Do smoke-free laws or policies impact smoking at home? A comparison between smoke-free and nonsmoke-free jurisdiction in India

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ABSTRACT

Background: Globally, various studies have looked at the effect of smoke-free declaration in public spaces on secondhand smoke (SHS) exposure at home. However, a formal evaluation has not been reported from India. We assessed and compared smoking at home in two jurisdictions in India—a compliance-validated smoke-free jurisdiction (Shimla in 2010) versus a nonsmoke-free jurisdiction (Haridwar) between 2009 and 2015.

Methods: We randomly sampled 247 households (with one smoker at least as on October 2009) each in Shimla (n = 123) and Haridwar (n = 124) during July–August 2015. Through an interviewer-administered questionnaire, information on number of bidi/cigarette smoked per day in the household (at home and at work) was collected from the smoking member across five time points: 2009, 2010, 2011, 2012, and 2015. From the nonsmoking member, we collected information regarding change in number of smokes per day and change in place of smoking in the household before and after 2010. We fitted a mixed effects maximum likelihood regression using random intercepts model for the effect of smoke-free declaration on number of smokes per day by the household adjusted for baseline differences, secular trends, clustering of data, and other potential confounders (time/year, number of children, number of adults, annual household income, and type of tobacco).

Results: Introduction of smoke-free declaration in Shimla resulted in a decrease (over 1 year) of 1.24 (0.95 confidence interval [CI]: 0.8, 1.7), 0.55 (0.95 CI: 0.14, 0.96), and 0.98 (0.95 CI: 0.3, 1.6) bidi/cigarette smoked per day per household at home, at work, and at “work and home combined,” respectively. Within homes, when compared to Haridwar, there was an improved desirable behavior such as reduction in smoking within home and increase in smoking outside home in Shimla (reported by nonsmoking member).

Conclusion: Smoke-free laws in public spaces in Shimla, India, were associated with the reduction in SHS exposure at home.

Keywords: Antismoking law, environmental tobacco smoke, secondhand smoke, Section 4 of Cigarettes and Other Tobacco Products Act, smoke-free legislation

Introduction

According to the recently concluded (GATS-India 2016–2017), tobacco use is a major public health challenge in India, with 267 million adults consuming different tobacco products.¹ Secondhand smoke (SHS) exposure in 2004 caused an estimated 0.6 million deaths, which was about 1% of worldwide mortality.

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Forty-seven percent of deaths from SHS occurred in women, 28% in children, and 26% in men. Every year, exposure to SHS causes over 600,000 premature deaths worldwide. Between GATS-India 2009–2010 and GATS-India 2016–2017, though there was a reduction in exposure to SHS at any public place (29%–23%) and at home (52%–39%), still a large proportion of adults remained exposed.

The Government of India has taken various initiatives for tobacco control in the country. India was among the first few countries to ratify the WHO Framework Convention on Tobacco Control in 2004. India enacted the comprehensive tobacco control legislation – The Cigarettes and Other Tobacco Products Act (COTPA). Section 4 of COTPA (2003 Act and its rules 2008) prohibits smoking in public places with the aim to protect people from SHS exposure. Since the rules came into force, many jurisdictions have been declared smoke-free, formal assessments of which have been done through compliance assessment studies using a protocol developed jointly by Johns Hopkins Bloomberg School of Public Health, International Union Against Tuberculosis and Lung Disease (The Union), and Campaign for Tobacco-Free Kids. The compliance across the jurisdictions to this section is variable. While Section 4 of the COTPA legislation concerns itself with smoking in public places, potential fallout of implementation could be a compensatory increase in smoking at home and increase SHS exposures of family members. It is however expected that the other tobacco control efforts would encourage people to decrease overall smoking and this potential issue is averted.

Globally, various studies have looked at the effect of smoke-free laws on SHS at home. Some studies have found no effect or found that it does not increase SHS at home. Studies have also shown that smoke-free environment at home also improves when a jurisdiction adopts smoke-free policies at public and workplaces. A formal evaluation of this has not been reported from India.

The current research has been planned to study the effect of smoke-free policies and their effect on SHS exposure at home in India. We assessed and compared changes (trends) in quantity of smoking (total, at work, and at home) and smoking behaviors in two jurisdictions during 2009–2015, one which had been declared smoke-free in 2010 (Shimla) and another which had not (Haridwar).

Methods

Study design

This was an observational study using a before-and-after design with a comparison.

Study settings

Shimla city (smoke-free jurisdiction) and Haridwar (nonsmoke-free jurisdiction) were the study sites [Figure 1]. Shimla is the capital of Himachal Pradesh, a state in North India. The prevalence of tobacco use among adults in Himachal Pradesh is about 21%, which can further be categorized as those who only smoke (17%), use smokeless tobacco only (3%), and use both smoke and smokeless tobacco (2%). In Himachal Pradesh, exposure to SHS among adults at home was about 83% while at work was 18% in the GATS-2009 survey. Shimla city is spread over an undulating altitude of average 2397 m (7864 feet) above sea level and stretches nearly 9.2 km (5.7 mi) from east to west. Shimla city has a population of 169,758 and a population density of 120 inhabitants per square kilometer. The literacy rate is 84%. Approximately 39% males and 4% females in Shimla are considered as current tobacco users.

Himachal Pradesh is one of the progressive states when it comes to tobacco control due to proactive approach of the Department of Health and Family Welfare of Government of Himachal Pradesh. Its efforts were further facilitated by

Figure 1: Map of India showing Shimla and Haridwar in India
the fact that Himachal Pradesh got grant support provided by the Bloomberg Initiative (The Union) in tobacco control.[19] Ban on gutka (a smokeless form of tobacco), raising of state-level value-added tax on tobacco products, and comprehensive enforcement of other provisions of COTPA such as banning tobacco advertisements have helped attain smoke-free status in the state.

On October 2, 2010, all public places in Shimla were declared smoke-free after a third party compliance study. The entire Himachal Pradesh state was declared smoke-free on July 2, 2013. A compliance study entails conformance to four provisions of smoke-free rules, as per the COTPA – these are absence of active smoking in public places; absence of bidi or cigarette butts in and around public places; absence of smoking aids such as ashtrays and matchboxes; and presence of designated signage which declares that smoking here is an offense.

Haridwar, a city in the state of Uttarakhand, has a population of 225,235 and a population density of 801 inhabitants per square kilometer. The literacy rate is 82%. Compared to Himachal Pradesh, tobacco control enforcement activities are at initial stages in Haridwar and other parts of Uttarakhand. The prevalence of current tobacco use among adults in Uttarakhand was 31% in the GATS-2009 survey: 44% among males and 6% among females. Nineteen percent of the adult population used only smoked tobacco, 9% used only smokeless tobacco, whereas 3% used both smoke and smokeless forms of tobacco. The exposure to SHS among adults at home was about 85% while at work was 24%.[4]

Study population
Households in Shimla city (city was smoke-free since October 2010) and Haridwar city (did not achieve the status of smoke-free) with at least one smoker as on October 2009 were the study population [Box 1].

Data collection
Sample size
A sample size of 120 households containing smoker(s) of either sex (each in Shimla and Haridwar) was finalized.

Box 1: Operational definition of household and secondhand smoke exposure at home
Household: A group of persons who normally live together and take their meals from a common kitchen unless the exigencies of work prevent any of them from doing so. Persons in a household may be related or unrelated or a mix of both.

Exposure to SHS at home: The total number of cigarettes/bidis smoked per day by the members of the household at home. If there was more than one smoker in the household, the number of smokes of each smoker would be added up to calculate the SHS exposure at home. Smoking at home does not include areas outside such as patios, balcony, and garden.

Each household contributed to five study points (as outcome data were collected for five time points for every household). This was sufficient to measure an absolute difference of 1.25 smokes per day (difference in change in number of bidis/cigarette smoked per day per household) over a year when a jurisdiction changed to smoke-free and a design effect of two (considering clustering due to repeat measures among households).

Sampling procedure
Data collection was done from July to August 2015. Shimla city had 25 wards, while Haridwar city had 30 wards. On the basis of per capita annual household income, wards were further categorized into low-, middle-, and high-income groups by the municipal corporation. Randomly, one ward was selected from each of the above three income categories. In the selected ward, a central location was identified. From the central location, a random street was identified by spinning a bottle. In the selected street, a list of households was prepared while excluding religious buildings, community centers, parks, hospitals, schools, restaurants, and hotels, and using systematic random sampling, forty households were identified for inclusion in the survey and visited by the survey team.

In each selected household, the interviewers assessed the eligibility of the household. A household was eligible if at least one member of that household was a smoker as on October 2009. An eligible adult household member was offered participation in the study and was requested to fill informed consent form. If no household member smoked, or consent was not received, the interviewer proceeded to the adjacent higher numbered household and the process continued till an eligible household has been identified. No revisits were made in case a home was locked. Interviews continued till 40 households with smokers were surveyed.

Interview process
In Shimla and Haridwar, data collection was conducted by the field investigators of Himachal Pradesh Voluntary Health Association (HPVHA) and Balajee Sewa Sansthan, respectively. The field investigators were trained on making observation and recording and reporting methods at each site by one of the coauthors (RJS); however, they were not aware of the study hypothesis.

Data variables and source of data
After obtaining informed consent, two different interviewer-administered pretested questionnaires were filled: one for a smoking member and another for a nonsmoking member [Supplementary Material Annexure]. All these provided details were further cross-checked or
verified by any available responsible adult member of the household.

Smoking history, segregated by workplace and at home, was collected to assess number of bidis/cigarette smoked per day by the household at time of interview (2015), at the time of smoke-free declaration (i.e., October 2010), 1 year before declaration (i.e., October 2009), and two consecutive years after declaration (i.e., October 2011 and October 2012). One household could have more than one smoker. In such case, usage of cigarettes/bidis among all smokers was added to determine number of bidis/cigarette smoked per day by the household at home and at work.

Additional data collected at time of the interview from the smoking family member were as follows: number of family members (including children), annual household income, type of ward (low, middle, high income), and form of tobacco smoked (cigarette/bidi/both). Details regarding change in bidis/cigarette smoked per day and change in place of smoking in the household before and after 2010 were obtained from the nonsmoking family member to validate the findings.

**Data entry and analysis**

Data collected were double-entered and validated using EpiData entry software (version 3.1, EpiData Association, Odense, Denmark). Data analysis was done using STATA (version 12.1, StataCorp LP, College Station, TX, USA, serial number: 30120504773).

Characteristics of the households were summarized using frequency, proportion, means, and standard deviation. Trends of mean cigarette/bidis smoked per day per household in Shimla and Haridwar across the five time points were visualized using a line diagram. Changes in smoking behavior at home in 2015 (with reference to 2009) among smokers of households in Shimla and Haridwar, as reported by nonsmoking member of the household, were summarized using frequency and proportions.

The primary outcome was change in intensity of smoking (average number of cigarettes/bidis smoked per day per household) at home that was attributable to smoke-free declaration. Number of cigarettes/bidis smoked per day by a household was a surrogate indicator for SHS exposure at home [Box 1].

We fitted a mixed effects ML regression using random intercepts model for the association between smoke-free declaration and number of bidis/cigarette smoked per day by the household: total and stratified by at home and at work (total three models). The association was summarized and inferred using beta (β) coefficients and 0.95 confidence intervals (CIs), respectively. Variables with unadjusted \( P < 0.1 \) were considered in the model which was built using forward stepwise method. The initial multilevel model was fitted after including variables that had unadjusted \( P < 0.05 \). Addition of the variable “number of adult family members” (unadjusted \( P = 0.05 \)) did not significantly improve the model (assessed using likelihood ratio test). The final model was average number of cigarettes/bidis smoked per day per household = constant + \( \beta_1 \times \) smoke-free declaration + \( \beta_2 \times \) tobacco form + \( \beta_3 \times \) number of children + \( \beta_4 \times \) annual household income + \( \beta_5 \times \) time with a random intercept for household. This equation was consistent for all the three models (smokes per day: total, at home, and at work). We assumed that the between- and within-household effects of smoke-free declaration were similar after adjustment for baseline differences among households, for clustering at the level of household (repeat measurements in the same households over time), and for confounding effect of time period.

**Ethics**

Ethics approval was obtained from the Ethics Advisory Group of The Union, Paris, France (EAG No 40/15). Administrative approval from relevant authorities was obtained before the implementation of the study. Before interview, written informed consent was obtained from the smoking and nonsmoking member of the household. The process of written informed consent was approved by the Ethics Committee. Procedures followed were in line with the ethical standards of the Ethics Committee and with the Declaration of Helsinki, 1975 (as revised in 2000).

**Results**

Of 247 households included in the study, 123 (50%) and 124 (50%) were from Shimla and Haridwar, respectively. Their baseline characteristics have been summarized in Table 1.

Trends of mean cigarettes or bidis smoked per day by the household at work, at home, and at work and home combined are depicted in Figure 2. Mean cigarettes or bidis smoked per day per household were consistently higher in Shimla between 2009 and 2012. After 2010, there were a consistent decreasing trend in Shimla and a consistent increasing trend in Haridwar. At home, the mean cigarettes or bidis smoked per day per household in 2015 were lower in Shimla when compared to Haridwar.
Table 2 depicts the change in smoking behavior at home in 2015 when compared to 2009. In Shimla, the proportion of households with decreased smoking was significantly higher when compared to Haridwar. Continuation of desirable behavior (smoking outside home) and discontinuation of undesirable behavior (smoking inside home) were significantly higher in Shimla than Haridwar.

After adjusting for form of tobacco, number of children at home, annual household income, and time, smoke-free declaration in Shimla was associated with a significant reduction in mean cigarettes or bidis smoked per day per household: at home, at work, and at work and home combined. The effect was highest on mean cigarettes or bidis smoked per day at home. Introduction of smoke-free declaration was associated with a decrease (over 1 year) of 1.25 cigarettes or bidis smoked per day. Smoking both bidi and cigarette, number of children in household, and annual household income (Indian Rupees [INR]) more than 500,000 also had an independent effect on mean cigarettes or bidis smoked per day per household [Tables 3-5].

Discussion

Summary of key findings
Shimla was declared smoke-free in 2010. Among smokers, this declaration was associated with a reduction in smoking not only at workplaces but also at home. Within home also, there was an improved desirable behavior such as reduction in smoking within home and increase in smoking outside home (say on terrace). We identified other independent predictors of mean cigarettes or bidis smoked per day by a household. With increasing number of children in a household, there was a decrease in number of cigarette or bidis smoked. Household with higher annual income showed significantly higher reduction, while households using both forms of tobacco showed significantly higher increase in mean cigarettes or bidis smoked per day.

There were many key findings. First, smoke-free declaration possibly had an effect on smoking at home as well as at workplace. The former would result in reduced SHS exposure at home and probably reduced SHS exposure to children (there were two children per household). SHS exposure to smoke among children is
Table 2: Change in smoking behavior at home in 2015 (with reference to 2009) among smokers of households in Shimla and Haridwar, as reported by nonsmoking member of the household

| Variable | Haridwar, n (%) | Shimla*, n (%) | P* |
|----------|----------------|----------------|----|
| Total    | 124 (100)      | 123 (100)      |    |
| Change in quantity of smoking* | | | |
| Increased smoking now | 59 (48) | 24 (20) | <0.001 |
| Decreased smoking now | 32 (26) | 73 (62) |    |
| No change | 32 (26) | 21 (18) |    |
| Change in place of smoking at home** | | | |
| Smoked inside home, now outside | 55 (45) | 59 (50) | 0.04 |
| Smoked inside home, now inside | 37 (30) | 37 (31) |    |
| Smoked outside home, now outside | 17 (14) | 20 (17) |    |
| Smoked outside home, now inside | 15 (12) | 3 (3) |    |

Shimla was declared smoke-free in 2010, * Column percentages, *Chi-square test, *Missing data for six households (one in Haridwar and five in Shimla), **Missing data for four households in Shimla

Table 3: Random intercepts model for effect of smoke-free declaration in Shimla on number (at work and home combined) of cigarette/bidi smoked per household per day after adjusting clustering effect of households (repeated measures within households), India (2009-2015)*

| Variable | β coefficient | 95% CI | P |
|----------|---------------|-------|---|
| Smoke-free declaration | | | |
| Yes | −0.98 | −1.6−−0.3 | 0.003 |
| No | Reference | Reference | Reference |
| Tobacco form | | | |
| Cigarette | Reference | Reference | Reference |
| Bidi | 0.37 | −0.8−1.6 | 0.55 |
| Both | 4.2 | 2.5-5.9 | <0.001 |
| Annual household income (INR) | | | |
| <100,000 | Reference | Reference | Reference |
| 100,000-500,000 | −1.1 | −2.4−0.3 | 0.13 |
| 500,001-1,500,000 | −3.82 | −5.2−−2.5 | <0.001 |
| ≥1,500,001 | −3.2 | −6.7−0.3 | 0.076 |
| Number of children in household | | | |
| <1.1 | −1.5−−0.7 | <0.001 |
| Time | −0.05 | −0.1−0.03 | 0.246 |
| Constant | 12.1 | 10.6-13.6 | <0.001 |

*Shimla city was considered as smoke-free declaration (yes) between 2010 and 2015. Shimla in 2009 and Haridwar between 2009 and 2015 were considered as smoke-free declaration (no). CI - Confidence interval, INR - Indian Rupees

Important because this group has no choice in accepting or not accepting the SHS exposure-derived risk. In Spain, smoke-free legislation in 2011 neither had an effect on SHS exposure at home among nonsmoking adults nor on children. Smoke-free legislation in Wales (2007) did not reduce the SHS exposure at home among children. In England, ban on public indoor and workplace smoking reduced smoking among adults at home but did not have an effect on reduction in damaging level of exposure to SHS among children. In Scotland, Ireland, France, Netherland, and Germany, it resulted in increase in total home smoke.

Second, in our study, households with high annual income (more than 500,000 INR) had relatively higher decrease in smokes at home when compared to those with low annual income (less than 100,000 INR). In Wales, though a decrease in smoking at home was observed post-smoke-free declaration, smoking continued in cars or at homes of children from poor families. In Taiwan as well, SHS exposure at home increased among families from lower socioeconomic status. In Wisconsin, percentage of households with a no smoking policy within 1 year of smoke-free legislation was higher among wealthier households.

Third, in our study, the declaration had an effect over 5 years in reducing SHS exposure at home and may still be continuing. We collected information on smoking for 5 years after the smoke-free declaration. Some studies have looked at the effect of smoke-free declaration over 1 year period and recommended longer follow-up periods.

Strengths and limitations
This study has several strengths. First, the data collected were reliable as the information from nonsmoking members of the household [Table 2] corresponded with the information collected from smoking member of the household [Figure 1]. The analysis was robust as there was a control arm and the effect of smoke-free declaration on mean cigarettes or bidis smoked per day per household was adjusted for baseline differences, secular trends, clustering of data, and other potential confounders. As double-data entry and validation were done, data included for analysis were robust and free of data entry errors.

This study had some limitations. Though the data were longitudinal, the information was not collected prospectively and therefore might have suffered from recall limitation. However, we expect this to be nondifferential across groups. Hence, we hope that this might not have
had an impact on the effect estimates. The other major limitation was social desirability bias – respondents tend to provide socially desirable answers – a smoker knowing very well that it is desirable to reduce smoking (in general and reinforced by our informed consent process) may respond favorably. However, information from nonsmoking members of the family validated our findings. There were other variables that could have affected smoking (either reduction or increase) among smokers which were not collected, such as access to cessation services, exposure to health pack warning and other health warning-related tobacco use, tobacco taxes, and enforcement of legislation. The SHS exposure at home was measured through a surrogate marker (average smokes per day by the household at home), unlike other studies globally that have used salivary/urinary cotinine levels. We could have also compared the overall compliance of COTPA in two selected places to have a better perspective.

### Conclusion

Limitations notwithstanding, smoke-free laws or policies in Shimla city of Himachal Pradesh state, India, probably reduced SHS exposure at home. The findings are reliable and robust. This has implications for other parts of the country to strongly enforce Section 4 of COTPA.

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### Conflicts of interest

There are no conflicts of interest.

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