Evaluating the efficacy of different smoking policies in restaurants and bars in Beijing, China: A four-year follow-up study

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ABSTRACT

Introduction: In 2006, the World Health Organization Framework Convention on Tobacco Control became effective in mainland China. In 2007, advocacy on voluntary smoking bans in restaurants was initiated in Beijing, and in 2008 the Beijing government implemented a smoking regulation, requiring big restaurants to prohibit or restrict smoking.

Objectives: To evaluate the efficacy of different smoking policies adopted by Beijing restaurants and bars from 2006 to 2010.

Methods: The study conducted field observations of patron smoking behavior and monitored fine particulate matter from secondhand smoke (SHS PM) from 91, 85, 94 and 79 Beijing restaurants and bars in 2006, 2007, 2008 and 2010, respectively, during peak-patronage times, with overlaps of venues during each two years. Area nicotine sampling during peak patronage times and servers’ personal nicotine sampling during their working shifts were also conducted in 2010.

Results: Smoking was nominally prohibited or restricted in 18% of restaurants and bars monitored in 2006, in 11% of venues in 2007, in 83% of venues in 2008, and in 69% of venues in 2010. However, smoking was observed in more than 40% of the nominal nonsmoking venues/sections in 2006 and 2010. The median of observed patron active smoker density (ASD) was 0.24, 0.27, 0.00 and 0.10 active smokers per 100 m³ in 2006, 2007, 2008 and 2010, respectively. The median of SHS PM concentrations was 53, 83, 18 and 27 μg/m³ respectively. In 2010, both the median SHS PM and air nicotine concentrations in designated nonsmoking sections were about 40% of those in designated smoking sections, according to simultaneous sampling in both sections. Servers’ personal exposure to air nicotine was quite similar in venues with different nominal smoking policies. In the 15 venues followed from 2006 to 2010, SHS PM concentrations changed randomly from 2006 to 2007, decreased in most venues in 2008, and then increased to some extent in 2010.

Conclusion: Voluntary smoking policy is rarely adopted and cannot protect people from SHS exposure in restaurants and bars. The 2008 Beijing governmental smoking regulation failed to significantly reduce SHS exposure shortly or two years after its implementation. Restricting smoking to designated sections cannot eliminate SHS exposure.

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Introduction

The adoption of the World Health Organization Framework Convention on Tobacco Control (WHO FCTC) and the availability of technical support from WHO resulted in the rapid diffusion of smoke-free legislation around the world (IARC, 2009). Though restaurants and bars are important workplaces and public places, they are often exempted from smoke-free air policies. As of July 2012, a total of 66 nations worldwide have enacted 100% smoke-free law in workplaces and hospitality venues, 46 of the 66 include both restaurants and bars (ANRF, 2012).

Studies show that, after the implementation of complete smoke-free laws, airborne nicotine concentrations have decreased more than 90% in both restaurants and bars in Italy (Gorini et al., 2008) and Guatemala (Barnoya et al., 2011), 83% in Irish bars (Mulcahy et al., 2005), and 82–98% in various hospitality venues in Uruguay (Blanco-Marquizo et al., 2010), Sweden (Larsson et al., 2008), Chile (Erazo et al., 2010), and Norway (Ellingsen et al., 2006). Similarly, concentrations of indoor respirable particulate matter have decreased more than 85% in restaurants, bars or

Various hospitality venues in Germany (Gleich et al., 2011), Scotland, Wales and England (Gotz et al., 2008; Semple et al., 2010), Argentina (Schoj et al., 2010), Ontario (Zhang et al., 2010), and some U.S. cities/states, such as Boston (Repace et al., 2006), Austin (Waring and Siegel, 2007), Delaware (Repace, 2004), Western New York (Travers et al., 2004), Massachusetts (Alpert et al., 2007), and Minnesota (Bohac et al., 2010). However, partial smoking restrictions that exempt some hospitality venues lead to only limited reduction or non-significant changes of airborne nicotine or indoor respirable particulate matter concentrations in hospitality venues in Finland (Johnsson et al., 2006), Chile (Erazo et al., 2010), and Rome (Valente et al., 2007).

In China, 52.9% of adult males and 2.4% of females were current smokers in 2010 (Li et al., 2011). A total of 740 million nonsmokers were potentially exposed in 2010. Of those nonsmoking adults exposed to SHS, 72% were in public places, compared to 67% at homes and 63% in work places in 2010 (Xiao et al., 2010). SHS was estimated to cause 22,000 lung cancer deaths and 33,800 is chemic heart disease deaths in 2002 (Gan et al., 2007). However, smoke-free legislation in China is quite limited, and smoking in hospitality venues is generally not regulated (Yang et al., 2008).

In 2006, the WHO FCTC became effective in mainland China (WHO, 2011a,b). Since then, smoking policies changed rapidly in public places, especially in restaurants. In January 2007, the Beijing Health Bureau and the Chinese Center for Disease Control and Prevention (CDC) called for voluntary smoking bans in restaurants in Beijing. On May 1st 2008, the Beijing government passed a regulation requiring large restaurants (the dimensions were not specified) within the city to prohibit or restrict smoking. Several other big cities, including Shanghai, Guangzhou, Hangzhou, and Yinchuan, have followed Beijing in the regulation of smoking in public places. Because the government is committed to the WHO FCTC, China must provide universal protection against SHS exposure within five years of the treaty’s entry into force in China (WHO, 2011a,b). On May 1st 2011, the Chinese Ministry of Health implemented the revised implementation guidelines of the Health Regulations in Public Places issued in 1987 to tighten its rules of restricting smoking in all indoor public places including restaurants and bars. See Fig. 1 for the changes of smoking policies in Beijing from 2006 to 2011.

Since smoke-free policies in restaurants and bars have just recently come to the attention of the Chinese population, there is little evidence on evaluating their efficacy. Given that China has about one-third of the world’s total smokers (CDC, 2010), it is important to add the evidence from China to the existing pool of scientific literature on smoking policy evaluation. The rapid changes of smoking policies in Beijing restaurants and bars provide a good opportunity to evaluate the efficacy of different policies. Environmental SHS concentrations in restaurants and bars have been monitored in the years 2006, 2007, 2008 and 2010 (Fig. 1), with overlaps of venues in each two years. This paper evaluates the efficacy of different smoking policies adopted from 2006 to 2010 in Beijing restaurants and bars using the data collected in those four years.

**Methods**

Data collected by four studies, which were conducted from 2006 to 2010 in line with the changes of smoking policies, were used to evaluate the efficacy of different smoking policies in Beijing Restaurants and Bars: self-motivated voluntary smoking restrictions by restaurant and bar owners in 2006, government-encouraged voluntary smoking restrictions in 2007, and governmental regulatory smoking restrictions in 2008 (Fig. 1).

**SHS monitoring from 2006 to 2008**

According to the Standards of Industry Classification issued by the National Statistics Agency of China, hospitality venues are classified into five categories: Chinese restaurants, Chinese fast food restaurants, Western restaurants, Western fast food restaurants, and bars. In 2006, a convenience sample was selected from each of these categories in eight different districts of Beijing, with consideration of venue size and average expenses per patron per visit: a total of 91 venues (81 restaurants and 10 bars) were selected. In 2007, a similar sampling approach was used, except that venue selection was restricted to two of the eight districts due to logistical issues. Venues were sampled from each of the five categories in the ratio of 10:1:1:1:1 according to the number of restaurants and bars listed on website yellow page. Venues monitored in 2006 in these two districts were also included. Twenty one restaurants and two bars were followed from 2006 to 2007, and another 50 restaurants and 12 bars located in the same two districts were conveniently selected, resulting in 85 venues (71 restaurants and 14 bars) included in 2007. In 2008, the Chinese CDC released a list of the first 100 restaurants which prohibited or restricted smoking as required by the 2008 smoking regulation. Forty four venues were conveniently selected from that list and 52 from the list of venues monitored in 2007, with data from 94 venues (87 restaurants and seven bars) available for analysis.

The same standard protocol for data collection was used from 2006 to 2008. Trained staff from the Chinese CDC visited each venue during peak patronage times as patrons, sat at a table as close to the center of the dining area as possible, bought some food or drinks, placed a bag with a real-time fine particulate matter (PM$_{2.5}$) monitor (TSI SidePak AM510 Aerosol Monitor, TSI, St. Paul, Minnesota, USA) on the table or a chair, with the sampling inlet close to the breathing zone, and monitored PM$_{2.5}$ concentrations for at least 30 min. They asked servers about the smoking policy in the venue, examined whether there were any nonsmoking signs, and counted the number of total patrons and active smokers right after entering and before leaving the dining area and every 15 min during their stay there. They also measured the dimensions of the dining area with a sonic meter or estimated the dimensions when the area was irregular in shape. All the observations and measurements were conducted discreetly to avoid causing potential behavior changes among patrons and workers. Outdoor PM$_{2.5}$ concentrations were also monitored for at least 5 min either right before entering or after leaving each venue. For each visit, the difference between the average indoor and outdoor PM$_{2.5}$ concentration was multiplied with an adjustment factor of 0.32, suitable for SHS (Hyland et al., 2008), and was taken as SHS related PM$_{2.5}$ (SHS PM). For venues
with designated smoking and nonsmoking sections, all the measurements and observations were made in nonsmoking sections only from 2006 to 2008. Field work was conducted from February to August in 2006, July to August in 2007 and October to December in 2008.

**SHS monitoring in 2010**

Because the venues included in the 2007 study were all located in two districts only, they were chosen to be followed up due to logistic issues. Four of the 85 venues included in 2007 were under remodeling, 15 were not found or changed to other business, and one bar was not accessible due to security check upon entry because all the peak-patronage-time observations and sampling were conducted discreetly. This resulted in 65 venues followed up from the 2007 study, 44 from the 2008 study, 43 followed up in three years in 2007, 2008, and 2010, and 15 followed up in all the four years from 2006 to 2010. The study was also aimed to compare results of different sampling methods of SHS, thus, to increase the sample size of smoking venues, a convenience sample of another 14 smoking venues according to owners’ report from the same two districts was included, leading to a total of 79 venues in 2010. In all these venues, PM$_{2.5}$ measurements and observations during peak patronage times were conducted discreetly and following the same protocol used from 2006 to 2008, except that they were made for 1 h indoor, simultaneously in both designated smoking and nonsmoking sections whenever possible, and during both lunch and dinner times in some venues. Airborne nicotine was also sampled during peak patronage time, using filters (EMFAB, Pall part #7217) treated with sodium bisulfate (Hammond et al., 1987) and pumps with flow rate set to 2 L/min. Each team of two investigators carried one field nicotine filter blank each day.

In addition, to measure workers’ exposure to SHS in smoking restaurants and bars, owners or managers of smoking venues (57 in total, smoking policies reported by owners or managers) were asked for permission to recruit nonsmoking servers who worked full daytime shifts to conduct personal airborne nicotine sampling. A total of 43 volunteers from 30 venues were recruited by personal solicitation in the venues. Each volunteer wore a cassette with a treated filter and battery-charged mini pump with a flow rate of about 150 ml/min. The cassette was clipped to clothes around a server’s waist and the mini pump was placed in his/her pocket or was clipped to his/her waist belt. Investigators helped the server wear a personal monitor, turned on the pump around the time when the venue was open to the public and collected the monitor at the end of the working shift or around the time when the venue was about to close to the public. Volunteers were paid with incentives for their participation of the study. The flow rate was checked both before and after each sampling, and the average rate was used for the concentration calculation. In each of the 30 venues with volunteers recruited, peak-patronage-time area sampling and personal nicotine sampling was conducted on the same day by different investigators, and owners or workers were not informed of the peak-time area sampling to keep the process discreet as in other venues. The monitor protocol was approved by the Committee for Protection of Human Subjects at University of California, Berkeley.

**Data analysis**

Both cross-sectional and longitudinal comparisons of SHS concentrations and patron smoking behaviors were conducted by different nominal smoking policies or changes of smoking policies. SHS was indicated by SHS PM or air nicotine, and patron smoking behavior was indicated by the active smoker density (ASD, number of active smokers per 100 m$^2$) and the active smoking rate (ASR, percentage of adult patrons that were observed smoking anytime during sampling). The nominal smoking policy in a venue was defined according to investigators’ observation of nonsmoking sign setups during peak-patronage-time sampling. For venues with monitoring during both lunch and dinner times in 2010, the average of these two periods were used.

Data on both SHS concentrations and patron smoking behaviors were skewed and nonparametric analyses were used. StataIC11 (College Station, Texas) was used for all the data analysis.

**Results**

**Cross-sectional analysis of the four studies**

Smoking was nominally prohibited or restricted in less than 20% of restaurants and bars monitored in 2006 and in 2007, in 83% in 2008, and in 69% in 2010 (Fig. 2). Nearly 40% of all venues had smoking observed in 2006 and in 2007, 24% in 2008 and 31% in 2010 (Fig. 2). Smoking was observed in two of the 16 nonsmoking venues/sections in 2006, only in venues allowing smoking in 2007, and in nearly half of the nominal nonsmoking venues/sections in 2008 and 2010. Table 1 presents the median SHS PM concentrations, ASR and ASD in each year. Distribution of SHS PM concentrations by different nominal smoking policy in each year was shown in Fig. 3. The median (interquartile range (IQR)) of the outdoor PM measurements was 271(141–503), 377 (275–605), 169 (72–328) and 95 (43–258) μg/m$^3$ (not adjusted by any converting factors), respectively, in the four years. For the first three years, ASR was lowest in nonsmoking venues, followed by smoking sections. In 2010, ASR was higher in nonsmoking venues than in nonsmoking sections. Similar trends were observed for ASD and SHS PM (Table 1). The median (IQR) of air nicotine levels during peak patronage time in 2010 was 1.40 (0.69–2.26) μg/m$^3$ in nonsmoking venues, 0.63 (0.29–1.44) μg/m$^3$ in nonsmoking sections, 1.67 (1.16–6.11) μg/m$^3$ in smoking sections and 2.68 (1.32–4.68) μg/m$^3$ in smoking venues. Simultaneous sampling of nicotine and SHS PM showed significant linear relationship between nicotine levels and SHS PM levels (Slope = 17, R$^2 = 0.54$). Kruskal–Wallis rank tests showed that ASD, ASR and SHS PM levels in each year, and air nicotine levels in 2010, were significantly different among venues or sections with different nominal policies, and two-sample Kolmogorov–Smirnov tests showed no significant difference of ASD, ASR or SHS PM in restaurants compared to bars. In all the four years, SHS PM levels were much higher...
in venues or sections where smoking was observed than where smoking was not observed (data not shown).

Longitudinal changes of SHS concentrations and patrons' smoking behavior

None of the 23 venues followed from 2006 to 2007 changed their smoking policies, and ASD, ASR and SHS PM increased nonsignificantly (p > 0.1) (Table 2). Compared to 2007, 31 venues adopted stricter smoking policies (which changed from allowing smoking to restricting/prohibiting smoking or from restricting to prohibiting smoking) in 2008 and 33 in 2010, with the median SHS PM level decreased 79% (p = 0.0001) in 2008 and 72% in 2010 (p = 0.0025); in venues without any policy changes, SHS PM levels reduced 82% (p = 0.0009) in 2008 and 47% in 2010 (p = 0.034). That is, SHS PM concentrations in 2008 and 2010 all decreased significantly, compared to 2007, regardless of smoking policy changes. Reduction of ASD and ASR among patrons was also observed in venues with stricter smoking policies in 2008 or 2010. Five of the 44 venues followed from 2008 to 2010 adopted stricter smoking policies while seven changed to less strict ones. None of the SHS PM levels, ASD or ASR changed significantly (all p > 0.2) in these 44 venues, regardless of their policy changes (Table 2).

A total of 15 venues were followed up in four years from 2006 up to 2010. Two venues restricted smoking in 2006 and 2007, six prohibited smoking and four restricted smoking in 2008, with four of these 10 venues with smoking observed during sampling. In 2010, one restaurant changed its smoking policy from restricting to prohibiting smoking while four venues changed to less strict smoking policies or allowing smoking again. Smoking was observed in four of the seven nonsmoking venues or sections. SHS PM concentrations changed randomly from 2006 to 2007, decreased in most venues in 2008, and then increased to some extent in 2010 (Table 3). Nonparametric trend test showed no significant trend of SHS levels in the 15 venues during the four years (p = 0.15, Fig. 4). A total of 43 venues were monitored in 2007, 2008 and 2010, and the same trend of overallSHS level changes was observed in these venues as in the 15 venues (Fig. 4).

Simultaneous monitoring in designated smoking sections and nonsmoking sections in 2010

Simultaneous observations and sampling were conducted in nominally designated smoking and nonsmoking sections of 15 venues restricting smoking in 2010. ASR in designated smoking sections [mean (SD): 6.6% (5.5%); median (IQR): 4.7% (1.0–12.4%)] was significantly higher than that in designated nonsmoking sections [mean (SD): 0.5% (1.0%); median (IQR): 0 (0–0.7%)]. The median airborne nicotine level in designated nonsmoking sections [mean (SD): 1.4 (1.7) μg/m³; median (IQR): 0.6 (0.3–2.1) μg/m³] was about 40% of that in designated smoking sections [mean (SD): 4.4 (5.4) μg/m³; median (IQR): 1.5 (1.1–6.7) μg/m³], and this
was also true for SHS PM levels in designated nonsmoking sections: mean (SD): 27 (24) μg/m³, median (IQR): 24 (11–39) μg/m³; smoking sections: mean (SD): 96 (90) μg/m³, median (IQR): 62 (16–198) μg/m³. Wilcoxon matched-pairs signed-rank test showed $p < 0.01$ for comparison of each of these indicators between designated smoking and nonsmoking sections.

**Full-shift personal airborne nicotine sampling in 2010**

Two personal samples were excluded from data analyses due to the extremely high concentration measured. One personal sampler from a nominal nonsmoking restaurant was 60.4 μg/m³, while it was 1.2 μg/m³ from the other personal sampler in the same venue, and 1.9 μg/m³ and 1.6 μg/m³ from the lunch-time and dinner-time sampling, respectively. Airborne nicotine concentration based on another personal sampler from a restaurant nominally restricting smoking was 284 μg/m³, while it was 6.8 μg/m³ based on the other personal sampler in the same venue, 12.2 μg/m³ and 6.7 μg/m³ from the lunch-time and dinner-time sampling, respectively, in the designated smoking section, and 2.9 μg/m³ and 2.1 μg/m³ from the lunch-time and dinner-time sampling, respectively, in the designated nonsmoking section. Furthermore, airborne nicotine concentrations from the other 28 venues (41 samplers) were all less than 10 μg/m³. Therefore, the two personal samplers, which had nicotine concentration of 60.4 μg/m³ and 284 μg/m³, respectively, were suspected to be contaminated by other sources of tobacco smoke rather than SHS in the sampling venues, so they were excluded from the data analysis.

A total of 20 volunteers were recruited from 14 venues nominally prohibiting smoking, 13 from 10 venues restricting smoking, and eight from six venues allowing smoking. The mean (SD) of time weighted average nicotine levels was 3.6 (2.2) μg/m³ in smoking venues, and the median (IQR) was 3.0 (1.7–5.9) μg/m³. They were quite similar in nominal nonsmoking venues and in venues restricting smoking to designated venues (Fig. 5). Personal nicotine sampling and peak-time area nicotine sampling (for venues with designated smoking section and nonsmoking section, peak-time area nicotine concentrations were weighted by the number of seats in each section to estimated the weighted peak-time area nicotine level in the whole venue) on the same day in the 30 venues showed...
significantly linear relationship ($R^2 = 0.29$), and no significant difference via paired test ($p = 0.36$) (Fig. 5). Kruskal–Wallis test showed no difference of nicotine concentrations either by personal sampling or by peak-patronage-time area sampling in venues with different nominal smoking policies ($p = 0.31$ and $p = 0.62$, respectively).

**Discussion**

According to the WHO air quality guidelines for particulate matters, which can be applied to both outdoor and indoor environments, especially in developing countries, the annual average PM$_{2.5}$ concentration should not exceed 10 µg/m$^3$ and the 24-h average PM$_{2.5}$ concentration should not exceed 25 µg/m$^3$ for both indoor and outdoor exposure (WHO, 2005). There is no safe levels of SHS exposure (USDHHS, 2006). However, for restaurant and bar servers and patrons in Beijing, China, their exposure to indoor PM$_{2.5}$ due to smoking is several times higher than the WHO 24-h PM$_{2.5}$ exposure limit and can be more than ten times the annual exposure limits. Exposure to SHS in restaurants and bars is estimated to cause 214 lung cancer deaths, 3001 ischemic heart disease deaths, and 1420 new asthma cases among servers and patrons annually in the U.S. (Liu et al., 2013). SHS exposure in Beijing restaurants and bars is also expected to cause a significant disease burden among servers and patrons, and imperative strategies are needed to protect them from SHS exposure.

**The efficacy of voluntary smoking restriction in Beijing**

In 2006, all the voluntary smoking bans in restaurants and bars were completely self-motivated by their owners, and in 2007, they were encouraged by the government. SHS PM concentrations in venues/sections with nominal nonsmoking policies in 2006 and 2007 were much lower than those in 2008 and 2010. This, in addition to less patron smoking observed, shows better public compliance to and enforcement of smoking restrictions in 2006 and 2007 than that in 2008 and 2010. A study showed that restaurant and bar owners who know more about SHS related health hazards are more willing to restrict or prohibit smoking in their own venues (Liu et al., 2011). In absence of governmental regulations, those owners who voluntarily restrict or prohibit smoking in their own venues are more likely to fully enforce the smoking policy imposed by themselves, and those patrons who prefer smoke-free dining environments are more likely to comply with the smoking policy. However, only a few owners voluntarily adopted smoking bans in 2006, and in venues followed from 2006 to 2007, none changed their smoking policies in response to the governmental advisory on voluntary smoking restrictions. In a society like China, where more than half of men smoke and where both hospitality venue owners and patrons have limited knowledge on specific hazards related to SHS (Liu et al., 2008, 2011), it is extremely challenging to depend on voluntary smoking bans to protect the public from SHS exposure in hospitality venues.

**The efficacy of the 2008 governmental smoking restriction in Beijing**

The 2008 smoking regulations required restaurants larger than a certain size to prohibit smoking or at least restrict smoking to designated sections. However, no practical details on the size or penalties for non-compliance were specified in its implementation guidelines, making the regulation difficult to enforce.

In 2008 and 2010, many venues started to prohibit or restrict smoking indoor in response to the 2008 smoking regulations. In these venues, the active smoking rate of patrons decreased, while no significant changes were observed in venues without any policy changes. This indicates that the 2008 smoking regulation has positive impacts on restraining patrons’ active smoking to some extent. The median SHS PM concentrations in venues followed-up decreased 81% in 2008 and 62% in 2010 compared to 2007. These results are consistent with the findings of a study evaluating efficacy of a partial smoking regulation in German hospitality venues (Gleich et al., 2011). The median indoor PM$_{2.5}$
Table 2  
Longitudinal comparison of SHS PM concentrations, active smoker density and active smoking rates in venues followed in different years, Beijing, China, 2006–2010.

<table>
<thead>
<tr>
<th>Changes of smoking policies</th>
<th>n</th>
<th>SHS PM concentrations</th>
<th>ASD</th>
<th>ASR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Median (IQR) (µg/m³)</td>
<td>Change (%)</td>
<td>p value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baseline Follow-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007 vs. 2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No changes</td>
<td>23</td>
<td>36 (10–89)</td>
<td>93 (8–293)</td>
<td>+158</td>
</tr>
<tr>
<td>2008 vs. 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stricter</td>
<td>31</td>
<td>105 (29–197)</td>
<td>22 (8–46)</td>
<td>−79</td>
</tr>
<tr>
<td>No changes</td>
<td>21</td>
<td>111 (14–267)</td>
<td>20 (5–66)</td>
<td>−82</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>108 (20–234)</td>
<td>21 (7–50)</td>
<td>−81</td>
</tr>
<tr>
<td>2010 vs. 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stricter</td>
<td>33</td>
<td>88 (29–134)</td>
<td>25 (3–53)</td>
<td>−72</td>
</tr>
<tr>
<td>No changes</td>
<td>32</td>
<td>53 (3–184)</td>
<td>28 (0–101)</td>
<td>−47</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>70 (14–151)</td>
<td>27 (1–80)</td>
<td>−62</td>
</tr>
<tr>
<td>2010 vs. 2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stricter</td>
<td>5</td>
<td>24 (19–29)</td>
<td>32 (20–70)</td>
<td>+31</td>
</tr>
<tr>
<td>No changes</td>
<td>32</td>
<td>20 (5–50)</td>
<td>27 (2–79)</td>
<td>+38</td>
</tr>
<tr>
<td>Less strict</td>
<td>7</td>
<td>25 (7–85)</td>
<td>35 (12–101)</td>
<td>+40</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>23 (7–54)</td>
<td>31 (8–75)</td>
<td>+34</td>
</tr>
</tbody>
</table>

IQR: inter quartile range.  
* stricter: smoking policy in the follow-up year changed from allowing smoking in the baseline year to restricting or prohibiting smoking or from restricting smoking in the baseline year to prohibiting smoking; less strict: with changes in the other way.  
# Percentage of change from baseline median level to follow-up median level, + means it increased and − means it decreased.  
* p values were based on Wilcoxon matched-pairs signed-rank tests.

Table 3  
Changes of nominal smoking policy, observed active smoking rate (ASR, %) and SHS PM (µg/m³) in 15 venues, Beijing, China, 2006–2010.

<table>
<thead>
<tr>
<th>Venue ID</th>
<th>2006 Smoking policy</th>
<th>2007 Smoking policy</th>
<th>2008 Smoking policy</th>
<th>2010 Smoking policy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASR</td>
<td>SHS PM</td>
<td>ASR</td>
<td>SHS PM</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restaurant 1</td>
<td>Allow</td>
<td>1.64</td>
<td>44</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 2</td>
<td>Allow</td>
<td>6.69</td>
<td>306</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 3</td>
<td>Allow</td>
<td>3.16</td>
<td>0</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 4</td>
<td>Allow</td>
<td>2.89</td>
<td>23</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 5</td>
<td>Allow</td>
<td>6.80</td>
<td>136</td>
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<tr>
<td>Restaurant 7</td>
<td>Allow</td>
<td>6.67</td>
<td>46</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 8</td>
<td>Allow</td>
<td>9.88</td>
<td>539</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 9</td>
<td>Allow</td>
<td>3.23</td>
<td>89</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 10</td>
<td>Allow</td>
<td>6.64</td>
<td>36</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 11</td>
<td>Allow</td>
<td>2.30</td>
<td>26</td>
<td>Allow</td>
</tr>
<tr>
<td>Restaurant 12</td>
<td>Restrict</td>
<td>0.71</td>
<td>34</td>
<td>Restrict</td>
</tr>
<tr>
<td>Restaurant 13</td>
<td>Restrict</td>
<td>11.91</td>
<td>35</td>
<td>Restrict</td>
</tr>
<tr>
<td>Bar 1</td>
<td>Allow</td>
<td>2.13</td>
<td>10</td>
<td>Allow</td>
</tr>
<tr>
<td>Bar 2</td>
<td>Allow</td>
<td>8.14</td>
<td>482</td>
<td>Allow</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>4.62</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td>3.20</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>IQR</td>
<td></td>
<td>2.17–6.69</td>
<td>28–124</td>
<td></td>
</tr>
</tbody>
</table>

ASR: active smoking rate, percentage of adult patrons that were observed smoking anytime during sampling; IQR: inter quartile range.

Notes: prohibit smoking: smoking was not allowed at all, with nonsmoking signs only in the venue; restrict smoking: smoking was allowed in designated smoking sections, with both nonsmoking signs and smoking signs in the venue; allow smoking: smoking was allowed everywhere in the venue, with no nonsmoking signs at all.
concentrations decreased about 88% in German restaurants and bars after the implementation of the partial smoking regulation. However, the reduction occurred in all the venues followed up in Beijing, regardless of policy changes. The potential reason may be that, in addition to the reduction of burning cigarettes density, other factors might have also attributed to the reduction of indoor PM$_{2.5}$, especially in 2008. The 2008 study was conducted shortly after the Beijing 2008 Olympic Games, which have led to more efforts to improve both indoor and outdoor air quality in many public places, including hospitality venues (Chen et al., 2011).

Smoking was observed in almost half of the nominal nonsmoking venues or sections in both 2008 and 2010, and different nominal smoking policies made no significant difference in the airborne nicotine concentrations to which servers were exposed in full shifts. This indicates poor public compliance and governmental enforcement up to two years after the regulation. No significant changes were observed on SHS concentrations or patrons’ smoking behavior from 2008 to 2010 and several venues even reverted to more lenient smoking policies. This indicates that after two years’ implementation of the regulation, enforcement and compliance remain poor. Some venues adopted stricter smoking policies in 2010 than in 2008, which might be a result of sporadic governmental supervision. Alternatively, it might be attributed to their owners’ increased awareness of SHS hazards or the emerging trend of smoking-free environments, thanks to the implementation of smoking regulations or other tobacco control activities initiated in Beijing during these two years, but if this is the case, the effects of these activities seemed very small. Literature shows that compliance to comprehensive smoke-free legislations is very high in Ireland (Fong et al., 2006), Scotland (Apsley and Semple, 2012), New Zealand (Edwards et al., 2008), California (Weber et al., 2003) and Thailand (Yong et al., 2010), while it is much poorer to partial smoking bans (with designated smoking sections permitted) in Chile (Erazo et al., 2010), Malaysia (Yong et al., 2010) and Finland (Johnson et al., 2006). Findings from this study are consistent with the literature.

In venues included in the 2010 study, SHS PM concentrations or active smoking rates in venues prohibiting smoking were higher than that in designated sections, probably because after two years’ implementation of the regulation, some patrons and owners became used to the fact that no material punishments would be imposed and thus became used to ignoring the nonsmoking signs, especially when there was no contrast of smoking and nonsmoking signs; some owners even removed the existing nonsmoking signs, switching back to more permissive smoking policies. This emphasizes WHO’s recommendation that: “Passing a policy is only one part of the process of protecting a population from exposure to SHS; both public education and enforcement efforts are necessary when the smoke-free policy is implemented” (WHO, 2009).

The efficacy of restricting smoking to designated sections

There is no known safe level of SHS exposure, and the most effective way to protect people from SHS exposure is 100% comprehensive smoking bans (USDHHS, 2006; WHO, 2009). In this study, simultaneous monitoring in both smoking and nonsmoking sections showed that the median PM$_{2.5}$ or air nicotine concentration in nonsmoking sections was about 40% of that in smoking sections. One reason might be the non-compliance to smoking restrictions in some nonsmoking sections in restaurants in Beijing, 2010, and another reason might be the diffusion of SHS from smoking sections, which has been reported by some previous studies. Seven studies which also conducted simultaneous measurements of SHS PM in designated smoking and nonsmoking sections in restaurants or clubs showed that SHS PM levels in designated nonsmoking sections were 28% to 78% of the levels in designated smoking sections (Lambert et al., 1993; Akbar-Khanzadeh, 2003; Bohanan et al., 2003; Carrington et al., 2003; Cains et al., 2004; Huss et al., 2010; Bohac et al., 2012) and eleven studies showed that this ratio ranges from 3% to 109% for airborne nicotine (Lambert et al., 1993; Jane et al., 2002; Akbar-Khanzadeh, 2003; Bohanan et al., 2003; Carrington et al., 2003; Cains et al., 2004; Moshammer et al., 2004; Navas-Acien et al., 2004; Kuusimaki et al., 2007; Schneider et al., 2008; Bohac et al., 2012). Thus restricting smoking can reduce but cannot eliminate patrons’ exposure to SHS in restricts. For servers, personal sampling from nonsmoking volunteers working in venues restricting smoking showed high levels of exposure to SHS. Obviously, restricting smoking cannot protect servers from exposure to SHS, as they need to serve patrons in both smoking and nonsmoking sections.

The expected efficacy of the tightened 2011 national smoking regulation

Based on best practice worldwide in the implementation of smoke-free measures, the Conference of the Parties to the WHO FCTC unanimously approved the guidelines of implementing Article 8 in 2007. However, because the State Tobacco Monopoly Administration (STMA) of China plays an important role in developing, passing and enacting tobacco control policies, and tax revenue is an important part of local governmental revenues (Kinglun and Li, 2010), both the 2008 Beijing governmental regulation and the 2011 national smoking regulation do not meet the recommendations outlined by the guidelines of implementing Article 8 of WHO FCTC. For example, the 2008 Beijing governmental regulation allows designated smoking areas, and does not include all restaurants and bars; both regulation do not specify authorities responsible for enforcement, and do not clarify fines or other monetary penalties for violations (Chinese CDC, 2011). For these reasons, it can be expected that the enforcement of the 2011 national smoking regulation, as the 2008 Beijing governmental regulation, will be poor and the efficacy limited.

Strengths and limitations of the evaluating study

The biggest strength of the evaluation study is that it is a follow-up study with four rounds of monitoring in five years, when smoking policies in restaurants and bars changed rapidly. It collected both cross-sectional and longitudinal data with similar protocols, offering good opportunities to evaluate the efficacy of different smoking policies. Another strength is the inclusion of personal nicotine sampling in the 2010 study, providing strong evidence of servers’ exposure to SHS during their work. There are some limitations of the study. First, convenience samples were used for logistical reasons, and regulation-compliant restaurants were over sampled in 2008. This may limit the generalization of results from cross-sectional measurements, and limit the comparability of cross-sectional measurements in different years, especially between results in 2008 and in other years. However, 15 venues were followed in all the four year, and 43 venues were followed in three years in 2007, 2008 and 2010, and the comparability of longitudinal measurements in these venues should be valid and convincing. Second, longitudinal data were collected in Beijing only, and no control cities were included in the study. This makes it difficult to attribute all the changes in SHS concentrations and patrons’ smoking behaviors to smoking regulations only, because other interventions like public education could also have their effects. Third, the study used PM$_{2.5}$ as a SHS tracer for the longitudinal analysis, which is sensitive to, but not specific to, SHS. However, the results of PM$_{2.5}$ sampling, observation and air nicotine sampling are consistent with each other. Forth, the study was conducted in different seasons of different years and not all the follow-up monitoring was scheduled for the same peak
patronage times (e.g. lunch or dinner) or on the same day of a week (e.g. weekdays or weekend), so the variations due to these factors cannot be estimated. Lastly, there was no validation of smoking status of the volunteering servers recruited for personal sampling, and we could not exclude their potential misreporting of their smoking status. However, the two outliers indicated that the rest of the personal sampling was probably from nonsmokers or smokers who did not smoke during the sampling time. In addition, personal nicotine sampling results were significantly related to the area nicotine sampling results during peak patronage time, and they were in comparable magnitudes. Thus, the lack of compliance to smoking restrictions was probably the major reason for not observing significant differences of personal nicotine sampling results among venues with different nominal smoking policies.

Conclusions

Although a voluntary smoking policy may be enforced better by owners and patrons may be more compliant, adoption is rare, regardless whether it is self-motivated by owners or advised by the government, and thus voluntary smoking bans cannot protect people universally from SHS exposure in restaurants and bars. The 2008 smoking regulation in Beijing did restrain patrons’ smoking to some extent, but it failed to reduce significantly SHS exposures of nonsmoking servers or patrons because of poor enforcement and compliance, and unclear definition of the smoking restriction and penalties. Restricting smoking to designated areas did not protect servers from SHS exposure.

Smoke-free legislations in China still set standards below the requirements by the WHO FCTC, which results in the fact that servers and patrons in restaurants and bars in Beijing are still exposed to high levels of SHS, even after the implementation of the 2008 smoking regulation. Because similar underlying limits of the Chinese government’s smoking ban in public places including restaurants and bars in May 2011, similar results can be expected until the Chinese government fully complies with the guidelines for implementation of WHO FCTC Article 8.

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