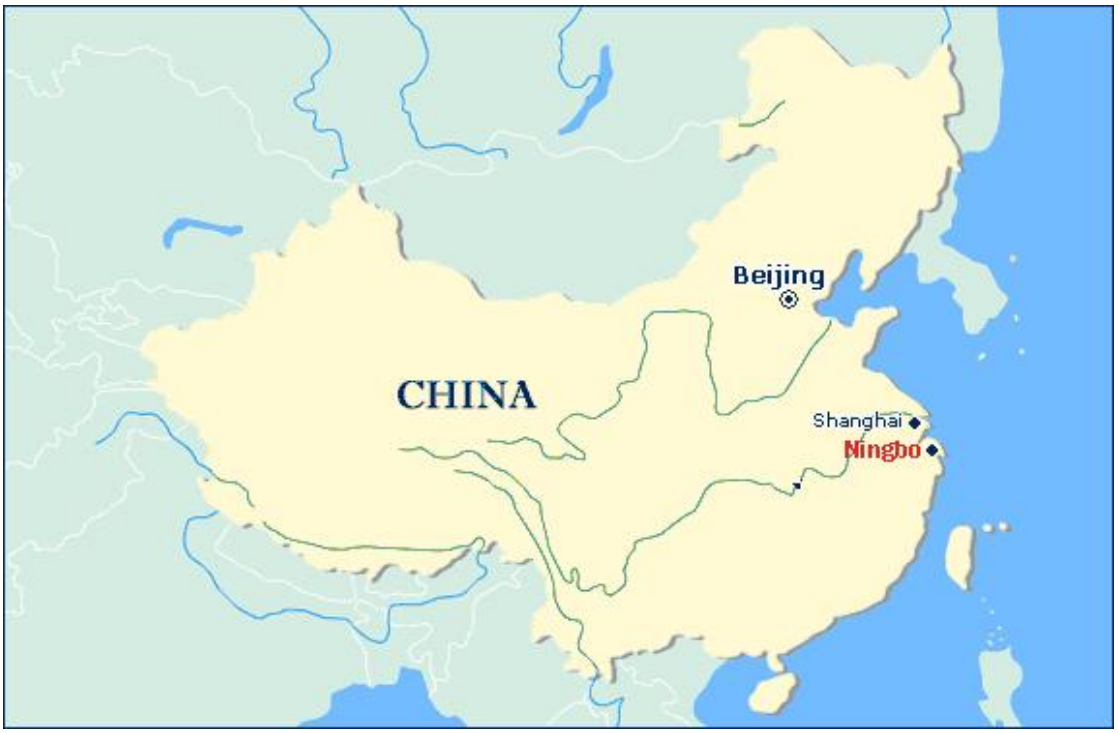

Figure 2: Sampling procedure of the survey.

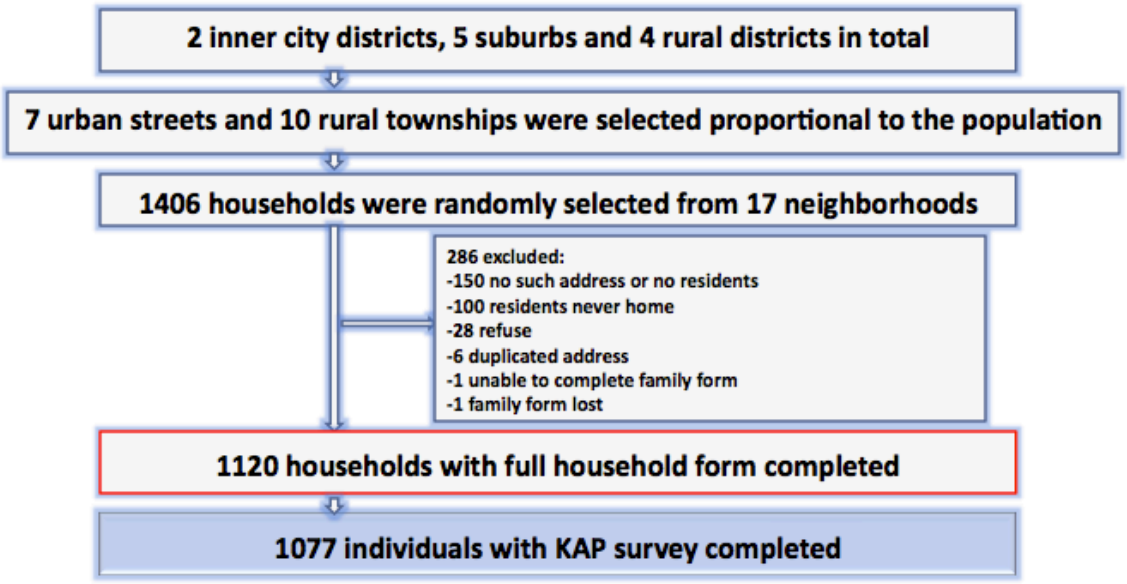

Figure 3: The full household form used in the study.

All who live with you in the recent 3 months, from oldest to youngest							
ID	Name	Age	Sex (1=M, 2=F)	Years of Schooling	Local Residency (1=Y, 2=N)	Days of smoking in the past 30 days	Selected (1=Y, 2=N)
1							
2							
3							
4							
5							
6							
7							
8							
9							

References

[1] WHO International Agency for Research on Cancer (2004). IARC monographs on the evaluation of carcinogenic risks to humans: Tobacco smoke and involuntary smoking. Lyon: International Agency for Research on Cancer. http://monographs.iarc.fr/ENG/Monographs/vol83/mono83.pdf (accessed Apr 5, 2013).

[2] Guerin, M.R., Jenkins, R.A., Tomkins, B.A. (1992). The chemistry of environmental tobacco smoke: composition and measurement. Chelsea, Michigan: Lewis Publishers, Inc.

[3] WHO (2003). WHO Framework Convention on Tobacco Control. Geneva, World Health Organization. http://whqlibdoc.who.int/publications/2003/9241591013.pdf (accessed Apr 7, 2013).

[4] WHO (2009). 10 facts on second-hand smoke. Geneva, World Health Organization. http://www.who.int/features/factfiles/tobacco/tobacco_facts/en/index.html (accessed Sep 20, 2012)

[5] Schönherr, E. (1928). Contribution to the statistical and clinical features of lung tumours (in German). Z Krebsforsch 1928; 27: 436–50.

[6] WHO (1999). International Consultation on Environmental Tobacco Smoke (ETS) and Child Health. Geneva: World Health Organization. http://www.who.int/tobacco/research/en/ets_report.pdf (accessed Apr 5, 2013).

[7] Scientific Committee on Tobacco and Health (1998). Report of the Scientific Committee on Tobacco and Health. The Stationary Office.

[8] National Research Council, Committee on Passive Smoking (1986). Environmental tobacco smoke: measuring exposures and assessing health effects. Washington, DC: National Academy Press.

[9] US Environmental Protection Agency (1992). Respiratory health effects of passive smoking: lung cancer and other disorders. Washington, DC: US Government Printing Office.

[10] California Environmental Protection Agency (1997). Office of Environmental Health Hazard Assessment. Health effects of exposure to environmental tobacco smoke. California: California Environmental Protection Agency.

[11] US Surgeon General (2006). The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. http://www.surgeongeneral.gov/library/reports/secondhandsmoke/report-index.html (accessed Apr 5, 2013).

[12] WHO (2010). Gender, women, and the tobacco epidemic. Geneva, World Health Organization. http://whqlibdoc.who.int/publications/2010/9789241599511_eng.pdf (accessed Apr 7, 2013).

[13] WHO (2001). Women and the tobacco epidemic. Geneva, World Health Organization. http://apps.who.int/iris/bitstream/10665/66799/1/WHO_NMH_TFI_01.1.pdf (accessed Apr 7,

2013).

[14] Garfinkel, L. (1981). Time trends in lung cancer mortality among nonsmokers and a note on passive smoking. J. natl Cancer Inst., 66, 1061–1066.

[15] Hirayama, T. (1984) Cancer mortality in nonsmoking women with smoking husbands based on a large-scale cohort study in Japan. Prev. Med., 13, 680–690.

[16] Cardenas, V.M., Thun, M.J., Austin, H., Lally, C.A., Clark, W.S., Greenberg, S. & Heath, C.W., Jr (1997). Environmental tobacco smoke and lung cancer mortality in the American Cancer Society's cancer prevention study II. Cancer Causes Control, 8, 57–64.

[17] Jee, S.H., Ohrr, H. & Kim, I. S. (1999). Effects of husbands' smoking on the incidence of lung cancer in Korean women. Int. J. Epidemiol., 28, 824–828.

[18] Nishino, Y., Tsubono, Y., Tsuji, I., Komatsu, S., Kanemura, S., Nakatsuka, H., Fukao, A., Satoh, H. & Hisamichi, S. (2001). Passive smoking at home and cancer risk: A population-based prospective study in Japanese nonsmoking women. Cancer Causes Control, 12, 797–802.

[19] Wells, A.J. (1991). Breast cancer, cigarette smoking, and passive smoking [Letter]. Am. J. Epidemiol., 133, 208–210.

[20] Morabia, A., Bernstein, M.S., Bouchardy, I., Kurtz, J. & Morris, M.A. (2000). Breast cancer and active and passive smoking: The role of the N-acetyltransferase 2 genotype. Am. J. Epidemiol., 152, 226–232.

[21] Cook, D.G. and D.P. Strachan (1997). Health effects of passive smoking. 3. Parental smoking and prevalence of respiratory symptoms and asthma in school age children. Thorax 52(12): 1081-1094.

[22] Strachan, D.P. and Cook, D.G. (1998). Health effects of passive smoking. 4. Parental smoking, middle ear disease and adenotonsillectomy in children. Thorax 53(1): 50-56.

[23] Strachan, D.P. and Cook, D.G. (1998). Health effects of passive smoking. 6. Parental smoking and childhood asthma: longitudinal and case-control studies. Thorax 53(3): 204-212.

[24] Lewis, S.A., Antoniak, M., Venn, A.J., Davies, L., Goodwin, A., Salfield, N., Britton, J., Fogarty, A.W. (2005). Secondhand smoke, dietary fruit intake, road traffic exposures, and the prevalence of asthma: a cross-sectional study in young children. Am J Epidemiol 161(5): 406-411.

[25] Sandler, D.P., Everson, R.B., Wilcox, A.J., Browder, J.P. (1985). Cancer risk in adulthood from early life exposure to parents' smoking. Am J Public Health 75(5): 487-492.

[26] WHO. Tobacco free initiative (TFI): MPOWER brochures and other resources. Geneva, World Health Organization. http://www.who.int/tobacco/mpower/publications/en/index.html (accessed Apr 8, 2013)

[27] Hill, K.G., Hawkins, J.D., Catalano, R.F., Abbott, R.D. & Guo, J. (2005). Family influences on the risk of daily smoking initiation. J Adolesc Health 37(3): 202-210.

[28] Peterson, A.V. Jr., Leroux, B.G., Bricker, J., Kealey, K.A., Marek, P.M., Sarason, I.G., Anderson, M.R. (2006). Nine-year prediction of adolescent smoking by number of smoking parents. Addict Behav 31(5): 788-801.

[29] Wen, C., Tsai, S., Cheng, T., Hsu, C., Chen, T. & Lin, H. (2005). Role of parents and peers in

influencing the smoking status of high school students in Taiwan. Tob Control 14 Suppl 1: i10-15.

[30] Kusel, J., Timm, B. & Lockhart, I. (2013). The impact of smoking in the home on the health outcomes of non-smoker occupants in the UK. Tob Induc Dis 11(1): 3.

[31] Gu, D., Wu, X., Reynolds, K., Duan, X., Xin, X., Reynolds, X., Xin, X., Reynolds, R.F., Whelton, P.K., He, J.; InterASIA Collaborative Group (2004). Cigarette smoking and exposure to environmental tobacco smoke in China: the international collaborative study of cardiovascular disease in Asia. Am J Public Health 94(11): 1972-1976.

[32] Jaakkola, M.S. and Jaakkola, J.J. (1997). Assessment of exposure to environmental tobacco smoke. Eur Respir J 10(10): 2384-2397.

[33] Wu, C., Thompson, M.E., Fong, G.T., Li, Q., Jiang, Y., Yang, Y. & Feng, G. (2010). Methods of the International Tobacco Control (ITC) China Survey. Tob Control 19 Suppl 2: i1-5.

[34] Hsia, J., Yang, G.H., Li, Q., Xiao, L., Yang, Y., Wu, Y.W. & Asma, S. (2010). Methodology of the Global Adult Tobacco Survey in China, 2010. Biomed Environ Sci 23(6): 445-450.

[35] Benowitz N.L. (1999). Biomarkers of environmental tobacco smoke. Environ Health Perspect 107 (Suppl. 2):349-55.

[36] WHO (2011). WHO report on the global tobacco epidemic, 2011. Geneva, World Health Organization.

[37]World Bank (1999). Curbing the epidemic: Governments and the Economics of tobacco Control. Washington D.C., The World Bank.

[38] WHO (2009). WHO Report on the Global Tobacco Epidemic 2009: implementing smoke-free environments. Geneva, World Health Organization. http://www.who.int/tobacco/mpower/2009/en/ (accessed Apr 6, 2013).

[39] Oberg, M., Jaakkola, M.S., Woodward, A., Peruga, A. & Pruss-Ustun, A. (2011). Worldwide burden of disease from exposure to second-hand smoke: a retrospective analysis of data from 192 countries. Lancet 377(9760): 139-146.

[40] WHO (2008). MPOWER: Six policies to reverse the tobacco epidemic. Geneva, World Health Organization.

[41] WHO (2007). Towards a tobacco-free China. Geneva, World Health Organization.

[42] CDC (2010). Global Adult Tobacco Survey (GATS): Fact Sheet of China, 2010. Atlanta, United States Center for Disease Control and Prevention.

[43] Hitchman, S.C. & Fong G.T. (2011). Gender empowerment and female-to-male smoking prevalence ratios. Bull World Health Organ 89(3): 195-202.

[44] Pathania, V. (2011). Women and the smoking epidemic: turning the tide. Bull World Health Organ. 2011 Mar 1(89 (3)): 162.

[45] WHO (2011). China tightens rules on smoking in public places and indirect advertising. Geneva, World Health Organization.

[46] Lv, J., Su, M., Hong, Z., Zhang, T., Huang, X., Wang, B. & Li, L. (2011). Implementation of the WHO Framework Convention on Tobacco Control in mainland China. Tob Control 20(4): 309-314.

[47] Jin, J. (2012). FCTC and China's politics of tobacco control. The 4th GLF Annual Colloquium, May 15th, 2012.

[48] Wan, X., Ma, S., Hoek, J., Yang, J., Wu, L, Zhou, J. & Ynag, G. (2012). Conflict of interest and FCTC implementation in China. Tob Control 21(4): 412-415.

[49] Wipfli, H., Avila-Tang, E., Navas-Acien, A., Kim, S., Onicescu, G., Yuan, J., Breysse, P., Samet, J. M. (2008). Secondhand smoke exposure among women and children: evidence from 31 countries. Am J Public Health 98(4): 672-679.

[50] Maziak, W., Ali, R.A., Fouad, M.F., Rastam, S., Wipfli, H., Travers, M.J., Ward K.D. & Eissenberg, T. (2008). Exposure to secondhand smoke at home and in public places in Syria: a developing country's perspective. Inhal Toxicol 20(1): 17-24.

[51] Abidin, E.Z., Semple, S., Omar, A., Rahman, H.A., Turner, S.W., & Ayres, J.G. (2011). A survey of schoolchildren's exposure to secondhand smoke in Malaysia. BMC Public Health 11: 634.

[52] King, B.A., Hyland, A.J., Borland, R., McNeil, A. & Cummings, K.M. (2011). Socioeconomic variation in the prevalence, introduction, retention, and removal of smoke-free policies among smokers: findings from the International Tobacco Control (ITC) Four Country Survey. Int J Environ Res Public Health 8(2): 411-434.

[53] Paulik, E., Maroti-Nagy, A., Nagymajtenyi, L., Rogers, T. & Easterling, D. (2013). The role of home smoking bans in limiting exposure to secondhand tobacco smoke in Hungary. Health Educ Res 28(1): 130-140.

[54] Xiao, L., Yang, Y., Li, Q., Wang, C.X. & Yang, G.H. (2010). Population-based survey of secondhand smoke exposure in China. Biomed Environ Sci 23(6): 430-436.

[55] Wang, C.P., Ma, S.J., Xu, X.F., Wang, J.F., Mei, C.Z. & Yang, G.H. (2009). The prevalence of household second-hand smoke exposure and its correlated factors in six counties of China. Tob Control 18(2): 121-126.

[56] Yao, T., Sung, H.Y., Mao, Z., Hu, T.W. & Max, W. (2012). Secondhand smoke exposure at home in rural China. Cancer Causes Control 23 Suppl 1: 109-115.

[57] Pizacani, B.A., Martin, D.P., Stark, M.J., Koepsell, T.D., Thompson, B. & Diehr, P. (2003). Household smoking bans: which households have them and do they work? Preventive Medicine, vol. 36, no. 1, pp. 99–107.

[58] Wakefield, M., Banham, D., Martin, J., Ruffin, R., McCaul, K. & Badcock, N. (2000). Restrictions on smoking at home and urinary cotinine levels among children with asthma. Am J Prev Med, vol. 19, no. 3, pp. 188–192.

[59] Mills A., Messer K., Gilpin E. & Pierce J. (2009). The effect of smoke-free homes on adult smoking behavior: a review. Nicotine Tobacco Res 2009; 11:1131–41.

[60] Ngok K. (2010). The development and limitations of China's tobacco control policy: A reluctant tobacco control movement.

[61] People's Government of Ningbo. Temporary regulation of smoking ban in public places in Ningbo. Published on May 31, 1996. (In Chinese). Retrieved from http://sifaku.com/falvfagui/27/zc1851a0zd3a.html. Accessed on Apr 9, 2013.

[62] People's Government of Ningbo. Ningbo patriotic health regulations. Approved on Dec 27, 2007. (In Chinese). Retrieved from http://www.cnncy.cn/ningbo/community_news.asp?id=49105&villageid=17. Accessed on Apr 9, 2013.

[63] Xinhua Net. Smokers are everywhere in workplaces. Published on Feb 4, 2008. (In Chinese). Retrieved from http://www.zj.xinhuanet.com/authority/2008-02/04/content_12409415.htm. Accessed on Apr 9, 2013.

[64] Cheng, K.W., Glantz, S.A. & Lightwood, J.M. (2011). Association between smokefree laws and voluntary smokefree-home rules. Am J Prev Med 41(6): 566-572.

[65] Mons, U., Nagelhout, G.E., Allwright, S., Guignard, R., Putte, B., Willemsen, M.C., Fong, G.T., Brenner, H., Potschke-Langer, M. & Breitling, L.P. (2012). Impact of national smoke-free legislation on home smoking bans: findings from the International Tobacco Control Policy Evaluation Project Europe Surveys. Tob Control.

[66] Li, Q., Hyland, A., O'Connor R., Zhao G., Du, L., Li, X. & Fong, G.T. (2010). Support for smoke-free policies among smokers and non-smokers in six cities in China: ITC China Survey. Tob Control 19 Suppl 2: i40-46.

[67] Kegler, M.C., Escoffery, K.C., Bundy, L., Berg, C.J., Haardorfer, R., Yembra, D. & Schauer, G. (2012). "Pilot study results from a brief intervention to create smoke-free homes." J Environ Public Health **2012**: 951426.

[68] Allmark, P., Tod, A.M., McDonnell, A., Al-Alawy, K., Mann, K., Hollis, E., Qutishat, D., Williamson, M. & Iliff, A. (2012). Evaluation of the impact of a smoke-free home initiative in Rotherham, a deprived district in Northern England. Eur J Public Health 22(2): 248-251.

[69] Chellini, E., Gorini, G., Carreras, G; Da noi non si fuma Study (2013). The "Don't smoke in our home" randomized controlled trial to protect children from second-hand smoke exposure at home. Tumori 99(1): 23-29.

[70] Akhtar, P.C., Haw, S.J., Currie, D.B., Zachary, R. & Currie, C.E. (2009). Smoking restrictions in the home and secondhand smoke exposure among primary schoolchildren before and after introduction of the Scottish smoke-free legislation. Tob Control 18(5): 409-415.

[71] Fiore M. C., Jae'n C. R. & Baker T.B. (2008). Treating Tobacco Use and Dependence: 2008 Update. In*Clinical Practice Guideline*. Rockville MD, U.S. Department of Health and Human Services.

[72] Kim, S.S., Chen, W., Kolodziej, M., Wang, X., Wang, V.J. & Ziedonis, D. (2012). A systematic review of smoking cessation intervention studies in China. Nicotine Tob Res **14**(8): 891-899.

[73] Yang, J., Hammond, D., Driezen, P., O'Connor, R.J., Li, Q., Yong, H.H., Fong, G.T. & Jiang, Y. (2011). The use of cessation assistance among smokers from China: Findings from the ITC China Survey. BMC Public Health **11**: 75.

[74] Zhang, J.Y., Chan, S.S., Fong, D.Y., Malone, R.E. & Lam, T. (2012). The social context of smoking cessation in China: an exploratory interview study. Tob Control **21**(1): 57-58.