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The Healthcare Costs of Secondhand Smoke Exposure in Rural China

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Abstract

Objective—The goal of this study was to assess the healthcare costs attributable to secondhand smoke (SHS) exposure among nonsmoking adults (age≥19) in rural China.

Methods—We analyzed data from the 2011 National Rural Household Survey which was conducted among adults in five provinces and one municipality in China (N=12,397). Respondents reported their smoking status, health conditions and healthcare expenditures. Relative risks were obtained from published sources. Healthcare costs included annual outpatient and inpatient hospitalization expenditures for five SHS-related diseases: asthma, breast cancer (female only), heart disease, lung cancer and tuberculosis. SHS-attributable healthcare costs were estimated using a prevalence-based annual cost approach.

Findings—The total healthcare costs of SHS exposure in rural China amounted to $1.2 billion in 2011, including $559.0 million for outpatient visits and $612.4 million for inpatient hospitalizations. The healthcare costs for women and men were $877.1 million and $294.3 million, respectively. Heart disease was the most costly condition for both women ($701.7

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million) and men ($180.6 million). The total healthcare costs of SHS exposure in rural China accounted to 0.3% of China's national healthcare expenditures in 2011. Over one fifth of the total healthcare costs of SHS exposure in rural China were paid by health insurance. The out-of-pocket expenditures per person accounted for almost half (47%) of their daily income.

Conclusion—The adverse health effects of SHS exposure result in a large economic burden in China. Tobacco control policies that reduce SHS exposure could have an impact on reducing healthcare costs in China.

Keywords

secondhand smoke; healthcare costs; rural; China

INTRODUCTION

China is the largest producer and consumer of tobacco in the world. According to the 2010 Global Adult Tobacco Survey, 301 million Chinese adults were current smokers, and the prevalence of smoking among adults in China was 52.9% for men and 2.4% for women in 2010.[1] In addition, a report from the Chinese Center for Disease Control and Prevention indicates that over 556 million adults were exposed to secondhand smoke (SHS) in China in 2010[2], a number which was greater than the number of current smokers.

China's adult smoking prevalence has decreased recently, dropping from 31.1% in 2002[2] to 28.1% in 2010[1]. However, exposure to SHS in China did not decline in the past decade.[2] In rural areas, SHS exposure among those aged 15 years old and above increased substantially from 54.0% in 2002 to 74.2% in 2010.[2,3] A recent study found that 68.0% of children and 67.7% of women living in rural areas were exposed to SHS at home in 2008.[4]

SHS exposure has been linked to several illnesses, including respiratory diseases and other adverse health effects in children, and lung cancer and heart disease in adults.[5,6] The health effects of SHS exposure could result in excess economic costs. A few studies have estimated the economic costs of SHS exposure in China. Leung et al[7] examined the impact and economic costs associated with SHS exposure among infants in Hong Kong with nonsmoking mothers. They found that postnatal exposure to SHS at home was linked to higher rates of hospitalizations for any illness compared with unexposed infants (OR=1.1), leading to 662 extra hospitalizations and $0.9 million excess inpatient costs in 1997. Gan and colleagues[8] estimated the disease burden of SHS exposure among Chinese adults aged 30 or over and found that SHS exposure was responsible for the loss of nearly 230,000 years of healthy life from lung cancer, and more than one quarter of a million years of healthy life from ischemic heart disease (IHD). Li and colleagues[9] estimated that the total cost of SHS exposure in China was 14.5 billion Yuan (US$ 2.1 billion) in 2000, and 29.4 billion Yuan (US$ 4.3 billion) in 2005. No study to date has analyzed the healthcare costs attributable to SHS exposure in rural China. Because persons living in rural China often have lower income levels than urban dwellers, they may suffer a heavier economic burden from SHS exposure. Therefore, estimates of the health-related costs attributable to SHS exposure in rural China are needed to understand the economic impact of SHS exposure, and to motivate policymakers to implement smokefree and other policies to reduce the health and economic

toll. Accordingly, the objective of this study is to estimate the healthcare costs attributable to SHS exposure for nonsmoking adults (age ≥19) in rural China.

METHODS

We used a prevalence-based, disease specific approach to estimate SHS-attributable healthcare costs.

Data Sources

All analyses in this study were conducted using data from the 2011 *National Rural Household Survey (NRHS)*. The NRHS is a nationally representative face-to-face survey of Chinese rural households conducted by the China National Health Development Center in 2011 in five provinces (Qinghai, Anhui, Hubei, Yunnan, Jiangsu), and one municipality (Chongqing) in China. These provinces and municipality cover about one sixth of the geographic area of China with locations around the country, covering a range of rural areas in China. In the five provinces, three rural villages were randomly selected based on different income levels (high, middle and low). In Chongqing, two districts were randomly selected, and three rural villages were then randomly selected in each district.

The head of each household was interviewed, and he/she also reported on behalf of all household members. The questionnaire consisted of three sections with 114 total questions. The following variables from the NRHS were used in our study: (1) gender; (2) smoking status (those who answered 'yes' to the question 'Did you smoke cigarettes in the previous 30 days?' were classified as a 'current smoker'); (3) SHS exposure - defined by whether a participant lived with a current smoker or not; (4) chronic conditions in the past twelve months; (5) disease-specific costs for outpatient visits in the past month, and disease-specific costs for inpatient hospitalizations in the past 12 months; and (6) how much of outpatient visits and inpatient visits was covered by health insurance.

Study sample—A total of 4,249 households (including 13,933 adults aged 19+) were interviewed in 2011. After excluding respondents with missing information on gender, smoking status, chronic conditions and healthcare expenditures, a total of 12,397 adults were included in the final study sample.

Measures

Secondhand smoke exposure—Our study focused on nonsmokers, i.e. those who reported not being current smokers. Though smokers may also suffer harmful health effects from SHS exposure, it is difficult to separate the effects from those due to active smoking. We defined *nonsmokers who are exposed to SHS at* as those nonsmokers who live in a household with at least one current smoker.

SHS-related diseases—We included five SHS-related diseases for adults based on the 2006 Surgeon General's report[5] and the 2005 California Environmental Protection Agency (EPA) report[6]. These diseases are asthma, breast cancer (for females aged 19–50 only), heart disease, lung cancer, and tuberculosis (TB), as shown in Table 1. In the NRHS, respondents could report one to three diseases diagnosed by doctors. Interviewers then recorded these

disease names in the dataset. We considered respondents to have SHS-related diseases if they reported any of the five diseases just discussed.

Relative risks—The relative risk (RR) of a disease from SHS exposure among nonsmokers is defined as the ratio of the disease rate for exposed nonsmokers to the disease rate for unexposed nonsmokers. The RRs of SHS-related diseases were obtained from published studies conducted in China except for asthma. Because RR estimates for asthma have not been published for Chinese population, we used the RR estimates from a Finland study,[10] as cited in the California EPA report.[6] The RRs by disease and gender are shown in Table 1.

SHS-attributable fraction (SAF_{shs})—A smoking-attributable fraction is commonly used for the estimation of health or economic burdens attributable to smoking, such as disease incidence, healthcare utilization, and healthcare expenditures. Similarly, the SHS-attributable fraction (SAF_{shs}) measures the proportion of health or economic burden in the specific population (e.g. nonsmoking adults) that can be attributed to SHS exposure. In this study, the SAF_{shs} for each subgroup stratified by disease (i) and gender (j) was estimated using the standard epidemiological formula (1)[16]:

$$\mathrm{SAF}_{\mathrm{shs,ij}}=[\mathrm{P}_{\mathrm{shs,j}}*(\mathrm{RR}_{\mathrm{shs,ij}}-1)]/[\mathrm{P}_{\mathrm{shs,j}}*(\mathrm{RR}_{\mathrm{shs,ij}}-1)+1] \quad (1)$$

Where

P_{shs} is the prevalence (%) of SHS exposure among nonsmokers;

RR_{shs} is the relative risk of illness for nonsmokers who were exposed to SHS compared to those who were not exposed.

Healthcare Costs

In this study, healthcare costs include expenditures for outpatient visits and inpatient hospital stays. Outpatient visits included ambulatory care visits at outpatient departments of hospitals and doctor visits at clinics. Expenditures for prescribed medicine during the outpatient visits or inpatient stays were included in the respective outpatient or inpatient expenditure categories. In the NRHS, respondents were asked to report (1) the average outpatient expenditures per month for each disease treated in the past 6 months, and (2) the disease name and total inpatient expenditures, including out-of-pocket payment and insurance payment, for the most recent hospitalization stay during the past 12 months. The SHS-attributable healthcare costs *(SAE_{shs})* among the rural population was estimated by disease (i) and gender (j) by multiplying the SAF by the total healthcare expenditures (THE) for the nonsmoking rural population according to the following formula:

$$\begin{aligned}\mathrm{SAE}_{\mathrm{shs,ij}}&=\mathrm{THE}_{\mathrm{ij}}*\mathrm{SAF}_{\mathrm{shs,ij}}\\&=\mathrm{POP}_{\mathrm{j}}*\mathrm{P}_{\mathrm{NS,j}}*\mathrm{DRATE}_{\mathrm{ij}}*(\mathrm{INPX}_{\mathrm{ij}}+\mathrm{OUTX}_{\mathrm{ij}}*12)*\mathrm{SAF}_{\mathrm{shs,ij}}\end{aligned} \quad (2)$$

where POP denotes the rural adult population aged ≥19; P_{NS} is the percentage of rural adults who were nonsmokers; DRATE is the disease prevalence rate among nonsmoking rural

adults; INPX denotes the average annual inpatient expenditures per person among rural nonsmoking adults who had that SHS-related disease; and OUTX denotes the average monthly outpatient expenditures per person among rural nonsmoking adults who had that SHS-related disease. POP was obtained from the 2011 Statistical Yearbook,[17] all other variables were estimated from the 2011 NRSH data.

Health Insurance Coverage

In the NRHS, respondents were asked to report the annual outpatient expenditures covered by health insurance for each disease treated in the past 6 months and the inpatient expenditures covered by health insurance for the most recent hospitalization stay during the past 12 months. We first calculated the mean value of health insurance-covered costs for each disease and then appled them to formula (2) to get the costs covered by health insurance among total SHS-attributable costs.

Sensitivity Analysis

Three sensitivity analyses were conducted. The first one was performed based on the lower bound and upper bound of the 95% confidence intervals of RR estimates in Table 1. The second one was performed using the RRs of SHS-related diseases estimated from US studies[5–6, 18–19] except for asthma, because US RR estimates for asthma were not available. The third one was performed by using published disease rates for the Chinese population.[20–22] This was done because the disease rates reported in the NRHS are lower than those generally published.

RESULTS

Number of nonsmoking adults living in rural China

The final study sample of the 2011 NRHS had nearly equal numbers of men and women, as shown in Table 2. Women were much more likely to be nonsmokers, and among nonsmokers, the prevalence of SHS exposure was 62.2% for women and 35.0% for men.

Number of persons with SHS-related diseases among nonsmoking adults in rural China

Table 3 shows the number and disease rates of SHS-related diseases in rural China by gender, type of healthcare service used, and disease. Both outpatient visits and inpatient hospitalization were most often reported by people with heart disease (especially women), followed by TB and asthma. There were no inpatient hospitalizations reported for lung cancer or breast cancer.

SHS-attributable healthcare costs among nonsmokers in rural China

The Table 4 shows the estimated SAF_{shs} by gender, disease, and healthcare service type. The SAF_{shs} values for all diseases were larger for women than men. Asthma had the highest disease-specific SAF_{shs} for both women (0.38) and men (0.25), while lung cancer showed the lowest SAF_{shs} for both women (0.07) and men (0.04). Table 4 also shows the healthcare costs of SHS exposure at by gender, disease, and healthcare service type estimated as the product of total number of persons with SHS-related disease, the average annualized costs

per person with the SHS-realted disease, and the SAF_{shs}. The total healthcare costs of SHS exposure in rural China in 2011 amounted to $1.2 billion: $559.0 million for outpatient visits and $612.4 million for inpatient hospitalizations. The total cost for women ($877.1 million) was almost three times as high as the cost for men ($294.3 million). For women, heart disease was the most costly disease ($701.7 million), followed by TB ($90.6 million), asthma ($44.5 million), breast cancer ($40.2 million), and lung cancer ($0.1 million). For men, the results showed a similar pattern: heart disease was the most costly disease ($180.6 million), followed by TB ($70.3 million), asthma ($41.9 million) and lung cancer ($1.5 million). About one fifth of healthcare costs ($237.7 million) were coverd by health insurance, including $28.5 millon for outpatient visits and $209.2 million for inpatient visits.

Sensitivity Analyses

The Table 5 shows the total healthcare costs of SHS exposure in rural China in 2011 ranged from $573.6 million to $1.7 billion using upper and lower bounds of the RR estimates. Costs almost doubled ($2.1 billion) when using the RRs for the US population and slightly increased to $1.22 billion when using published disease rates for the Chinese population.

DISCUSSION

Our findings indicate that SHS exposure in rural China imposes a large economic burden ($1.2 billion) for China, accounting for 0.02% of China's GDP ($6.7 trillion in 2011[17]) and 0.3% of the national health care expenditures in 2011($385 billion in 2011[17]). Given the total rural population of 650 million in 2011,[17] this amounted to $1.80 per person in China. Nearly three quarters of the total healthcare cost of SHS exposure in rural China was for women because a majority of women are nonsmokers who live with smokers. Over one fifth of the total healthcare cost of SHS exposure in rural China was paid by health insurance. The out-of-pocket expenditures per person ($1.44) accounted for almost half (47%) of their daily income ($3.03) in rural China.

Our estimates likely underestimated the economic burden of SHS exposure for several reasons. First, our calculation only included five SHS-related diseases for adults. Children are also vulnerable to SHS exposure and suffer from diseases that are related to SHS exposure including low birth weight[6], middle ear disease[6], and attention deficit hyperactivity disorder.[23] According to the SHS exposure rate for Children (68%) in rural China[4], we estimated that about 100.4 million children were exposed to SHS in rural China in 2011. Therefore, the total costs would be much higher if the costs of children's SHS exposure could be also included. Second, our study was limited to direct healthcare costs only. Future studies that include indirect morbidity and mortality costs attributable to SHS exposure are needed. Third, besides the home environment, people are also exposed to SHS in workplaces and public places. A recent report found that 73% and 63% of Chinese were exposed to SHS in public places and workplaces in 2010,[2] respectively. However, we were not able to separate the impact of SHS exposure at home from exposure in other settings. Fourth, our study is based on self-reported data and only the head of household was interviewed, which may create recall bias. Fifth, the RRs we used were lower than those from western countries. For example, the RR of heart disease among men was 1.22 for the

Chinese population compared to 1.50 for the U.S population.[5] The RR of TB was 1.55 for the Chinese population compared to 2.33 for the U.S population.[19] According to the sensitivity analysis which assumed the RRs for the US population, we found that the estimated total healthcare costs of attributable to SHS in rural China would almost double from $1.2 billion to $2.1 billion if we used the US RRs, and the costs would then account for 0.6% of China's national health care expenditures in 2011. The higher RRs in the US population reflect a more mature epidemic of smoking, and suggest that risks of smoking-related disease in China may increase in the future. Sixth, very few cases of SHS-related diseases were reported in the NRHS, with the exception of heart disease. It is possible that these diseases were underreported due to the lack of a formal diagnosis. Therefore, we conducted another sensitivity analysis using disease rates from published Chinese studies and found that the estimated SHS-attributable total healthcare costs in rural China increased to $1.22 billion. In addition, the rate of outpatient visits for heart disease in our study was much higher than that from a published Chinese study (2.89% vs. 0.77%). This might be because the latter study included all of China and our study focuses only on rural areas. More studies are needed to address this. Finally, the relative risks used in this study were based on findings from previous studies which did not control for exposure to air pollution. This may cause an upward bias of our estimated SHS-attributable fractions and healthcare costs.

The study by Yang et al. provided the most recent estimate of the total healthcare cost of active smoking in China at $6.2 billion in 2008, including $2.8 billion for urban areas and $3.4 billion for rural areas.[24] Converting these estimates into 2011 dollars using the Consumer Price Index (105.9 in 2008 and 105.4 in 2011),[17] the healthcare cost of active smoking for rural China would be $3.38 billion. Therefore, our estimated healthcare cost attributable to SHS exposure was more than one-third of the cost of active smoking in rural areas. The ratio of SHS costs to active smoking costs in our study was higher than a study conducted in Hong Kong, which reported a ratio of 29%.[25] Our study demonstrates that the true impact of smoking on healthcare costs in rural areas would be one third higher than the estimates by Yang et al. [24] when the burden of SHS exposure is included. Given that the majority of women and children are nonsmokers and exposed to SHS in rural China, tobacco control interventions that reduce SHS exposure are needed.

This research serves as a starting point for a comprehensive assessment of the health and economic impact of SHS exposure in China. The findings provide useful evidence for policymakers who are developing interventions to reduce SHS exposure and increase public awareness in China.

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What this paper adds

What is already known on this subject

- SHS exposure rate increased substantially in tha past decade in China. SHS exposure has been linked to several illnesses.
- No study to date has analyzed the healthcare costs attributable to SHS exposure in rural China

What important gaps in knowledge exist on this topic

- This study is the first to estimate the healthcare costs of SHS exposure in rural China.

What this study adds

- We found that the healthcare costs of SHS exposure at constitute a large economic burden to China.
- Our findings demonstrate the importance of implementation of tobacco control policies that reduce SHS exposure in rural China as a means of reducing healthcare costs.

Table 1

Relative risk of SHS-related diseases

SHS-Related Disease	ICD-9 Code	Relative Risks (95% CI)		Country of study	Source
		Female	Male		
Asthma	493	1.97 (1.19, 3.25)	1.97 (1.19–3.25)	Finland	Jaakkola et al[10]
Breast cancer (female)	174	1.60 (1.00–2.40)	N/A	China	Shrubsole et al[11]
Heart disease	410–414	1.24 (1.15–1.34)	1.22 (1.10–1.35)	China	He et al[12,13]
Lung cancer	162	1.13 (1.05–1.21)	1.13 (1.05–1.21)	China	Zhao et al[14]
TB	011	1.55 (1.01–2.40)	1.55 (1.01–2.40)	China	Dong et al[15]

Note: TB=tuberculosis

Table 2

Prevalence of nonsmoking and number of nonsmoking adults living in rural China, 2011

	Percentage of adults who are nonsmokers from NRHS	Number of adults living in rural China in 2011* (millions)	Number of nonsmoking adults in rural China (million)
Female	97.8	245.04	239.65
Male	47.6	257.29	122.47

* Source: China Statistical Yearbook, 2012 [17]

Table 3

Disease prevalence rate and number of persons with SHS-related diseases among nonsmoking adults in rural China, 2011

	Disease rate* (%)			Number of persons with SHS-related diseases among non-smoking adults in rural China (1,000)**		
	Female (N=6,139)	Male (N=2,919)	Total	Female	Male	Total
Outpatient Visits						
Asthma	0.15	0.17	0.15	359	208	551
Breast cancer (female)	0.03	N/A	0.03	72	0	110
Heart disease	3.31	2.02	2.89	7,932	2,474	10,612
Lung cancer	0.02	0.03	0.02	48	37	73
TB	0.11	0.27	0.17	264	331	624
Inpatient Hospitalizations						
Asthma	0.03	0.10	0.06	72	122	220
Breast cancer (female)	0	N/A	0	0	N/A	0
Heart disease	0.83	0.69	0.78	1,989	845	2,864
Lung cancer	0	0	0	0	0	0
TB	0.03	0.14	0.07	72	171	257

* Data source: NRHS survey.

** Derived by multiplying “Disease rate” (1st column in Table 3) and “Number of nonsmoking adults in rural China” (last column in Table 2).

Table 4

SHS-attributable fraction (SAF_{shs}) and SHS-attributable healthcare costs among nonsmokers in rural China, 2011

SHS-related diseases	SAFSHS		Average annual healthcare cost per person with the SHS-related disease ($)*		Cost attributable to SHS exposure ($ million)**		Total SHS-attributable cost ($ million)	Costs coverd by health insurance ($ million)
	Female	Male	Female	Male	Female	Male		
Outpatient								
Asthma	0.38	0.25	246	183	33.3	9.7	42.9	2.2
Breast cancer	0.27	N/A	2,057	N/A	40.2	N/A	40.2	2.0
Heart disease	0.13	0.07	349	362	359.6	64.0	423.6	21.7
Lung cancer	0.07	0.04	38	952	0.1	1.5	1.7	0.1
TB	0.25	0.16	371	481	24.9	25.7	50.6	2.5
Subtotal					458.1	100.9	559.0	28.5
Inpatient								
Asthma	0.38	0.25	413	1,037	11.2	32.2	43.4	14.7
Breast cancer	0.27	N/A	0	N/A	0.0	N/A	0.0	0.0
Heart disease	0.13	0.07	1,324	1,930	342.1	116.6	458.7	156.7
Lung cancer	0.07	0.04	0	0	0.0	0.0	0.0	0.0
TB	0.25	0.16	3,587	1,611	65.7	44.6	110.3	37.6
Subtotal					419.0	193.4	612.4	209.2
Total					877.1	294.3	1,171.4	237.7

* Note: 1 US$ = 6.3 Yuan (exchange rate in 2011)

** It equals the product of the number of persons with of SHS-related diseases (last column of Table 3), average annualized cost per person with the SHS-realted disease, and the SAF_{shs}, according to Equation (2).

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Table 5

Sensitive analyses of SHS-attributable healthcare costs among nonsmokers in rural China, 2011

SHS-Related Disease	From NRHS	From Sensitivity Analysis 1		From Sensitivity Analysis 2			From Sensitivity Analysis 3	
	Cost attributable to SHS exposure ($ million)	Cost attributable to SHS exposure ($ million)	Cost attributable to SHS exposure ($ million)	Using the Relative Risk (95% CI) for US Population		Cost attributable to SHS exposure ($ million)	Using published disease rates for the Chinese population (%)	Cost attributable to of SHS exposure ($ million)
		Lower bound of RR	Upper bound of RR	Female	Male			
Outpatient								
Asthma	42.9	11.7	68.4	1.97 (1.19, 3.25)[10]	1.97 (1.19–3.25)[10]	42.9	0.16[19]	44.6
Breast cancer	40.2	0	68.8	1.68 (1.31–2.15)[6]	N/A	44.0	0.21[20]	281.3
Heart disease	423.6	266.5	581.0	1.50 (1.04–1.60)[5]	1.50 (1.04–1.60)[5]	790.1	0.77[19]	108.1
Lung cancer	1.7	0.7	2.6	1.29 (1.04–1.60)[6]	1.29 (1.04–1.60)[6]	3.5	0.04[21]	2.3
TB	50.6	1.2	97.8	2.33 (1.97–2.75)[19]	2.33 (1.97–2.75)[19]	94.8	0.08[22]	25.7
Subtotal	559.0	280.1	818.6			975.3		462.0
Inpatient								
Asthma	43.4	11.1	73.3	1.97 (1.19, 3.25)[10]	1.97 (1.19–3.25)[10]	43.4	0.16[19]	111.1
Breast cancer	0.0	0	0	1.68 (1.31–2.15)[6]	N/A	0.0	0.21[20]	0.0
Heart disease	458.7	279.9	637.7	1.50 (1.04–1.60)[5]	1.50 (1.04–1.60)[5]	867.6	0.77[19]	447.5
Lung cancer	0.0	0	0	1.29 (1.04–1.60)[6]	1.29 (1.04–1.60)[6]	0.0	0.04[21]	0.0
TB	110.3	2.6	210.9	2.33 (1.97–2.75)[18]	2.33 (1.97–2.75)[18]	204.5	0.08[22]	200.8
Subtotal	612.4	293.5	921.9			1,115.5		759.3
Total	1,171.4	573.6	1,740.0			2,090.8		1,221.4