Original investigation

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Cigarette Smoking and Secondhand Smoke Exposure Before and After a Tobacco-Free Olympic Policy Period: Qingdao, China

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Abstract

Introduction: We explored the impact of a temporary tobacco-free public policy for the 2008 Summer Olympics on the smoking prevalence and secondhand smoke exposure among the population of a co-hosting city, Qingdao, China.

Methods: The Qingdao Diabetes Survey was analyzed for 2006 (n = 4599) and 2009 (n = 4680), which are survey years before and after the tobacco-free Olympics public policy period (July 2007 to January 2009). We analyzed the differences in self-reported smoking prevalence and exposure to secondhand smoke at home and/or workplace, and compared odds of smoking by survey year and of exposure to secondhand smoke among nonsmokers.

Results: From 2006 to 2009, the male smoking prevalence declined from 51.4% (95% confidence interval [CI] = 49.0% to 53.9%) to 42.6% (95% CI = 40.2% to 45.1%), and the proportion of lighter smokers decreased more. Among nonsmokers, the secondhand smoke exposure rate declined from 62.2% (95% CI = 60.5% to 63.9%) to 56.8% (95% CI = 55.1% to 58.6%). Regression analyses show 34% lower odds of men smoking after Olympics (OR = 0.66, 95% CI = 0.57% to 0.77%). Rural residents and individuals who are not retired were more likely to smoke. Female nonsmokers report 17% less exposure to secondhand smoke after Olympics (OR = 0.83, 95% CI = 0.70% to 0.98%). Urban nonsmokers were more likely to be exposed than their rural counterparts.

Conclusions: Smoking prevalence among men and secondhand smoke exposure among women significantly decreased in Qingdao, China, after the tobacco-free Olympics public policy period. As only the proportion of lighter smokers decreased, this may help explain why urban nonsmokers reported increased exposure. Unintended increased secondhand smoke exposure and cessation support need to be addressed in large-scale policy campaigns.

Implications: Hosting the Olympic Games can help to initiate large-scale tobacco-free public policies for hosting cities. Although previous studies have demonstrated reduction in nonsmoker exposure to secondhand smoke, the impact on the hosting city's smoking prevalence or exposure rates is unclear. After the Olympic Games in Qingdao, China, smoking prevalence among men

significantly decreased, mostly due to light smokers. Secondhand smoke exposure at home and/or workplace significantly decreased among female nonsmokers. Urban nonsmokers had an unintended consequence of increased secondhand smoke exposure after the tobacco-free Olympic policy period. Concurrent promotion of cessation support for heavier smokers may be needed.

Introduction

China is the biggest tobacco producer and consumer in the world with an economic dependence on the tobacco industry and an ongoing tobacco-related health crisis.[1] In 2005, China ratified the World Health Organization Framework Convention on Tobacco Control,[2] which came into force in January 2006. Progress has been slow with a 2015 national adult tobacco survey conducted by China's Center for Disease Control and Prevention revealing consistently high adult male smoking rates for the previous 5 years: 52.1% for men but only 2.7% for women.[3] In addition, secondhand smoke (SHS) exposure declined from 60.6% to 54.3% in the workplace and 64.3% to 57.1% at home between 2010 and 2015.

In 2008, China was the host country for the Olympics, and China took the opportunity as a catalyst to build capacity for tobacco control.[4] Since 1988, the Olympic Games, one of the world's premier sporting events, has been one of the most effective marketing platforms for tobacco control.[5] Qingdao, a city of 8.7 million people, co-hosted the Summer Olympics, and like China's six other Olympic cities, Qingdao implemented the Olympics' tobacco-free public policies from July 2007 to January 2009. Tobacco-free public policies were implemented in six types of public places (taxis or hospitals or hotels or restaurants or government offices or and institutional or company workplaces) in both urban and rural districts.[6] A tobacco-free media campaign promoted the new government directive with giveaways (flyers, calendars) and media (TV, newspapers).[7] From August 2008 to September 2008 during the Summer Olympics, the Qingdao government expanded the tobacco-free public policy to more public places with complete (all public transportation, cultural venues, commercial venues, workplaces, educational facilities, indoor areas of medical facilities, gyms, and stadiums) and partial (amusement parks, waiting room of transport vehicles) policy coverage.[8] Tobacco advertising was also banned on television, radio, newspaper, and the Internet during this period.[9]

Our objective was to determine the impact of these tobacco-free public policies on the hosting city's population smoking prevalence and SHS exposure. Using two population-based surveys conducted in Qingdao that included tobacco-related questions, our hypothesis was that smoking prevalence and SHS exposure would decrease for the population after the tobacco-free Olympics public policy period.

Methods

Study Sample

We used two population-based cross-sectional surveys in 2006 and 2009 from the Qingdao Diabetes Survey, conducted by the Qingdao Diabetes Prevention Program and funded by the World Diabetes Foundation. A representative sample of the general population aged 35–74 years who had lived in Qingdao for at least 5 years were recruited through a stratified, random cluster sampling method using an official household registry system based on the 2000 Qingdao population composition, as described elsewhere.[10] If the participant reported difficulty in understanding or filling out the questionnaire, study staff read the questionnaire to the participant and recorded the participant's response. In total, 5355 participants (response rate 87.8%) and 5165 participants (response rate 86.1%) were recruited in 2006 and 2009, respectively.[11] We excluded subjects with missing data on demographics (2006, n = 412; 2009, n = 279) and tobacco-related questions (2006, n = 344; 2009, n = 206). The final study sample included more than 4500 people for each survey year (in 2006, 2784 women and 1815 men; in 2009, 2836 women and 1844 men). Participants with missing information (2006, n = 756; 2009, n = 485) were more likely to be women (2006) or live in rural areas (2006 and 2009) than those with complete information.

The Qingdao Municipal Health Bureau and local ethics committee approved the 2006 survey, and the ethics committee of Qingdao Municipal Center for Disease Control and Prevention approved the 2009 survey. Written consent was obtained from each participant prior to data collection.

Framework

We used a social-ecological model[12] as a framework for our analyses to reflect various levels of influence on health behaviors and their cross-influence. Individual factors include demographics such as age, gender, marital status, education, income, and beliefs. Family- and community-level factors include whether there is smoking at home and/or work, and urban or rural residence.

Measures

Demographics

Demographic variables included age (35–74 years), marital status (married/cohabitated, other), place of residence (urban, rural), income level, education level, and work status (employed or self-employed or retired or out of work or never worked). We categorized low education level as the first 9 compulsory years, middle education level as graduating senior high school, and high education level as college and higher. We categorized work status such that employed includes self-employed, and not employed includes out of work or never worked. Income levels were determined according to minimum wage standard and average income per month in Qingdao. The minimum wage was 540–610 Chinese Yuan (CNY)/month (83–94 US dollars [USD]/month)[13] in 2006 and 620–760 CNY/month (95–116 USD/month)[14] in 2009. The average income per month was 2183 CNY/month (333 USD/month)[15] in 2007 (data in 2006 are not available) and 2709 CNY/month (414 USD/month) in 2009.[16] We used this range of minimum wage and average income per month over the 2 years to create a low-income-level category of less than 1000 CNY/month, middle-income-level category of 1000–2999 CNY/month, and high-income-level category of at least 3000 CNY/month.

Tobacco Use and Exposure

Tobacco use and exposure to smoke was self-reported. Participants who chose "yes" to the question "do you smoke cigarettes" were classified as current smokers. Participants who chose "I quit" or "no" to this question were classified as nonsmokers. Participants reporting "yes" to the question "do you suffer from smokers at home and/or workplace for the past 5 years" were categorized as having exposure

to SHS at home and/or workplace; detailed location was not specified in the questionnaire. All participants were asked about the relationship between smoking and health. The responses were classified as smoking harms health, smoking doesn't harm health, and don't know. Smoking intensity was categorized as light (<10 cigarettes daily), moderate (10–19 cigarettes daily), and heavy (≥20 cigarettes daily). Cigarettes were the predominant type of tobacco used in this population (96.9% of smokers). Smoking prevalence among women was very low (2.7% [95% confidence interval (CI) = 2.1% to 3.4%] in 2006 and 2.2% [95% CI = 1.8% to 2.8%] in 2009) and was not analyzed further.

Statistical Analysis

Complex survey methods[17,18] were used for all analyses to account for stratification and weighting by age or gender or and urban or rural residence to the Qingdao population. Sampling weights correspond to the inverse probability of selection from the target population; in stratified sampling, the weights in a stratum are proportional to the ratio of the frequency of the stratum in the population to the frequency of the stratum in the sample (Unweighted sampling demographics were available in the supplement table). We computed percent change in the prevalence of smoking and SHS exposure in subgroup analyses among men or women by age group, marital status, place of residence, income level, education level, work status, and belief that smoking causes health harms. We computed *p* value of the percent change based on Z- score (estimate/SE) for ln(proportion smoking in 2009) – ln(proportion smoking in 2006) or ln(proportion SHS exposure in 2009) – ln(proportion SHS exposure in 2006). Because the smoking rate in women was very low, we excluded women from further analyses of current smoking. In addition, multivariable logistic regression was conducted using complex sample models to examine the association of (1) smoking among men, (2) SHS exposure at home and/or work among nonsmoking men, and (3) SHS exposure at home and/or work among nonsmoking women by survey year, demographics including urban or rural residence, and belief about smoking health harms. All analyses were performed using SPSS (version 22; SPSS, Inc, Chicago, IL). A *p*-value of less than .05 (two tailed) was considered statistically significant.

Results

Decrease in Male Smoking Prevalence

The male smoking prevalence was 51.4% (95% CI = 49.0% to 53.9%) in 2006 and 42.6% (95% CI = 40.2% to 45.1%) in 2009. The female smoking prevalence was 2.7% (95% CI = 2.1% to 3.4%) in 2006 and 2.2% (95% CI = 1.8% to 2.8%) in 2009. No significant estimated percent change across 2006 and 2009 was found for women. Table 1 shows the male smoking prevalence by demographic subgroups in 2006 and 2009, and the percent change across the years. In 2009, the percent change in smoking rates dropped significantly among men who were younger, lived in either urban or rural areas, were married/cohabiting, had low education level, reported middle-income levels, were employed, and were aware of smoking harms ($p < .05$). Almost all men (90%) reported awareness that smoking is harmful to health, which was not significantly different between either year or urban/rural areas (data not shown).

Figure 1 shows how the proportion of male smoking intensity changed over the 2 years, as the smoking prevalence declined. Among all male smokers from 2006 to 2009, the proportion of light smokers decreased (32.8% [95% CI = 29.6% to 36.2%] vs. 25.3% [95% CI = 22.1% to 28.8%]), the proportion of moderate smokers remained similar (37.3% [95% CI = 34.0% to 40.7%] vs. 34.4% [95% CI = 31.0% to 38.1%]), and the proportion of heavy smokers increased (29.9% [95% CI = 26.9% to 33.1%] vs. 37.3% [95% CI = 36.7% to 43.9%]) (chi-square test statistic = 22.7, $p < .001$). The increasing proportion of heavy smokers (data not shown) was significant among men who lived in rural areas (34.9%–45.2%, $p < .05$), had low education level (34.1%–43.9%, $p < .05$), and had low-income level (30.8%–43.1%, $p < .05$).

SHS Exposure at Home and/or Workplace Declined Significantly

The overall rate of nonsmokers reporting exposure to SHS declined from 62.2% (95% CI = 60.5% to 63.9%) in 2006 to 56.8% (95% CI = 55.1% to 58.6%) in 2009. Table 2 shows SHS exposure at home and/or workplace by gender. Rates similarly declined among nonsmoking men (59.1% to 53.3%) and women (63.2% to 58.1%), but only significantly for women. In 2009, the rate of nonsmoking men reporting SHS exposure decreased significantly in the younger age group, rural residents, employed, and those who believed smoking harms health; rates increased for the oldest group. Similarly, the rate of nonsmoking women reporting SHS exposure decreased significantly for the youngest age group, rural residents, married/cohabitated, lowest income group, lowest education level, employed, and those who believed smoking harms health; rates increased for urban residents, middle-income group, middle and upper education groups, and retired.

The opposite direction between nonsmoker exposure and residency (ie, urban nonsmokers had increased exposure whereas rural nonsmokers had decreased exposure) was explored further (data not shown). Among nonsmoking women, urban SHS exposure increased significantly across all demographic and attitude measures, except there was no statistical significance for other marital status and employed or not employed women. In contrast, rural exposure among nonsmoking women decreased significantly across almost all categories, except there was no statistical significance for other marital status. Among nonsmoking men, urban exposure increased significantly in the 65- to 74-year-old age group and retirees. In contrast, rural exposure among nonsmoking men decreased significantly in the 35- to 44-year-old age group, married/cohabitating persons, middle-income level, middle education level, employed, and those who agreed that smoking causes health harms.

Factors Associated With Smoking and SHS Exposure in Multivariable Regression Analyses

Table 3 shows there was 34% lower odds of men being current smokers after Olympics in 2009 compared to 2006 (odds ratio [OR] = 0.66, 95% CI = 0.57% to 0.77%). Other factors significantly associated with current smoking among men included rural residence, being employed or not employed (compared to retired), and not agreeing that smoking causes health harms; men aged 65–74 years were less likely to smoke than those aged 35–44 years.

Table 3 also shows 17% lower odds of nonsmoking women reporting exposure to SHS in 2009 compared to 2006 (OR = 0.83, 95% CI = 0.70% to 0.98%), but there was not a significant decrease for nonsmoking men. In addition, being a rural resident was negatively associated with being exposed for both male and female nonsmokers. Nonsmoking men in the oldest age group were less likely than those in the youngest to be exposed to SHS. Nonsmoking women who did not know whether smoking is harmful were also less likely to report exposure to SHS than those who agreed that smoking harms health.

Table 1. Male Smoking Rates by Survey Year and Within Demographic Subgroup, Qingdao Diabetes Survey 2006 and 2009

	2006		2009			
Demographics	Sample size, *n*	Weighted smoking rate,% (95% CI)[a]	Sample size, *n*	Weighted smoking rate,% (95% CI)[a]	% Change from 2009 to 2006[b]	*p* value of % change[c]
Overall	938	51.4 (49.0% to 53.9%)	813	42.6 (40.2% to 45.1%)	−17.1	8.33×10^{-07}
Age group (y)						
35–44	364	55.6 (51.4% to 59.7%)	234	43.6 (38.9% to 48.4%)	−21.6	3.08×10^{-04}
45–54	323	56.4 (52.0% to 60.7%)	247	45.0 (40.5% to 49.6%)	−20.2	5.00×10^{-04}
55–64	177	44.1 (39.1% to 49.2%)	202	45.0 (40.3% to 49.8%)	2.0	.80
65–74	74	35.8 (29.1% to 43.0%)	130	34.6 (29.8% to 39.8%)	−3.4	.78
Place of residence						
Urban	362	45.9 (42.2% to 49.6%)	156	37.4 (32.6% to 42.4%)	−18.5	.01
Rural	576	56.8 (53.6% to 60.1%)	657	45.4 (42.7% to 48.1%)	−20.1	6.50×10^{-07}
Marital status						
Married/cohabitated	909	51.4 (48.9% to 53.9%)	757	42.5 (40.0% to 45.0%)	−17.3	3.60×10^{-10}
Others	29	53.1 (37.5% to 68.1%)	56	44.5 (34.4% to 55.0%)	−16.2	.37
Income level (CNY/month)						
< 1000	542	51.4 (48.2% to 54.7%)	531	47.2 (44.1% to 50.4%)	−8.2	.07
1000–2999	316	52.1 (47.8% to 56.3%)	244	38.0 (34.0% to 42.2%)	−27.1	4.81×10^{-06}
≥3000	80	49.5 (41.4% to 57.6%)	38	32.7 (24.0% to 42.9%)	−33.9	.01
Education level (y)						
≤9	512	54.1 (50.7% to 57.5%)	639	43.7 (40.9% to 46.4%)	−19.2	2.54×10^{-06}
10–12	230	50.0 (45.1% to 54.8%)	134	44.0 (38.1% to 50.2%)	−12.0	.14
≥12	196	48.1 (42.9% to 53.3%)	40	33.4 (24.9% to 43.1%)	−30.6	.01
Work status						
Retired	132	34.9 (30.0% to 40.2%)	120	32.5 (27.8% to 37.6%)	−6.9	.51
Employed	684	55.1 (52.1% to 58.2%)	621	45.0 (42.1% to 48.0%)	−18.3	3.74×10^{-06}
Not employed	122	56.2 (49.0% to 63.2%)	72	45.0 (36.6% to 53.9%)	−19.9	.06
Belief that smoke harms health						
Yes	797	49.5 (46.8% to 52.1%)	720	41.4 (38.8% to 43.9%)	−16.4	1.77×10^{-07}
No	102	81.7 (72.8% to 88.2%)	65	66.7 (55.8% to 76.0%)	−18.4	.03
Don't know	33	45.2 (34.6% to 56.3%)	28	38.6 (27.0% to 51.6%)	−14.6	.44

CNY = Chinese Yuan.

[a]Weighted to Qingdao population data for survey year, place of residence, gender, and age.

[b]% Change calculated as (percent of 2009 – percent of 2006) ÷ percent of 2006.

[c]*p* value was computed based on Z-score (estimate/SE) for ln(proportion smoking in 2009) – ln(proportion smoking in 2006).

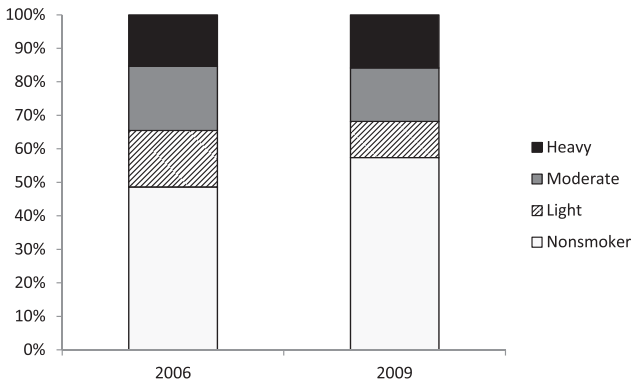

Figure 1. Smoking trends in Qingdao men, Qingdao Diabetes Survey 2006 and 2009. From 2006 to 2009, smoking rates among Qingdao men decreased, and among all male smokers, the proportion of light smokers decreased (32.8% vs. 25.3%) and the proportion of heavy smokers increased (29.9% vs. 37.3%). Data shown are self-reported smoking status from the Qingdao Diabetes Survey among men aged 3574 years. $p < .05$ for chi-square test comparisons across smoking intensity category in 2006 and 2009 surveys.

Discussion

The city of Qingdao, China, had fewer smoking men and fewer nonsmoking women exposed to SHS after implementing the tobacco-free Olympics public policy. The Qingdao male smoking prevalence decrease (51.4% in 2006 to 42.6% in 2009) was greater than China's overall male smoking prevalence decrease (52.9% in 2005 to 50.1% in 2010).[19] However, our findings show this decrease was mostly among light smokers, and that the proportion of heavier smokers increased. The Qingdao overall nonsmoker SHS exposure at home and/or work (56.8% in 2009) was also lower than China's national rate in 2010 (67.3% for exposure at home and 63.3% for exposure at the workplace).[20,21] Similar findings for nonsmokers have been described in cross-sectional surveys around the first tobacco-free Asian Games in Guangzhou in 2010, with self-reported SHS exposure decreased in public places under tobacco-free policies (full: 58.8% in 2009 to 50.3% in 2011; partial: 89.5% in 2009 to 87.4% in 2011, $p < .05$ for both).[22] Our findings suggest that the tobacco-free Olympics public policy was beneficial to the hosting city's population tobacco use and exposure for both smokers and nonsmokers.

Interestingly, SHS exposure at home and/or workplace increased for urban residents but decreased for rural residents. One possible explanation is that most facilities affected by the policy were located in urban districts, which may induce smokers to smoke at home or other places. In urban districts where the population density is extremely high, most residents live in apartments and work in indoor facilities, whereas their rural counterparts may live in houses with a yard or work outside in the field. As the proportion of lighter smokers

Table 2. Nonsmoker Secondhand Smoke (SHS) Exposure Rates at Home and/or Workplace by Gender and Survey Year and Within Demographic Subgroup, Qingdao Diabetes Survey 2006 and 2009

Demographics	SHS exposure rate among nonsmoking men, *N*, % (95% CI)		% change[a] and *p* value[b] in SHS exposure among nonsmoking men from 2009 to 2006[c]	SHS exposure rate among nonsmoking women, *N*, % (95% CI)		% change[a] and *p* value[b] in SHS exposure among nonsmoking women from 2009 to 2006[c]
	2006	2009		2006	2009	
Overall	877, 59.1 (55.6% to 62.5%)	1031, 53.3 (50.0% to 56.6%)	−9.8, **.02**	2712, 63.2 (61.2% to 65.1%)	2749, 58.1 (55.9% to 60.2%)	−8.1, **6.20 × 10^{-04}**
Age group (y)						
35–44	276, 67.4 (61.3% to 72.9%)	282, 53.2 (46.7% to 59.6)	−21.1, **1.82 × 10^{-03}**	970, 68.8 (65.7% to 71.8%)	788, 60.4 (56.4% to 64.3%)	−12.2, **1.24 × 10^{-03}**
45–54	240, 61.0 (54.3% to 67.3%)	281, 55.2 (48.9% to 61.3%)	−9.5, **.21**	947, 63.7 (60.5% to 66.9%)	890, 59.6 (56.1% to 63.0%)	−6.4, **.09**
55–64	218, 59.8 (52.9% to 66.3)	236, 50.9 (44.4 to 57.4%)	−14.9, **.06**	523, 59.4 (54.8% to 63.9%)	670, 54.7 (50.5% to 58.8%)	−7.9, **.13**
65–74	143, 36.1 (28.3% to 44.8%)	232, 53.0 (46.3% to 59.5%)	46.8, **3.83 × 10^{-03}**	272, 50.2 (44.0% to 56.5%)	401, 52.4 (46.9% to 57.8%)	4.4, **.60**
Place of residence						
Urban	447, 61.0 (56.0% to 65.7%)	276, 69.8 (63.8% to 75.2%)	14.4, **.02**	1292, 62.3 (59.4% to 65.1%)	909, 76.7 (73.5% to 79.7%)	23.1, **2.45 × 10^{-11}**
Rural	430, 56.8 (51.8% to 61.6%)	755, 43.4 (39.7% to 47.1%)	−23.6, **1.37 × 10^{-05}**	1420, 63.9 (61.3% to 66.5%)	1840, 41.1 (38.5% to 43.7%)	−35.7, **1.32 × 10^{-30}**
Marital status						
Married/cohabitated	856, 58.7 (55.1% to 62.2%)	973, 52.8 (49.4% to 56.1%)	−10.1, **.67**	2558, 63.9 (61.9% to 65.8%)	2569, 58.0 (55.8% to 60.2%)	−9.2, **9.61 × 10^{-05}**
Others	21, 71.9 (48.9% to 87.2%)	58, 60.3 (45.1% to 73.7%)	−16.1, **.33**	154, 52.9 (44.4% to 61.2%)	180, 59.0 (50.6% to 66.9%)	11.5, **.31**
Income level (CNY/month)						
< 1000	509, 54.1 (49.4% to 58.7%)	583, 47.0 (42.7% to 51.4%)	−13.1, **.03**	2258, 63.0 (60.9% to 65.1%)	1954, 50.0 (47.4% to 52.6%)	−20.6, **2.24 × 10^{-13}**
1000–2999	285, 66.4 (60.4% to 71.9%)	381, 57.7 (52.4% to 62.9%)	−13.1, **.03**	409, 63.5 (58.5% to 68.3%)	757, 72.3 (68.6% to 75.8%)	13.9, **.01**
≥3000	83, 61.5 (50.0% to 71.9%)	67, 67.8 (55.4% to 78.2%)	10.2, **.44**	45, 65.9 (50.6% to 78.4%)	38, 64.6 (46.1% to 79.5%)	−2.0, **.91**
Education level (y)						
≤9	430, 51.0 (45.9% to 56.0%)	773, 48.6 (44.8% to 52.3%)	−4.7, **.37**	1745, 61.6 (59.2% to 64.0%)	2185, 49.7 (47.3% to 52.1%)	−19.3, **1.20 × 10^{-11}**
10–12	235, 65.8 (59.1% to 72.0%)	175, 56.9 (49.0% to 64.6%)	−13.5, **.09**	689, 65.9 (62.2% to 69.5%)	434, 74.6 (69.9% to 78.8%)	13.2, **2.83 × 10^{-03}**
≥12	212, 65.8 (58.9% to 72.2%)	83, 73.1 (62.1% to 81.9%)	11.1, **.22**	278, 65.5 (59.3% to 71.2%)	130, 83.6 (75.1% to 89.6%)	27.6, **1.40 × 10^{-04}**
Work status						
Retired	246, 47.9 (41.4% to 54.4%)	240, 60.4 (54.0% to 66.5%)	26.1, **.01**	83, 54.5 (50.9% to 58.0%)	738, 68.3 (64.5% to 71.9%)	25.3, **1.77 × 10^{-07}**
Employed	527, 64.9 (60.5% to 69.1%)	703, 50.5 (46.4% to 54.5%)	−22.2, **2.28 × 10^{-06}**	1310, 67.1 (64.4% to 69.7%)	1706, 51.0 (48.2% to 53.9%)	−24.0, **3.89 × 10^{-15}**
Not employed	104, 52.2 (41.5% to 62.6%)	88, 55.9 (44.4% to 66.7%)	7.1, **.64**	529, 64.8 (60.3% to 69.0%)	305, 66.0 (59.9% to 71.7%)	1.9, **.75**
Belief that smoke harms health						
Yes	808, 60.5 (56.8% to 64.0%)	950, 52.9 (49.4% to 56.3%)	−12.6, **2.88 × 10^{-03}**	2491, 64.1 (62.1% to 66.1%)	2538, 58.9 (56.6% to 61.1%)	−8.1, **7.74 × 10^{-04}**
No	21, 60.5 (37.1% to 79.9%)	33, 68.7 (50.3% to 82.7%)	13.6, **.56**	51, 55.9 (40.8% to 70.0%)	41, 66.4(50.7% to 79.2%)	18.8, **.32**
Don't know	48, 34.5(22.1% to 49.5%)	48, 51.5 (36.1% to 66.6%)	49.3, **.11**	170, 52.2 (44.1% to 60.3%)	170, 40.9 (32.8% to 49.5%)	−21.6, **.06**

CNY = Chinese Yuan.

[a]% change calculated as (percent of 2009 – percent of 2006) ÷ percent of 2006.

[b]*p* value was computed based on Z-score (estimate/SE) for ln(proportion SHS exposure in 2009) – ln(proportion SHS exposure in 2006).

[c]Weighted to Qingdao population data for survey year, place of residence, gender, and age.

Table 3. Logistic Regression Analysis of Factors Associated With Smoking Status Among Men and Secondhand Smoke Exposure Among Nonsmokers by Gender, Qingdao Diabetes Survey 2006 and 2009

Demographics	Current smokers (males), *N* = 3659	Secondhand smoke exposure among male nonsmokers, *N* = 1908	Secondhand smoke exposure among female nonsmokers, *N* = 5461
	OR (95% CI)	OR (95% CI)	OR (95% CI)
–2 Log likelihood	4859.28	581.90	4462.24
Chi-square	11.71	3.15	10.19
p value for Hosmer and Lemeshow test	0.16	0.92	0.25
Survey year			
2006 (reference)	1.0	1.0	1.0
2009	0.66 (0.57% to 0.77%)	0.97 (0.75% to 1.26%)	0.83 (0.70% to 0.98%)
Age group (y)			
35–44 (reference)	1.0	1.0	1.0
45–54	1.01 (0.84% to 1.22%)	0.87 (0.63% to 1.20%)	1.04 (0.85% to 1.28%)
55–64	0.94 (0.76% to 1.18%)	0.82 (0.57% to 1.19%)	0.88 (0.68% to 1.13%)
65–74	0.67 (0.51% to 0.88%)	0.60 (0.39% to 0.92)	0.78 (0.58% to 1.04%)
Residency			
Urban (reference)	1.0	1.0	1.0
Rural	1.30 (1.08% to 1.57%)	0.66 (0.49% to 0.88%)	0.80 (0.65% to 0.98%)
Marital status			
Others (reference)	1.0	1.0	1.0
Married/cohabitated	0.84 (0.57% to 1.23%)	0.58 (0.31% to 1.09%)	1.31 (0.97% to 1.78%)
Education level (y)			
≤9 (reference)	1.0	1.0	1.0
10–12	0.99 (0.81% to 1.20%)	1.09 (0.81% to 1.48%)	1.13 (0.91% to 1.40%)
≥12	0.80 (0.62% to 1.05%)	1.30 (0.86% to 1.97%)	1.21 (0.82% to 1.77%)
Income level (CNY/month)			
< 1000 (reference)	1.0	1.0	1.0
1000–2999	0.95 (0.80% to 1.13%)	1.10 (0.83% to 1.45%)	1.06 (0.84% to 1.34%)
≥3000	0.94 (0.67% to 1.30%)	0.97 (0.57% to 1.65%)	0.71 (0.37% to 1.36%)
Work status			
Retired (reference)	1.0	1.0	1.0
Employed	1.55 (1.21% to 1.98%)	1.14 (0.78% to 1.65%)	1.24 (0.98% to 1.58%)
Not employed	1.63 (1.20% to 2.22%)	0.71 (0.45% to 1.14%)	1.07 (0.83% to 1.39%)
Belief that smoke harms health			
Yes (reference)	1.0	1.0	1.0
No	3.59 (2.55% to 5.06%)	1.84 (0.81% to 4.18%)	1.33 (0.68% to 2.57%)

CNY = Chinese Yuan.

decreased but that of heavier smokers increased, the increased urban exposure may be related to these heavier smokers going home to smoke whereas their rural counterparts smoking in their yards or fields. This increase in SHS exposure among nonsmokers has been previously described among Chinese nonsmoking pregnant women as an unintended consequence of tobacco-free public policy.[23] Urban residents may also be more aware of SHS exposure due to the population and geographic density and hence reported more exposure. Another contributing factor may be that the rural areas already had higher smoking prevalence rates and thus had greater declines in SHS exposure rates. Further improvement in eliminating SHS exposure needs a comprehensive tobacco-free policy,[24,25] including cessation support, and effective implementation and enforcement.[26] The tobacco-free public policy and education were more effective among lighter smokers; heavy smokers were addictive to tobacco, thus require additional measures and long-term education to facilitate their smoking cessation.

The implementation of the tobacco-free Olympics policy in Qingdao seems to have been effective, as a survey of staff who worked in the regulated public places showed significant improvement in smoking prevalence, knowledge, and policy acceptance.[7] Among 646 subjects who completed a survey before and after training about the policy, smoking prevalence at work decreased (39.3% to 27.0%), knowledge scores improved, positive attitudes toward the smoking policy increased (44.8% to 53.3%), and thinking positively about the economic impact of the smoking policy increased (33.9% to 45.1%). The study also reported that tobacco-free areas were established for taxis, hotels, restaurants, and hospitals, as well as institutions and companies. At more than half of the venues, institutions and companies had a special team set up to persuade customers not to smoke in public places.

The World Health Organization acknowledged that the 2008 Beijing Olympic Games promoted tobacco-free environments, supported a cultural shift, and left a legacy of healthier lives.[27] However, after the tobacco-free Olympic public policy ended in January 2009, tobacco use rebounded to some extent in all of China's Olympic cities.[6] Qingdao strengthened existing local tobacco control policies in 2013 and implemented tobacco-free indoor public areas and workplaces.[28] By 2014, the Qingdao Municipal Center for Disease Control and Prevention reported that adult male smoking prevalence was 40.5%, and nonsmoker SHS exposure rate was 49.1% at home and 32.7% at the workplace, all below national levels.[29] In June 2015, Beijing launched the strongest tobacco-free public areas and workplace policies, as well as tobacco advertising.[30] The

2008 China Olympics also led to other Chinese tobacco-free "mega-events," which have large impacts on the environment and the population.[31] The World Health Organization published a 2010 "Guide to Tobacco-Free Mega-Events"[32] and Chinese mega-events like the 2010 Shanghai World Expo,[33] 2010 Guangzhou Asian Games,[22] and 2011 Xi'an World Horticultural Expo[34]; tightened tobacco control measures; and attempted to create tobacco-free environments. Furthermore, Shanghai and Guangzhou also developed their tobacco-free city plans and policies, which have been acknowledged by the International Tobacco Control Policy Evaluation Project as one of the best local legislations in China.[35]

Tobacco-free mega-events can be of particular benefit to developing countries, where policy environments tend to be weaker in terms of taxes, advertising bans, and tobacco-free policies.[36] Many events that aim to promote healthy lifestyles and well-being[37] may encourage potential international stakeholders to join global tobacco control efforts. Previous research has shown that cities play a critical role in changing social norms of tobacco use and may be the driving force for this change in developing countries.[38] Hence, tobacco bans in cities hosting mega-events are important strategies to initiate and sustain tobacco-free social norm changes. However, it is important to recognize that there are limitations to this approach. A comparative analysis of Olympic tobacco-free policies 1988–2014 found that none of the host cities had adopted all 11 tobacco control measures and that the tobacco industry bypassed policies through advertising, sponsorship, industry-sponsored youth antismoking campaigns (which have been considered ineffective[39]), and "accommodation" of Olympic visitors by creating smoking areas.[5]

Our study findings were limited because the surveys are cross-sectional and do not track individual changes over time. Second, the findings may be underestimates because they rely on self-reported cigarette use or SHS exposure rather than biochemical validation. However, given the strong smoking norms in China and that the original research study was not related to smoking, it is unlikely that reporting bias among participants is significant. Third, the surveys were not specific to the tobacco-free Olympic public policy, and therefore, no questions were asked regarding public attitudes or exposure to the tobacco-free Olympics campaign; furthermore, the survey instrument about SHS exposure combined at home and/or workplace and we could not separate the responses. Fourth, the complex survey methods used can reduce potential bias due to differential nonresponse by age, gender, and urban/rural residence; however, there is still the possibility of selection bias related to smoking and SHS exposure. Finally, the surveys originally aimed to study adult diabetes, and people aged less than 35 years were not included. Other studies have reported a benefit for younger age groups. Smoking rates in students aged 13–15 years were higher nationally (2013)[40] than those in Qingdao (2014) at 6.9% and 1.5%,[41] and students were exposed to SHS (home, public places, transportation vehicles) at 72.9% and 54.8%,[42] respectively. Young male nonsmokers (15–24 years old) were exposed to higher SHS at home, compared to older age groups, but no significant difference was found among female nonsmokers.[43] In Guangzhou after implementation of smoke-free public policies, SHS exposure declined significantly in primary or secondary schools, but not in universities.[22]

Tobacco-free Olympics and other mega-events in developing countries' cities can create important opportunities to decrease tobacco use, nonsmokers' SHS exposure rates, and capacity building for local tobacco control policy making efforts. Our study suggests that more attention may be needed to address the unintended consequence of urban nonsmokers' increased SHS exposure, which may include concurrent promotion of tobacco cessation support. Future research might include a longitudinal study with biochemical validation around a tobacco-free mega-event, and an analysis of the cost-effectiveness of tobacco-free mega-events.

Supplementary Material

Supplementary data are available at *Nicotine & Tobacco Research* online.

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Declaration of Interests

None declared.

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References

1. Hu TW, Mao Z, Ong M, et al. China at the crossroads: the economics of tobacco and health. *Tob Control*. 2006;15(suppl 1):i37–i41.
2. Lv J, Su M, Hong Z, et al. Implementation of the WHO framework convention on tobacco control in mainland China. *Tob Control*. 2011;20(4):309–314.
3. Chinese Center for Disease Control and Prevention. *Chinese Center for Disease Control and Prevention Released 2015 China Adult Tobacco Survey Report*. 2015. http://www.chinacdc.cn/yw/201512/t20151228_123960.htm. Accessed December 30, 2015.
4. Yan L. Olympic Games in China—a catalyst for smoke-free environments. *Tob Control*. 2008;17(4):217.
5. Lee K, Fooks G, Wander N, Fang J. Smoke rings: towards a comprehensive tobacco free policy for the Olympic Games. *PLoS One*. 2015;10(8):e0130091.
6. Zhang L, Chang W, Guo R, Zhang G. Achievements and weaknesses of smoking control project in Olympic cities [J]. *Chin. J. Health Educ*. 2009;12:023.
7. Li S-p, Lin Y-f, Liu H. Evaluation of the effect of the Olympic city public smoking project in Qingdao City. *Prev Med Tribune*. 2011;17(4):327–330.
8. Qingdao Municipal Government. *Legislation to Reinforce Tobacco Control in Public Places*. 2008. http://govinfo.nlc.gov.cn/sdsqdfz/zfgb/444836a/201310/t20131009_3994992.shtml. Accessed January 28, 2016.

9. State Administration for Industry and Commerce. *Further Regulation on Media Advertising During Olympics*. 2008. http://www.saic.gov.cn/zwgk/zyfb/lhfw/lhfw/200807/t20080726_57087.html. Accessed February 25, 2016.
10. Qie LY, Sun JP, Ning F, et al.; Qingdao Diabetes Survey Group in 2006 and 2009. Cardiovascular risk profiles in relation to newly diagnosed type 2 diabetes diagnosed by either glucose or HbA1c criteria in Chinese adults in Qingdao, China. *Diabet Med*. 2014;31(8):920–926.
11. Ren J, Sun J, Ning F, Pang Z, Qie L, Qiao Q; Qingdao Diabetes Survey Group in 2006 and 2009. Gender differences in the association of hypertension with gamma-glutamyltransferase and alanine aminotransferase levels in Chinese adults in Qingdao, China. *J Am Soc Hypertens*. 2015;9(12):951–958.
12. Sallis JF, Owen N, Edwin B, Fisher. Ecological models of health behavior. In: Glanz K, Rimer BK, Viswanath K, eds. *Health Behavior and Health Education: Theory, Research, and Practice*. San Francisco, CA: Jossey-Bass; 2008:565–585.
13. Qingdao Municipal Government. *Minimum Wage Standard Regulation in Qingdao ([2006] No. 79). Qingdao 2006*.
14. People's Government of Shandong Province. *Minimum Wage Standard Regulation in Shangdong Province ([2007] No. 258). Shandong 2007*.
15. Statistics. QMBo. Qingdao Economic and social development statistics bulletin 2006. Qingdao Daily 2007; Economic News 16.
16. Qingdao Economic Development Statistics Qingdao Municipal Bureau of Statistics. 2010. http://www.stats-qd.gov.cn/statsqd/inc/webmenupagebmdt.asp?newsid=35779&typeid=1875&dy=nianjian. Accessed February 10, 2016.
17. IBM. *IBM SPSS Statistics 22 Algorithms*. 2013. ftp://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/22.0/en/client/Manuals/IBM_SPSS_Statistics_Algorithms.pdf. Accessed June 27, 2018.
18. Skinner CJ, Holt D, Smith TMF. *Analysis of Complex Surveys*. New York, NY: John Wiley; 1989.
19. The World Bank. 2016. *Smoking Prevalence, Males (% of Adults)*. 2016. http://data.worldbank.org/indicator/SH.PRV.SMOK.MA/countries?display=default. Accessed February 15, 2016.
20. Li Q, Hsia J, Yang G. Prevalence of smoking in China in 2010. *N Engl J Med*. 2011;364(25):2469–2470.
21. Center for Disease Prevention and Control, Chinese Ministry of Health. *Global Adult Tobacco Survey (GATS) China 2010 Country Report*. Beijing, China: China Sanxia Publishing House; 2010.
22. Ye X, Yao Z, Gao Y, et al. Second-hand smoke exposure in different types of venues: before and after the implementation of smoke-free legislation in Guangzhou, China. *BMJ Open*. 2014;4(2): e004273.
23. Yao T, Lee AH, Mao Z. Potential unintended consequences of smoke-free policies in public places on pregnant women in China. *Am J Prev Med*. 2009;37(2):S159–S164.
24. López MJ, Nebot M, Schiaffino A, et al.; Spanish Smoking Law Evaluation Group. Two-year impact of the Spanish smoking law on exposure to secondhand smoke: evidence of the failure of the "Spanish model". *Tob Control*. 2012;21(4):407–411.
25. Naiman AB, Glazier RH, Moineddin R. Is there an impact of public smoking bans on self-reported smoking status and exposure to secondhand smoke? *BMC Public Health*. 2011;11(1):1–9.
26. Yang T, Jiang S, Barnett R, Peng S, Yu L. Individual and city-level determinants of secondhand smoke exposure in China. *Int J Health Geogr*. 2015;14:36.
27. Dapeng J, Ljungqvist A, Troedsson H. *The Health Legacy of the 2008 Beijing Olympic Games: Successes and Recommendations*. 2010. http://www.olympic.org/Documents/Commissions_PDFfiles/Medical_commission/The_Health_Legacy_of_the_2008_Beijing_Olympic_Games.pdf. Accessed March 22, 2016.
28. The 15th Standing Committee of the Qingdao People's Congress. *Qingdao Tobacco Control Legislation*. 2013. http://www.qdwsjsw.gov.cn:7001/info_view?newsid=12411. Accessed February 27, 2016.
29. Qingdao Municipal Center for Disease Control and Prevention. *Qingdao Municipal Center for Disease Control and Prevention Released 2014 Qingdao Adult Tobacco Survey Report*. 2015. http://www.qdcdc.org:7004/info_view?newsid=99485. Accessed March 15, 2016.
30. The 14th Standing Committee of the Beijing People's Congress. *Beijing Tobacco Control Regulation*; 2014 http://zhengwu.beijing.gov.cn/fggz/bjdffg/t1374530.htm. Accessed February 26, 2016.
31. Müller M. What makes an event a mega-event? Definitions and sizes. *Leis Stud*. 2015;34(6):627–642.
32. World Health Organization, *Region WP. A Guide to Tobacco-Free Mega Events*. Beijing, China: World Health Organization; 2010.
33. Li X, Zheng P, Fu H, Berg C, Kegler M. Results from an evaluation of tobacco control policies at the 2010 Shanghai world expo. *Tob Control*. 2013 Sep;22 (Suppl 2): ii21–ii6.
34. Yuan Y. Smoke-free Expo help Xi'an tobacco control. *Xi'an Evening News*. 2011;16.
35. World Health Organization Western Pacific Region and University of Waterloo, *ITC Project Smoke-Free Policies in China: Evidence of Effectiveness and Implications for Action*. Manila, Philippines: World Health Organization Regional Office for the Western Pacific; 2015.
36. Idowu D. *Mega Sport Events Leading the Way in Battle Against Tobacco Use*. 2011. http://www.sportanddev.org/en/newsnviews/news/?3736/Mega-sport-events-leading-the-way-in-battle-against-tobacco-use. Accessed March 3, 2016.
37. WHO. *Enter the Stadium, Tobacco Free Sports*. 2002. http://www.who.int/tobacco/media/en/enter-stadium.pdf. Accessed March 3, 2016.
38. Redmon P, Koplan J, Eriksen M, Li S, Kean W. The role of cities in reducing smoking in China. *Int J Environ Res Public Health*. 2014;11(10):10062–10075.
39. Landman A, Ling PM, Glantz SA. Tobacco industry youth smoking prevention programs: protecting the industry and hurting tobacco control. *Am J Public Health*. 2002;92(6):917–930.
40. Global Youth Tobacco Survey: *China*. 2014. http://www.tcrc.org.cn/html/zy/cbw/jc/2827.html. Accessed June 8, 2018.
41. Qi F, Li S, Jia X, et al. Smoking and exposure to tobacco advertising among junior high school students in Qingdao city. *Chin J Public Health*. 2016;32(10):1314–1318.
42. Geng M, Jia X, Li S, et al. Survey on current situation and harm cognition of passive smoking among junior students in Qingdao city. *Chin J Sch Health*. 2018;39(4):549–553.
43. King BA, Mirza SA, Babb SD; GATS Collaborating Group. A cross-country comparison of secondhand smoke exposure among adults: findings from the global adult tobacco survey (GATS). *Tob Control*. 2013;22(4):e5.