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Tobacco price increase and smoking behaviour changes in various subgroups: a nationwide longitudinal 7-year follow-up study among a middle-aged Japanese population

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ABSTRACT

Objective Few longitudinal studies have examined the effect of tobacco price increase on both cessation among smokers and relapse among quitters. Our objective was to investigate the differential impact of the tobacco price increase on the changes in smoking status in the total population and various subgroups.

Methods We analysed data from a Japanese nationally representative longitudinal study of 30 773 individuals aged 50–59 years (weighted sum of discrete-time number = 215 411) with smoking information, using inverse probability weighting to account for non-response at follow-up. Generalised estimating equation models were used to calculate the odds ratios (ORs) for smoking behavioural changes (cessation among smokers and relapse among quitters), using discrete-time design. Stratified analyses were conducted according to demographic, socioeconomic and health behavioural characteristics.

Results From 2005 to 2012, current smoker prevalence among the middle-aged Japanese population decreased from 30.5% to 24.3%. Of all the factors surveyed, only the tobacco price increase in 2010 (up by 37%, the highest increase during the period) was significantly associated with both cessation among smokers (OR 2.14, 95% confidence interval 1.90 to 2.41) and prevention of relapse among quitters (0.60, 0.46 to 0.77). Regarding the subgroup analysis, the tobacco price increase was associated with a significant reduction in relapse in the lowest income, recent quitters and very poor health subgroups. However, different associations were observed for cessation; a significant association between price increase and cessation was observed among all subgroups except for the heavy smoker and recently unemployed subgroups.

Conclusions We confirmed that the tobacco price rise was associated with increasing cessation and decreasing relapse concurrently. Furthermore, this price rise was associated with favourable smoking changes in nearly all population subgroups; a large differential impact was not observed across the various subgroups.

INTRODUCTION

Increases in tobacco excise tax that result in higher tobacco prices are considered best practice to reduce population tobacco use and inherent smoking inequality.[1 2] A longitudinal study design is appropriate to estimate the effects of a price increase.[3] Since few previous studies focused on the impact of price increase on relapse, longitudinal studies which provide evidence of the effect of tobacco price on both cessation among smokers and relapse among quitters are scarce.[1 4–7] In addition, the impact of tobacco price increases on smoking behaviour in different social groups has been investigated; mixed results have been reported for differences in gender, occupation and education subgroups.[8–10] Generally, increases in tobacco price reduce cigarette use, especially among the poor and the young rather than the affluent and the old.[1] The impact of tobacco price increases is of great interest to the public health community because they play a pivotal role in people's decisions to use tobacco.[2] In Japan, a special tobacco tax was imposed on 1 December 1998 and the real price of tobacco increased on 1 July 2003, 1 July 2006, 1 October 2010 and 1 April 2014. The price of a pack (20 cigarettes) of the most popular brand in Japan, Mild Seven (the brand name was changed to 'Mevius' in 2013), increased from 250 to 270 yen (8% increase) in 2003, to 300 yen (11% increase) in 2006, to 410 yen (37% increase) in 2010, and to 430 yen (5% increase) in 2014.[11] Partly owing to these price increases, current smoking prevalence among Japanese adults (both sexes) aged 20 years or more has decreased from 31% in 2001 to 22% in 2013.[12]

Furthermore, most studies did not account for attrition at follow-up in the analyses.[1] Therefore, we used data collected between 2005 and 2012 from a nationally representative middle-aged population in Japan and investigated trajectories of smoking status and determinants of important smoking behavioural changes (ie, cessation and relapse), and the association between the tobacco price increase and smoking changes, accounting for attrition at follow-up. Our objective was to reveal the differential impact of the tobacco price increase on the changes in smoking status in the total population and various subgroups, such as socioeconomic, work, smoking or health status in Japan.

METHODS

Data

We used data from the Longitudinal Survey of Middle-aged and Elderly Persons, a nationally representative study conducted by the Ministry of Health, Labour and Welfare (MHLW).[13–15] The study participants, who were aged 50–59 years on 31 October 2005, were selected by two-stage random sampling, and were followed up every year via face-to-face survey (1st–5th year) and mailed

survey (6th–8th year). Of 5280 districts selected for the nationwide population-based cross-sectional survey in 2004,[12] 2515 districts were randomly selected. Within the districts, 40 877 residents aged 50–59 years were surveyed on 2 November 2005. A total of 33 815 individuals responded, giving a response rate of 82.7%. The second to eighth waves of the survey were conducted in November 2006–2012 and consisted of 31 403, 30 013, 28 945, 28 151, 25 740, 24 879 and 23 614 respondents, respectively (the retention rate during the period 2005–2012 was 69.8%). We obtained permission from MHLW to use the data. The analyses of national survey data were considered to be exempt from the need for ethical review according to the Epidemiological Research Guidelines.

Smoking behaviours and the changes

Smoking status was classified as never-smoker, quitter or current smoker based on the question 'Do you smoke now?' with possible responses of 'I have never smoked'; 'I have stopped smoking'; or 'I smoke now'. Smoking status was followed up every year with the question 'Do you smoke now?' with possible responses of 'I do not smoke now' or 'I smoke now'. According to these responses, smoking status at the time of survey was determined to be never-smoker, quitter or current smoker. For current smokers, the number of cigarettes per day was determined by asking: 'how many cigarettes do you usually smoke a day?'. Response categories were 1–10, 11–20, 21–30 and 31 or more per day. 'Recent quitter' was defined as someone who had stopped smoking within the last year.

Usually individuals move in and out of different smoking status categories over time. We evaluated smoking behavioural changes between consecutive waves: each baseline and the next follow-up in discrete-time design, that is, all variations of the kth to the (k+1)th waves, for k=1,…,7. Smoking cessation at the (k+1)th wave was identified as a current smoker at the time of the baseline survey (kth wave) who had become a quitter at the time of the next survey (ie, (k+1)th wave). Relapse at the (k+1)th wave was defined as a quitter at the time of the baseline kth survey who had become a current smoker at the time of the (k+1)th survey. Note that in our discrete-time design, the risk set for cessation at the (k+1)th wave comprised those who were classified as current smokers at the kth wave. In the same way, the risk set for relapse at the (k+1)th wave comprised those who were classified as quitters at the kth wave. Thus, participants who initiated cessation during the follow-up period entered the risk set for relapse thenceforth; likewise, participants who restarted smoking entered the risk set for cessation thenceforth. This approach allowed us to treat multiple events (multiple cessation/relapse) among the same participants.

Variables

A broad set of covariates, which could be associated with smoking behaviour, included: (1) sex, (2) age (50–54, 55–59 or 60–65 years), (3) education (junior high school, high school, technical school or junior college, or university (4 years) or more), (4) marital status (married, divorced/widowed, or never married), (5) equivalent household income (quintiles), (6) housing tenure (not owning housing or owning housing), (7) working condition (working, unemployed or other (eg, retired or housewife)), (8) self-rated health (excellent, good, poor or very poor) and (9) alcohol consumption (everyday drinker, 1–6 times/week drinker, 1–3 times/month drinker, seldom drinker or never drinker). Equivalent household income was calculated by combining income reported by a respondent and his/her spouse and dividing the sum of the income by the square root of the

number of family members, in order to adjust for household size,[16] and was categorised by quintile. We divided working condition into four categories: working, retired/homemaker/other, recently unemployed (within 1 year) or other unemployment (including unknown date for the start of unemployment). Those not working were categorised as unemployed if they were seeking employment; otherwise, they were considered economically inactive (eg, retired or homemaker).

Statistical analyses

The longitudinal approach is suited to the study of changes in smoking behaviour over time. However, a high percentage of the participants will be lost to follow-up.[17] If those lost differ in important respects to those who remain in the study, the results can be biased.[3] To account for the non-random non-response, we used inverse probability weighting (IPW) for the remaining participants in each survey by modelling the probability of not dropping out from the study (details are shown in the online supplementary data).[18] The unweighted available data analyses are presented in the online supplementary data.

The χ^2 tests were used to compare the difference in smoking status according to characteristic variables. Using the discrete-time design, where each wave of participants was treated as an analytical unit, the IPW logistic generalised estimating equation (GEE) model was used to calculate the adjusted odds ratios (AORs) and 95% confidence intervals (CIs) for smoking behavioural changes (cessation and relapse) from the kth to (k+1)th waves during the follow-up interval (k=1,…, 7). The dependence of observations that belong to the same individual due to the discrete-time design that allows multiple events, and the IPW were accounted for by sandwich variance estimators assuming an unstructured correlation matrix within the same individual.[19] Since the tobacco price increased on 1 July 2006 and 1 October 2010 during the study period, the periods 2005–2006 and 2009–2010 (a year from November to November) were interpreted as a proxy variable for tobacco price increase. The period 2005–2006 was not analysed for relapse because we had no data in the recent quitter variable. Furthermore, the range of the price increase was larger in 2010 than in 2006. Thus, we mainly focused on the 2010 tobacco price increase. The last period (2008–2009) before the period of the 2010 price increase was used as a reference category. To examine the differential impact of the 2010 tobacco price increase in various subgroups, GEE was separately conducted in each subgroup (stratified analysis). Furthermore, to confirm the interaction effect between the 2010 tobacco price increase (period 2009–2010) and each subgroup, we also conducted GEE using an interaction term (see online supplementary data) to estimate the AORs between subgroups. The trend association was assessed by linear trend for covariate category, treated as an ordinal variable. Trend analyses for the period variable were used to observe hardening or softening[20] in smokers over time. Participants with a missing value for any baseline characteristic (except income) were excluded from the IPW-GEE analyses.

Probability values for statistical tests were two-tailed and p<0.05 was considered statistically significant. All analyses were performed using SAS V.9.2 (SAS Institute, Cary, North Carolina, USA).

RESULTS

Of 31 403 individuals who responded to both the first and second surveys, we excluded those with missing smoking information (n=630), and analysed the remaining 30 773 individuals

(total number of discrete-time person-years = 215 411) using IPW accounting for non-response.

The distribution of smoking at each wave, and the changes between waves, are shown in table 1. In the first survey, 30.5% were current smokers, reducing to 24.3% in the eighth survey among respondents with IPW adjustments for non-response, although those decreased to 19.5% when we used only available respondents (unweighted; see online supplementary table S1). Around 3–9% of participants either relapsed or stopped smoking between waves—with slightly more stopping, leading to a reduction in smoking prevalence over time. Following the large tobacco price increase between the fifth and sixth surveys, more stopping and less relapsing were observed during 2009–2010 than during other periods.

The distribution of covariates among total baseline participants (total number of discrete-time person-years) is shown in online supplementary table S2. The rates of current smokers and quitters were significantly different according to all the baseline characteristics such as sex, age, education and marital status. The results from the unweighted available data analyses did not differ largely (see online supplementary table S3).

OR for cessation according to baseline characteristics among current smokers are shown in table 2. After excluding participants with missing variable information (n=6562), 52 699 current smokers (weighted number) were analysed by GEE. Cessation rates during the periods '2005–2006' (OR 1.29, 95% CI 1.13 to 1.46), '2007–2008' (OR 1.20, 95% CI 1.06 to 1.36) and '2009–2010' (OR 2.14, 95% CI 1.90 to 2.41) were significantly higher than the rate during the period '2008–2009'. Further, lower numbers of cigarettes smoked per day, older age groups, being married, owning housing, recent unemployment and lower alcohol consumption (including never drinkers) were significantly associated with cessation compared with the reference categories.

Rates of cessation in various subgroups were compared between the period '2008–2009' and '2009–2010' and are shown in figure 1. Among all subgroups, a significant impact on cessation was observed during the period '2009–2010' except in two subgroups: 31 or more cigarettes smoked per day and recent unemployment.

ORs for relapse according to baseline characteristics among quitters are shown in table 3. After excluding participants with missing variable information (n=5132), 51 491 quitters (weighted number) were analysed for GEE. Since information for recent quitting was not available in the first survey, discrete time for the period 2005–2006 was not used for relapse (n=6493). The relapse rate for '2009–2010' is significantly lower than the rate for '2008–2009' (OR 0.60, 95% CI 0.46 to 0.77). Furthermore, sex, recent quitter, higher household income, and very poor self-rated health were significantly associated with relapsed smoking compared with reference categories. A significant p for trend confirmed the results for household income and self-rated health.

Rates of relapse in various subgroups compared between '2008–2009' and '2009–2010' are shown in figure 2. A significant impact on relapse reduction during the period '2009–2010' was observed in many subgroups, that is, both sexes, recent quitter, older age groups, technical school or junior college education, married and never married status, lowest household income, owning housing, unemployed categories, very poor self-rated health, and seldom or never drinkers. The results from the unweighted available data analyses for cessation and relapse showed similar estimates with few differences in significance (see online supplementary tables S4 and S5 and figures S1 and S2).

Table 1 Distribution and changes in smoking status, adjusted results using inverse probability weighting (percentages in parentheses)

Years	2005	2006	2007	2008	2009	2010	2011	2012	Baseline total (2005–2011)
Attained age of panel samples	50–59	51–60	52–61	53–62	54–63	55–64	56–65	57–66	50–65
Smoking status									
Never-smoker	14 646 (47.6)	14 529 (47.2)	14 430 (46.9)	14 304 (46.5)	14 079 (45.8)	13 907 (45.2)	13 632 (44.3)	13 625 (44.3)	99 527 (46.2)
Quitter*	6735 (21.9)	7215 (23.5)	7542 (24.5)	8048 (26.2)	8337 (27.1)	9314 (30.3)	9431 (30.7)	9687 (31.5)	56 623 (26.3)
Current smoker†	9392 (30.5)	9028 (29.3)	8801 (28.6)	8421 (27.4)	8357 (27.2)	7552 (24.5)	7710 (25.1)	7462 (24.3)	59 261 (27.5)
Number of cigarettes smoked									
1–10	1307 (13.9)	1389 (15.4)	1349 (15.3)	1402 (16.7)	1541 (18.4)	1862 (24.7)	1845 (23.9)	1823 (24.4)	10 694 (18.1)
11–20	4147 (44.2)	4037 (44.7)	4047 (46.0)	3884 (46.1)	3861 (46.2)	3889 (51.5)	3791 (49.2)	3755 (50.3)	27 656 (46.7)
21–30	2805 (29.9)	2570 (28.5)	2488 (28.3)	2326 (27.6)	2224 (26.6)	1368 (18.1)	1525 (19.8)	1337 (17.9)	15 307 (25.8)
31 or more	1133 (12.1)	1032 (11.4)	917 (10.4)	809 (9.6)	731 (8.8)	432 (5.7)	549 (7.1)	547 (7.3)	5603 (9.5)
Time frame for changes		2005–2006‡	2006–2007	2007–2008	2008–2009	2009–2010‡	2010–2011	2011–2012	Average changes
Changes									
Relapsed smoking (quitter* to current)		295 (4.4)	318 (4.4)	270 (3.6)	310 (3.9)	180 (2.2)	472 (5.1)	294 (3.1)	2138 (3.8)
Stopped smoking (current† to quitter)		782 (8.3)	622 (6.9)	725 (8.2)	610 (7.2)	1188 (14.2)	616 (8.2)	549 (7.1)	5093 (8.6)

*Responders who had stopped smoking at the time of each survey were used as denominator in the analyses for changes.
†Responders who currently smoked at the time of each survey were used as denominator in the analyses for changes.
‡Time period when tobacco price increase occurred, that is, July 2006 and October 2010.
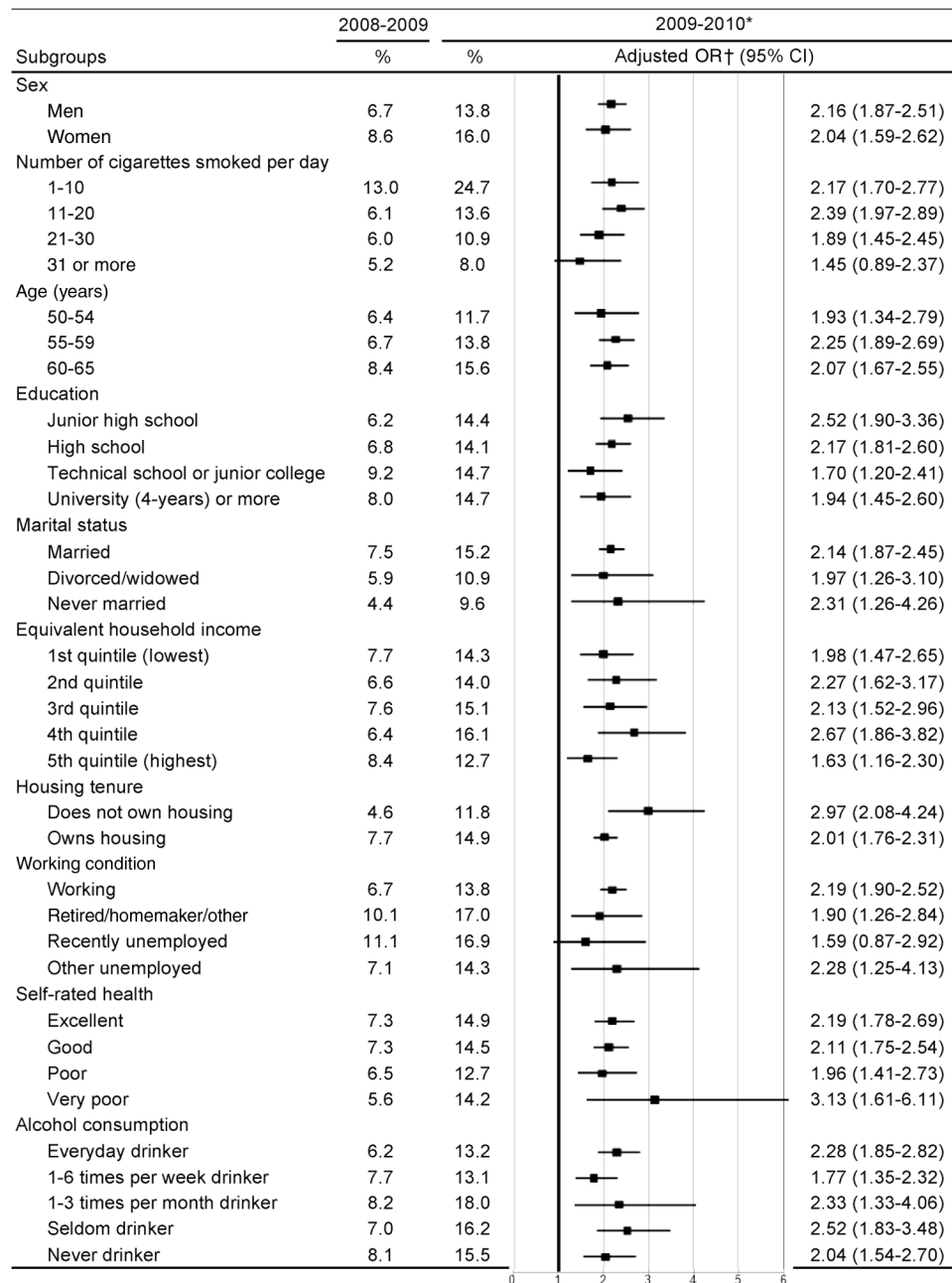
Table 2 OR for short-term cessation

Characteristics	Number of smokers	Number of smokers who quitted	Per cent	Adjusted OR* (95% CI)	p for trend
Duration					0.945
2005–2006†	8964	744	8.3	**1.29 (1.13 to 1.46)**	
2006–2007	8577	599	7.0	1.01 (0.89 to 1.15)	
2007–2008	8088	673	8.3	**1.20 (1.06 to 1.36)**	
2008–2009	7487	532	7.1	1 (reference)	
2009–2010†	7171	1025	14.3	**2.14 (1.90 to 2.41)**	
2010–2011	6311	571	9.1	1.18 (0.92 to 1.50)	
2011–2012	6101	443	7.3	0.91 (0.76 to 1.09)	
Sex					
Men	41 245	3398	8.2	1 (reference)	
Women	11 455	1188	10.4	1.03 (0.91 to 1.16)	
Number of cigarettes smoked per day					<0.001
1–10	9251	1454	15.7	**3.09 (2.62 to 3.64)**	
11–20	24 585	1956	8.0	**1.49 (1.28 to 1.73)**	
21–30	13 846	897	6.5	**1.18 (1.01 to 1.37)**	
31 or more	5017	280	5.6	1 (reference)	
Age (years)					<0.001
50–54	11 934	888	7.4	1 (reference)	
55–59	27 007	2301	8.5	**1.12 (1.02 to 1.23)**	
60–65	13 759	1397	10.2	**1.32 (1.13 to 1.54)**	
Education					0.656
Junior high school	12 632	1076	8.5	1 (reference)	
High school	25 653	2225	8.7	1.04 (0.90 to 1.20)	
Technical school or junior college	5786	514	8.9	1.00 (0.84 to 1.19)	
University (4 years) or more	8630	771	8.9	1.05 (0.90 to 1.23)	
Marital status					
Married	42 804	3955	9.2	**1.56 (1.25 to 1.95)**	
Divorced/widowed	6002	414	6.9	1.09 (0.85 to 1.40)	
Never married	3893	217	5.6	1 (reference)	
Equivalent household income					0.123
1st quintile (lowest)	9483	849	9.0	1 (reference)	
2nd quintile	8562	699	8.2	0.90 (0.74 to 1.11)	
3rd quintile	8689	728	8.4	0.97 (0.79 to 1.19)	
4th quintile	8222	677	8.2	0.98 (0.80 to 1.20)	
5th quintile (highest)	8004	765	9.6	1.14 (0.93 to 1.39)	
Did not answer/missing	9739	869	8.9	0.92 (0.75 to 1.14)	
Housing tenure					
Does not own housing	11 212	779	7.0	1 (reference)	
Owns housing	41 488	3807	9.2	**1.26 (1.05 to 1.50)**	
Working condition					
Working	43 425	3645	8.4	1 (reference)	
Retired/homemaker/other	4320	457	10.6	1.11 (0.94 to 1.32)	
Recently unemployed (within 1 year)	1524	202	13.3	**1.45 (1.10 to 1.92)**	
Other unemployed (including unknown date)	3430	282	8.2	0.91 (0.70 to 1.19)	
Self-rated health					0.231
Excellent	18 135	1551	8.6	1 (reference)	
Good	22 658	1996	8.8	1.07 (0.99 to 1.16)	
Poor	8952	720	8.0	1.01 (0.85 to 1.19)	
Very poor	2955	320	10.8	1.21 (0.94 to 1.57)	
Alcohol consumption					
Everyday drinker	21 238	1715	8.1	1 (reference)	
1–6 times per week drinker	11 172	949	8.5	1.01 (0.90 to 1.14)	
1–3 times per month drinker	2515	260	10.3	**1.29 (1.09 to 1.53)**	
Seldom drinker	7840	728	9.3	1.12 (0.99 to 1.28)	
Never drinker	9934	934	9.4	**1.16 (1.00 to 1.34)**	

Discrete-time cohorts; generalised estimating equation (GEE) analyses with weighting.
Bold indicates statistical significance of p<0.05.
*Adjusted for all listed variables.
†Tobacco price increases occurred at 1 July 2006 and 1 October 2010.

	2008–2009	2009–2010*	
Subgroups	%	%	Adjusted OR† (95% CI)
Sex			
Men	6.7	13.8	2.16 (1.87–2.51)
Women	8.6	16.0	2.04 (1.59–2.62)
Number of cigarettes smoked per day			
1–10	13.0	24.7	2.17 (1.70–2.77)
11–20	6.1	13.6	2.39 (1.97–2.89)
21–30	6.0	10.9	1.89 (1.45–2.45)
31 or more	5.2	8.0	1.45 (0.89–2.37)
Age (years)			
50–54	6.4	11.7	1.93 (1.34–2.79)
55–59	6.7	13.8	2.25 (1.89–2.69)
60–65	8.4	15.6	2.07 (1.67–2.55)
Education			
Junior high school	6.2	14.4	2.52 (1.90–3.36)
High school	6.8	14.1	2.17 (1.81–2.60)
Technical school or junior college	9.2	14.7	1.70 (1.20–2.41)
University (4-years) or more	8.0	14.7	1.94 (1.45–2.60)
Marital status			
Married	7.5	15.2	2.14 (1.87–2.45)
Divorced/widowed	5.9	10.9	1.97 (1.26–3.10)
Never married	4.4	9.6	2.31 (1.26–4.26)
Equivalent household income			
1st quintile (lowest)	7.7	14.3	1.98 (1.47–2.65)
2nd quintile	6.6	14.0	2.27 (1.62–3.17)
3rd quintile	7.6	15.1	2.13 (1.52–2.96)
4th quintile	6.4	16.1	2.67 (1.86–3.82)
5th quintile (highest)	8.4	12.7	1.63 (1.16–2.30)
Housing tenure			
Does not own housing	4.6	11.8	2.97 (2.08–4.24)
Owns housing	7.7	14.9	2.01 (1.76–2.31)
Working condition			
Working	6.7	13.8	2.19 (1.90–2.52)
Retired/homemaker/other	10.1	17.0	1.90 (1.26–2.84)
Recently unemployed	11.1	16.9	1.59 (0.87–2.92)
Other unemployed	7.1	14.3	2.28 (1.25–4.13)
Self-rated health			
Excellent	7.3	14.9	2.19 (1.78–2.69)
Good	7.3	14.5	2.11 (1.75–2.54)
Poor	6.5	12.7	1.96 (1.41–2.73)
Very poor	5.6	14.2	3.13 (1.61–6.11)
Alcohol consumption			
Everyday drinker	6.2	13.2	2.28 (1.85–2.82)
1–6 times per week drinker	7.7	13.1	1.77 (1.35–2.32)
1–3 times per month drinker	8.2	18.0	2.33 (1.33–4.06)
Seldom drinker	7.0	16.2	2.52 (1.83–3.48)
Never drinker	8.1	15.5	2.04 (1.54–2.70)

* Tobacco price increase occurred on 1 October 2010. Duration of 2008–2009 was used as a reference category.
† Adjusted for all listed variables.

Figure 1 Rates of smoking cessation in various subgroups during 2008–2009 and 2009–2010. GEE analyses with weighting.

DISCUSSION

We examined the association between a tobacco price increase and both cessation among smokers and relapse among quitters, using a large longitudinal data set, and accounting for attrition.[1] In the current study, from 2005 to 2012, current smoker prevalence among the middle-aged Japanese population decreased from 30.5% to 24.3% using IPW, partly due to tobacco price increases in 2006 and 2010. Since there is a higher attrition tendency among smokers than never-smokers, available data analysis would have resulted in a biased estimate (see online supplementary table S1). We therefore considered that IPW adjustments for non-responses might provide an appropriate figure of smoking prevalence.

Impact of tobacco price increase

Of all the factors surveyed, only the period 2009–2010 (when the 37% price increase occurred) was significantly associated with both promoting cessation among smokers and preventing relapse among quitters (tables 2 and 3). There are no local level variations in tobacco prices in Japan and the regulated increased price was applied throughout the country under the Tobacco Business Law[21] (ie, there was no time delay in the market price rise across Japan). We could therefore assume that all study participants were equally affected by the increase. The tobacco price was increased on 1 October 2010, at least 1 month before the survey in November 2010, but there may have been an earlier response due to anticipation effects,[22] as also seen in a
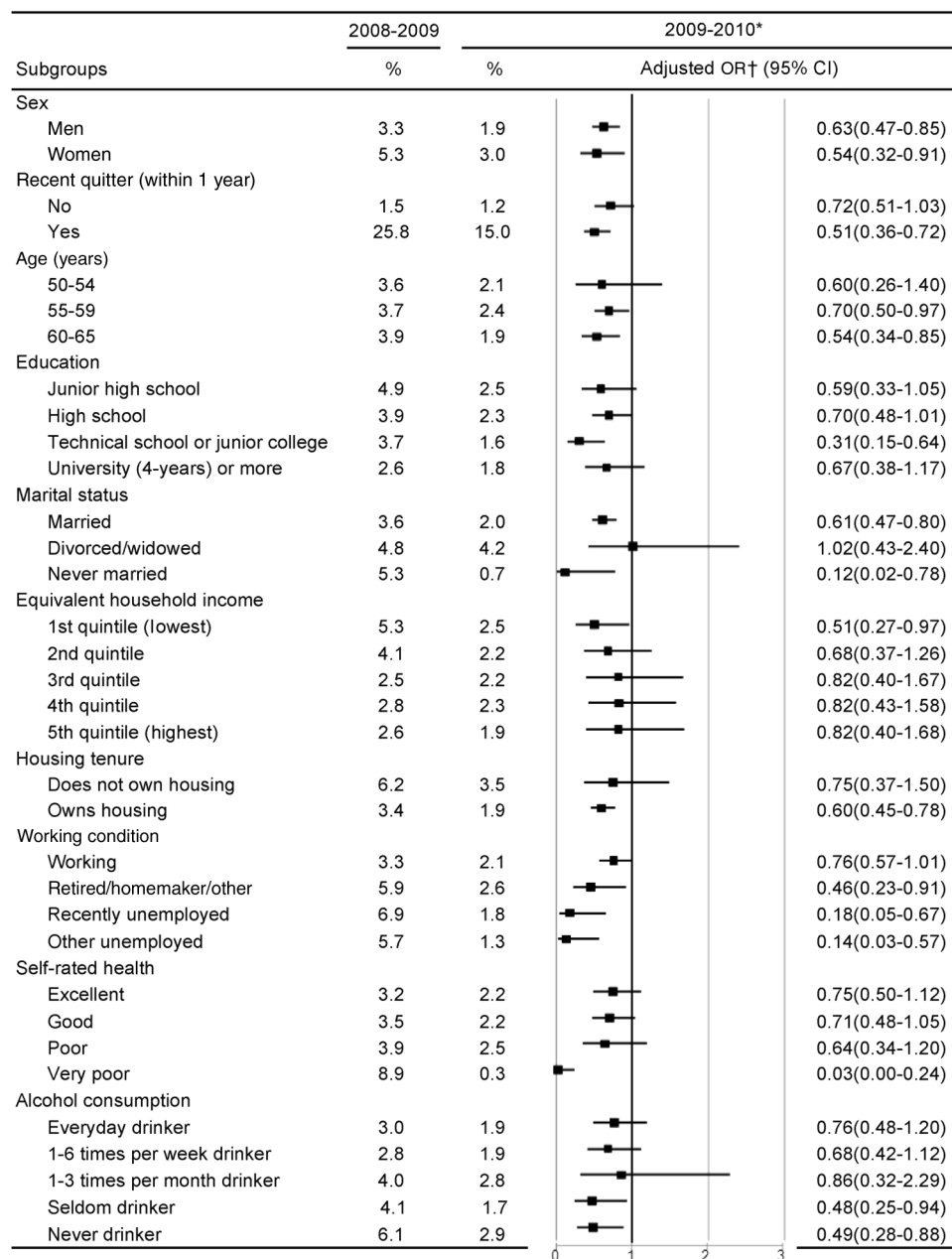
Table 3 OR for relapse

Characteristics	Number of ex-smoker	Number of smoker who relapsed	Per cent	Adjusted OR* (95% CI)	p for trend
Duration					0.295
2006–2007	6933	304	4.4	1.13 (0.92 to 1.38)	
2007–2008	7067	237	3.4	0.96 (0.77 to 1.18)	
2008–2009	7365	275	3.7	1 (reference)	
2009–2010†	7441	158	2.1	**0.60 (0.46 to 0.77)**	
2010–2011	8145	399	4.9	1.06 (0.81 to 1.39)	
2011–2012	8046	248	3.1	0.93 (0.66 to 1.31)	
Sex					
Men	35 471	1094	3.1	1 (reference)	
Women	9527	528	5.5	**1.39 (1.13 to 1.71)**	
Recent quitter (within 1 year)					
No	40 999	639	1.6	1 (reference)	
Yes	3999	982	24.6	**17.9 (14.6 to 22.0)**	
Age (years)					0.884
50–54	6000	224	3.7	1 (reference)	
55–59	21 538	738	3.4	0.97 (0.81 to 1.17)	
60–65	17 460	659	3.8	1.10 (0.85 to 1.41)	
Education					0.637
Junior high school	7889	352	4.5	1 (reference)	
High school	20 435	762	3.7	0.98 (0.77 to 1.26)	
Technical school or junior college	5507	242	4.4	1.17 (0.81 to 1.71)	
University (4 years) or more	11 168	266	2.4	0.88 (0.67 to 1.14)	
Marital status					
Married	39 206	1321	3.4	0.73 (0.45 to 1.20)	
Divorced/widowed	3599	200	5.6	0.87 (0.49 to 1.56)	
Never married	2193	99	4.5	1 (reference)	
Equivalent household income					**0.017**
1st quintile (lowest)	6514	359	5.5	1 (reference)	
2nd quintile	6986	254	3.6	0.80 (0.61 to 1.06)	
3rd quintile	7047	242	3.4	0.80 (0.61 to 1.03)	
4th quintile	7481	221	3.0	**0.77 (0.59 to 0.99)**	
5th quintile (highest)	8037	235	2.9	**0.75 (0.58 to 0.98)**	
Did not answer/missing	8934	311	3.5	0.77 (0.56 to 1.07)	
Housing tenure					
Does not own housing	5740	285	5.0	1 (reference)	
Owns housing	39 258	1336	3.4	0.86 (0.65 to 1.14)	
Working condition					
Working	36 176	1176	3.3	1 (reference)	
Retired/homemaker/other	4873	219	4.5	1.00 (0.73 to 1.38)	
Recently unemployed (within 1 year)	1505	79	5.3	1.17 (0.62 to 2.20)	
Other unemployed (including unknown date)	2443	148	6.1	1.28 (0.86 to 1.91)	
Self-rated health					**0.016**
Excellent	16 525	502	3.0	1 (reference)	
Good	18 676	627	3.4	1.07 (0.92 to 1.24)	
Poor	7346	318	4.3	1.19 (0.92 to 1.52)	
Very poor	2450	174	7.1	**1.55 (1.04 to 2.32)**	
Alcohol consumption					
Everyday drinker	15 239	470	3.1	1 (reference)	
1–6 times per week drinker	11 993	368	3.1	1.06 (0.87 to 1.29)	
1–3 times per month drinker	2508	81	3.2	1.06 (0.78 to 1.44)	
Seldom drinker	6605	270	4.1	1.01 (0.83 to 1.24)	
Never drinker	8653	433	5.0	1.04 (0.83 to 1.30)	

Discrete-time cohorts; generalised estimating equation (GEE) analyses with weighting.
Bold indicates statistical significance of p<0.05.
*Adjusted for all listed variables.
†Tobacco price increases occurred at 1 July 2006 and 1 October 2010.

Subgroups	2008-2009	2009-2010*		
	%	%	Adjusted OR† (95% CI)	
Sex				
Men	3.3	1.9		0.63(0.47-0.85)
Women	5.3	3.0		0.54(0.32-0.91)
Recent quitter (within 1 year)				
No	1.5	1.2		0.72(0.51-1.03)
Yes	25.8	15.0		0.51(0.36-0.72)
Age (years)				
50-54	3.6	2.1		0.60(0.26-1.40)
55-59	3.7	2.4		0.70(0.50-0.97)
60-65	3.9	1.9		0.54(0.34-0.85)
Education				
Junior high school	4.9	2.5		0.59(0.33-1.05)
High school	3.9	2.3		0.70(0.48-1.01)
Technical school or junior college	3.7	1.6		0.31(0.15-0.64)
University (4-years) or more	2.6	1.8		0.67(0.38-1.17)
Marital status				
Married	3.6	2.0		0.61(0.47-0.80)
Divorced/widowed	4.8	4.2		1.02(0.43-2.40)
Never married	5.3	0.7		0.12(0.02-0.78)
Equivalent household income				
1st quintile (lowest)	5.3	2.5		0.51(0.27-0.97)
2nd quintile	4.1	2.2		0.68(0.37-1.26)
3rd quintile	2.5	2.2		0.82(0.40-1.67)
4th quintile	2.8	2.3		0.82(0.43-1.58)
5th quintile (highest)	2.6	1.9		0.82(0.40-1.68)
Housing tenure				
Does not own housing	6.2	3.5		0.75(0.37-1.50)
Owns housing	3.4	1.9		0.60(0.45-0.78)
Working condition				
Working	3.3	2.1		0.76(0.57-1.01)
Retired/homemaker/other	5.9	2.6		0.46(0.23-0.91)
Recently unemployed	6.9	1.8		0.18(0.05-0.67)
Other unemployed	5.7	1.3		0.14(0.03-0.57)
Self-rated health				
Excellent	3.2	2.2		0.75(0.50-1.12)
Good	3.5	2.2		0.71(0.48-1.05)
Poor	3.9	2.5		0.64(0.34-1.20)
Very poor	8.9	0.3		0.03(0.00-0.24)
Alcohol consumption				
Everyday drinker	3.0	1.9		0.76(0.48-1.20)
1-6 times per week drinker	2.8	1.9		0.68(0.42-1.12)
1-3 times per month drinker	4.0	2.8		0.86(0.32-2.29)
Seldom drinker	4.1	1.7		0.48(0.25-0.94)
Never drinker	6.1	2.9		0.49(0.28-0.88)

* Tobacco price increase occurred on 1 October 2010. Duration of 2008-2009 was used as a reference category.

† Adjusted for all listed variables.

Figure 2 Rates of smoking relapse in various subgroups during 2008–2009 and 2009–2010. GEE analyses with weighting.

previous study.[23] Another Japanese study has shown that intention to quit among smokers immediately before the tax increase (August–September 2010) was high,[24] as 53% and 72% of those who intended to quit were planning this for 'before' or 'on' the day of the tax increase. Furthermore, no other major tobacco control measures were taken during the period 2009–2010 in Japan[21]; thus, cessation during this period, compared with 2008–2009 (as a reference), could be assumed to be the effect of the tobacco price.

Additionally, the rate of cessation during the periods 2005–2006 and 2007–2008 was significantly higher (for quitting only) compared with that during 2008–2009. There was an 11% price increase in 2005–2006. The smoking-cessation agent varenicline has been covered by insurance providers since April

2008[25] and electronic locking devices utilising verification cards have been mandated since 2008 and were installed in nearly every tobacco vending machine by July 2008 across the nation.[26] Furthermore, these events were reported in the mass media. This might have resulted in the significantly high cessation rates in 2005–2006 and 2007–2008.

Differential effects of the tobacco price increase in various subgroups were observed for both cessation and relapse. Previous studies have reported that tobacco price increases promote cessation and prevent relapse more among the poor than among the affluent.[1 9 10] However, this study did not support this association for cessation, that is, significantly positive AORs for cessation were observed among all income subgroups with no large difference in point estimate. This was in

line with a previous study[23] and confirmed by an additional result that no significant interaction term between year and income was found in the GEE analyses for cessation. As for relapse, when the tobacco price increased, it was only significantly associated with prevention of relapse in the lowest income subgroup (figure 2).

Further, we observed no effect modification of the price increase on either cessation or relapse by sex in this study (figures 1 and 2), which is in line with the results from a review paper that reported no clear evidence for differential effects by sex.[9] This is possibly because this study did not include the younger generation who are likely to stop smoking when specific events occur such as pregnancy or childcare.[27] As for number of cigarettes smoked per day, the price increase was not significantly associated with increased cessation in the subgroup of heavy smokers (31 or more cigarettes smoked per day), although the point estimate was positive. In all other subgroups of fewer cigarettes smoked per day, the price increase was significantly associated with cessation (figure 1).

Interestingly, differential impacts of the price increase on relapse were observed according to baseline characteristics such as recent quitter or long-term quitter, level of household income and self-rated health. Consistent with previous studies,[28] recent quitters were more likely to relapse than long-term quitters. However, we found that, when the price increased (figure 2), it was significantly associated with prevention of relapse among recent quitters; the same was not true for long-term quitters, although the relapse rate among recent quitters was high, even in 2009–2010 (15.0%). Similarly, quitters with very poor self-rated health had a significantly higher association with relapse than those with excellent health. When the price increased, it was only significantly associated with prevention of relapse in the very poor health subgroup, although point estimates of <1 AOR were observed in all other health subgroups. Taken together, our findings suggest the existence of several high-risk subgroups (eg, heavy smoker and short-term quitter) for tobacco control.

Policy implications

During the period 2009–2010, smoking prevalence decreased (from 27.2% to 24.5%) at the same time as the 2010 tobacco price increase. However, in 2011, there was a slight increase to 25.1%. The notion of 'hardening' among smokers must also be taken into consideration. After some smokers who were less dependent and found it easier to quit have done so, the remaining smokers may become less likely to quit over time, that is, hardening.[20] However, since the trend of the period was not significant for either cessation or relapse in both weighted and unweighted analyses, no evidence of a hardening in smokers was obtained. The entire distribution of smoking volume shifted down over time (table 1). This might be a key step in moving towards cessation. Although this study did not investigate long-term cessation, it is important to determine whether smokers successfully quit in the long term or not. Further studies to investigate long-term changes including cessation or reduction in the number of cigarettes smoked per day will be required in the future.

In recent years, the price of tobacco in Japan has been considered very low according to the affordability index.[29] Cigarettes were more affordable in Japan than in any other developed countries surveyed in 2009; the price of a pack of 20 cigarettes could be earned in 11.5 min compared with 30 min in many other countries.[29] After the 2010 price increase, this figure rose slightly (to around 16 min) but remained low compared with other countries.

Our current findings suggest that we need to consider the stages of tobacco control policy in Japan. The early stages of public health interventions, such as health information campaigns, often cause health equity problems.[30] The *inverse equity hypothesis*[31] avers that such interventions disproportionately benefit the wealthy, so there is an initial increase in inequality (early stage). Deprived sections of society catch up after the affluent have gained maximum benefit (late stage). Although the tobacco price increased in 2010 in Japan, the low price may mean that the 'early stage' of the tobacco price intervention will continue. Further price increases may thus be necessary to alleviate health inequalities.

In the Japanese health promotion strategy, Health Japan 21 (Second version), government ask for reduction of both smoking prevalence and health in equality (including smoking inequality).[32] This study identified high-risk populations for tobacco control, that is, groups that are less sensitive to tobacco price increase, although they may respond to further higher tobacco price increases. Since some subgroups are less likely to quit smoking or continue to not smoke, even if the tobacco price is increased by up to 37%, and furthermore respond slowly to price increases, additional tobacco control measures targeting the high-risk subgroups may be required.

Limitations

There are several limitations to the study. First, the smoking variables were self-reported without biomarker validation; however, the quality of the self-reporting was generally high.[33 34] Second, unmeasured factors such as tax avoidance and product substitution based on a wide price range may have biased the estimated effect.[1 35] However, tax avoidance is likely to be low in this setting; Japan's island nation status makes it difficult to avoid tax across national borders. Although low-price tobacco products (eg, the cheap Echo brand) gained market share in Japan after 2010, according to the tobacco industry's reports,[36] the increase was small (0.5% from 2010 to 2011). Therefore, the impact of product substitution may be trivial. Third, we considered the income of the respondents and their spouses, if available, since the income of other family members could not be obtained from the survey. It should be noted that household income, as defined in this study, probably underestimated household income.[15]

What this paper adds

What is already known on this topic?
▶ The impact of tobacco price increases on smoking behaviour in different social groups has been investigated; mixed results have been reported for differences in gender, occupation and education subgroups.
▶ Since few previous studies focused on the impact of price on relapse, longitudinal studies that have examined the effect of tobacco price on both cessation and relapse are scarce.

What this study adds?
▶ Of all the factors surveyed, only the tobacco price increase in 2010 was significantly associated with cessation (100% increase) and relapse (40% decrease).
▶ The tobacco price rise was associated with favourable smoking changes in nearly all population subgroups.

CONCLUSION

Since recent quitters are likely to relapse,[6 28] it is important to enhance both promotion of cessation and prevention of relapse. We confirmed that tobacco price rises were significantly associated with increasing cessation among smokers and decreasing relapse among quitters concurrently.[1] Furthermore, this price rise was associated with favourable smoking changes in nearly all population subgroups; a large differential impact was not observed across the various subgroups.

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Title

Tobacco price increase and smoking behavior changes in various subgroups: A nationwide

longitudinal 7-year follow-up study among a middle-aged Japanese population

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Supplementary methods

Covariates

Baseline characteristics of each discrete-time cohort were defined as follows. Age was

categorized as 50-54, 55-59 and 60-65 years-old. Education was classified into four categories: junior

high school, high school, technical school or junior college, or university (4-years) or more. As

education was taken from the second survey, missing value for these categories included a no-response

in the second survey. Marital status was categorized as married, divorced/widowed, or never married.

For equivalent household income, the cut-offs for the household income quintiles were 110, 179, 248

and 353 thousand yen per month at baseline discrete-time cohort. Self-rated health was classified into

four categories as excellent, good, poor and very poor.

Although subjects with a missing value for any covariates were excluded from the regression

analyses, a missing value category for income was used as a dummy variable because of their relatively

large sample size.

Analysis to account for non-response

The questionnaire was mailed only to individuals who had participated in the previous wave

or the one prior to that, who then mailed the questionnaire back [1]. No new respondents were added

after the first wave. Subjects who did not respond to two consecutive surveys were dropped out from

the subsequent follow-up survey. As considerable differences between responders and non-responders in baseline characteristics were observed (data not shown), a logistic regression model was constituted to account for non-response at each wave [2], using potential confounding factors including a non-response variable (at least one non-response during 2nd to 7th survey). For example, because participants who responded to the 3rd survey but not the 4th survey were recruited for the 5th survey according to the study design [1], the non-response variable was regarded as a key predictor of non-participation in the subsequent survey [3]. This is in line with the method described by Schafer et al., i.e. at each session we asked participants, "How likely are you to drop out of this study before the next session?" Collecting this additional covariate and including it in the analyses may effectively make the assumption of "missing at random" appropriate in the study [4]. As a result, the non-responses were explained by covariates in the logistic models (data not shown). The c-statistics did not indicate poor fit of the models, and the logistic models created inverse probability weights to account for the non-responses in each discrete-time cohort ($IPW_{1st-2nd}$, $IPW_{2nd-3rd}$, $IPW_{3rd-4th}$,...$IPW_{7th-8th}$). Finally, we multiplied the IPWs to constitute a final weight for each subject of baseline discrete-time cohort: i.e. a final weight for subjects in the baseline cohort in the third survey, namely $IPW_{final\_3rd-4th}$, were calculated by multiplying $IPW_{1st-2nd}$, $IPW_{2nd-3rd}$ and $IPW_{3rd-4th}$. After we confirmed that there were no extremely large outliers in each IPW, we made final weights for all discrete-time cohorts and applied each final weight to each baseline discrete-time cohort to fully account for the attrition at follow-up. To treat each wave equally, a standardized weight for each wave was used to keep the total subject number at each baseline cohort constant (n=30,773). This adjustment enabled us to interpret the prevalence of current smoking, accounting for attrition. Weighted number and weighted odds ratios are shown in the main results after excluding participants with no smoking information at each survey. The unweighted available-data analyses are shown as supplementary analyses (tables S1 and S3).

Since no probabilities of smoking behavioral changes between consecutive waves were large (<10%) in our data, the AORs obtained from the logistic GEE can approximate the ratio of the discrete-time behavioral change rates during 1-year intervals between the surveys.

Analysis using an interaction term

To confirm the interaction effect between the 2010 tobacco price increase (period 2009-2010) and each subgroup, we conducted GEE using an interaction term. If an interaction term is significant, this means that there is a significant association during 2009-2010 among a certain subgroup population.

All models for cessation indicated no significant interaction term between the period 2009-2010 and each subgroup. As for relapse, three interaction terms of ''2009-2010/technical school or junior college education'', ''2009-2010/other unemployment'' and ''2009-2010/very poor self-rated health'' categories showed the significant AORs (95% CI) between subgroups of 0.45 (0.23, 0.87), 0.27 (0.09, 0.85) and 0.07 (0.01, 0.53) for relapse, respectively, when an interaction term was used in the model. Other interaction terms were not significant for relapse.

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Table S1. Distribution and changes in smoking status (percentages in parentheses for non-missing respondents and data): unweighted available-data analysis

Years	2005	2006	2007	2008	2009	2010	2011	2012	Baseline total (2005-2011)
Attained age of panel samples	50-59	51-60	52-61	53-62	54-63	55-64	56-65	57-66	50-65
Smoking status									
Never smoker	14,750 (47.9)	13,950 (48.0)	13,429 (48.1)	13,077 (48.0)	12,160 (48.7)	11,576 (49.1)	11,110 (49.4)	11,104 (49.3)	90,052 (48.4)
Quitter†	6745 (21.9)	6842 (23.5)	6850 (24.5)	7072 (26.0)	6766 (27.1)	7128 (30.2)	6827 (30.3)	7018 (31.2)	48,230 (25.9)
Current smoker‡	9278 (30.2)	8273 (28.5)	7667 (27.4)	7090 (26.0)	6050 (24.2)	4886 (20.7)	4566 (20.3)	4381 (19.5)	47,810 (25.7)
Number of cigarettes smoked									
1-10	1282 (13.8)	1256 (15.2)	1151 (15.0)	1160 (16.4)	1050 (17.4)	1118 (22.9)	1003 (22.0)	949 (21.7)	8020 (16.8)
11-20	4078 (44.0)	3690 (44.6)	3503 (45.7)	3263 (46.0)	2812 (46.5)	2512 (51.4)	2394 (52.4)	2299 (52.5)	22,252 (46.5)
21-30	2808 (30.3)	2379 (28.8)	2212 (28.9)	1978 (27.9)	1665 (27.5)	981 (20.1)	886 (19.4)	867 (19.8)	12,909 (27.0)
31-	1110 (12.0)	948 (11.5)	801 (10.5)	689 (9.7)	523 (8.6)	275 (5.6)	283 (6.2)	266 (6.1)	4629 (9.7)
Time frame for changes		2005-2006*	2006-2007	2007-2008	2008-2009	2009-2010*	2010-2011	2011-2012	Average changes
Changes									
Relapsed smoking (quitter† to current)		290 (4.3)	298 (4.4)	236 (3.5)	259 (3.7)	141 (2.1)	319 (4.5)	162 (2.4)	1705 (3.5)
Stopped smoking (current‡ to quitter)		777 (8.4)	570 (6.9)	631 (8.2)	523 (7.4)	900 (14.9)	396 (8.1)	353 (7.7)	4150 (8.7)

†Responders who had stopped smoking at the time of each survey were used as denominator in the analyses for changes.

‡Responders who currently smoked at the time of each survey were used as denominator in the analyses for changes.

*Time period when tobacco price increase occurred; i.e., July 2006 and October 2010.

Table S2. Baseline characteristics and smoking status of study subjects (sum of all discrete-time cohorts). Weighted results.

Baseline characteristics	Total subjects (n=215,411) No. (%)	Current smoker rate* %	Quitter rate* %
Sex			
Male	106,156 (49.3)	43.3	42.1
Female	109,255 (50.7)	12.2	11.0
Age			
50-54 years-old	41,016 (19.0)	31.3	23.0
55-59 years-old	107,182 (49.8)	28.5	25.6
60-65 years-old	67,213 (31.2)	23.6	29.3
Education			
Junior high school	40,638 (18.9)	36.1	24.5
High school	103,310 (48.0)	26.8	24.3
Technical school or junior college	33,599 (15.6)	18.7	20.2
University (4-years) or more	33,644 (15.6)	27.3	40.9
Missing	4221 (2.0)	33.9	24.6
Marital status			
Married	180,986 (84.0)	26.1	27.1
Divorced/widowed	21,823 (10.1)	32.6	21.1
Never married	11,612 (5.4)	38.9	24.4
Missing	990 (0.5)	49.1	21.6
Equivalent household income			
1st quintile (Lowest)	37,671 (17.5)	30.2	22.2
2nd quintile	34,750 (16.1)	27.8	24.9
3rd quintile	33,756 (15.7)	28.5	26.3
4th quintile	32,887 (15.3)	27.1	29.0
5th quintile (Highest)	33,984 (15.8)	25.3	30.1
Did not answer/ missing	42,363 (19.7)	26.2	25.9
Housing tenure			
Does not own housing	31,029 (14.4)	42.3	24.1
Owns housing	183,629 (85.2)	24.9	26.7
Missing	753 (0.3)	55.0	20.1
Employment status			
Working	151,057 (70.1)	30.2	29.0
Retired/Home-maker/Other	32,599 (15.1)	14.5	16.5
Recently unemployed (within one year)	5766 (2.7)	29.0	27.4
Other unemployed (including unknown date)	15,434 (7.2)	25.0	19.4
Missing	10,555 (4.9)	32.8	28.0
Self-rated health			
Excellent	78,190 (36.3)	25.2	26.8
Good	92,039 (42.7)	27.3	25.1
Poor	32,573 (15.1)	31.1	27.6
Very poor	10,808 (5.0)	34.3	29.1
Missing	1802 (0.8)	29.5	26.5
Alcohol consumption			
Everyday drinker	50,569 (23.5)	45.9	37.6
1-6 times per week drinker	42,895 (19.9)	28.3	34.7
1-3 times per month drinker	12,740 (5.9)	22.1	24.3
Seldom drinker	43,643 (20.3)	19.8	19.0
Never drinker	62,911 (29.2)	18.0	16.9
Frequency-unknown drinker/missing	2654 (1.2)	43.4	28.0

*P for difference calculated by chi-square test is "<0.001" for all categories in this table.

Table S3. Baseline characteristics and smoking status of study subjects (sum of all discrete-time cohorts). Unweighted results.

Baseline characteristics	Total subjects (n=186,092) No. (%)	Current smoker rate* %	Quitter rate* %
Sex			
Male	89,700 (48.2)	41.7	42.7
Female	96,392 (51.8)	10.8	10.3
Age			
50-54 years-old	38,423 (20.6)	30.3	23.0
55-59 years-old	92,864 (49.9)	26.5	25.5
60-65 years-old	54,805 (29.5)	21.2	28.8
Education			
Junior high school	32,645 (17.5)	32.5	24.3
High school	91,296 (49.1)	25.7	23.9
Technical school or junior college	29,660 (15.9)	16.9	19.9
University (4-years) or more	29,557 (15.9)	26.7	40.3
Missing	2934 (1.6)	30.9	23.7
Marital status			
Married	159,738 (85.8)	24.8	26.6
Divorced/widowed	16,835 (9.0)	29.0	20.4
Never married	9020 (4.8)	35.1	24.4
Missing	499 (0.3)	36.1	25.5
Equivalent household income			
1st quintile (Lowest)	30,317 (16.3)	26.5	21.8
2nd quintile	30,545 (16.4)	26.1	24.5
3rd quintile	30,259 (16.3)	27.2	26.1
4th quintile	29,771 (16.0)	26.0	28.5
5th quintile (Highest)	30,684 (16.5)	24.5	29.5
Do not answer/ missing	34,516 (18.5)	24.1	25.4
Housing tenure			
Does not own housing	22,911 (12.3)	38.2	24.3
Owns housing	163,003 (87.6)	23.9	26.2
Missing	178 (0.1)	38.8	21.4
Employment status			
Working	135,125 (72.6)	28.9	28.6
Retired/Home-maker/Other	27,201 (14.6)	12.4	15.4
Recently unemployed (within one year)	4673 (2.5)	25.7	26.7
Other unemployed (including unknown date)	12,258 (6.6)	20.3	18.4
Missing	6835 (3.7)	25.6	27.8
Self-rated health			
Excellent	69,968 (37.6)	24.1	26.3
Good	80,816 (43.4)	25.8	24.8
Poor	26,585 (14.3)	28.8	27.1
Very poor	7287 (3.9)	28.2	30.8
Missing	1436 (0.8)	26.0	27.2
Alcohol consumption			
Everyday drinker	43,343 (23.3)	44.3	38.1
1-6 times per week drinker	37,417 (20.1)	26.3	34.6
1-3 times per month drinker	11,405 (6.1)	20.7	23.7
Seldom drinker	38,466 (20.7)	18.3	18.4
Never drinker	53,358 (28.7)	15.9	15.8
Frequency-unknown drinker/missing	2103 (1.1)	40.4	28.5

*P for difference calculated by chi-square test is "<0.001" for all category in this table.

Table S4. Odds ratio for cessation. Discrete-time cohorts of unweighted available-data; GEE analyses.

Characteristics	smokers no.	no. who quit	%	Adjusted odds ratio* (95%CI)	P for trend
Duration					0.568
2005-2006†	8898	742	8.3	**1.26 (1.11, 1.42)**	
2006-2007	7910	553	7.0	1.00 (0.89, 1.14)	
2007-2008	7102	592	8.3	**1.18 (1.05, 1.34)**	
2008-2009	6381	462	7.2	1 (reference)	
2009-2010†	5410	798	14.8	**2.13 (1.90, 2.39)**	
2010-2011	4362	366	8.4	1.04 (0.91, 1.19)	
2011-2012	3973	306	7.7	0.93 (0.81, 1.07)	
Sex					
Male	34569	2809	8.1	1 (reference)	
Female	9467	1010	10.7	1.07 (0.97, 1.18)	
Number of cigarettes smoked per day					**<0.001**
1-10	7314	1175	16.1	**3.05 (2.62, 3.55)**	
11-20	20432	1623	7.9	**1.45 (1.25, 1.67)**	
21-30	11955	777	6.5	**1.16 (1.00, 1.35)**	
31-	4335	244	5.6	1 (reference)	
Age					**<0.001**
50-54 years-old	10973	821	7.5	1 (reference)	
55-59 years-old	22698	1917	8.5	**1.12 (1.02, 1.22)**	
60-65 years-old	10365	1081	10.4	**1.35 (1.20, 1.53)**	
Education					0.277
Junior high school	9702	791	8.2	1 (reference)	
High school	22067	1907	8.6	1.06 (0.96, 1.16)	
Technical school or junior college	4745	449	9.5	1.05 (0.91, 1.20)	
University (4-years) or more	7522	672	8.9	1.08 (0.96, 1.22)	
Marital status					
Married	36753	3344	9.1	**1.44 (1.21, 1.72)**	
Divorced/widowed	4426	307	6.9	1.06 (0.86, 1.31)	
Never married	2857	168	5.9	1 (reference)	
Equivalent household income					**0.002**
1st quintile (Lowest)	7091	611	8.6	1 (reference)	
2nd quintile	7316	606	8.3	1.00 (0.89, 1.13)	
3rd quintile	7665	637	8.3	1.04 (0.92, 1.18)	
4th quintile	7317	611	8.4	1.08 (0.95, 1.22)	
5th quintile (Highest)	7122	681	9.6	**1.23 (1.08, 1.39)**	
Do not answer/ missing	7525	673	8.9	1.02 (0.91, 1.15)	
Housing tenure					
Does not own housing	7948	547	6.9	1 (reference)	
Owns housing	36088	3272	9.1	**1.26 (1.14, 1.39)**	
Working condition					
Working	37400	3124	8.4	1 (reference)	
Retired/Home-maker/Other	3190	355	11.1	**1.18 (1.04, 1.34)**	
Recently unemployed (within one year)	1126	140	12.4	**1.38 (1.15, 1.65)**	
Other unemployed (including unknown date)	2320	200	8.6	0.99 (0.85, 1.17)	
Self-rated health					0.306
Excellent	15792	1377	8.7	1 (reference)	
Good	19378	1688	8.7	1.03 (0.96, 1.11)	
Poor	7005	556	7.9	0.96 (0.86, 1.06)	
Very poor	1861	198	10.6	**1.24 (1.05, 1.46)**	
Alcohol consumption					
Everyday drinker	18060	1421	7.9	1 (reference)	
1-6 times per week drinker	9266	824	8.9	1.08 (0.98, 1.18)	

1-3 times per month drinker	2178	231	10.6	**1.33 (1.15, 1.55)**
Seldom drinker	6633	606	9.1	**1.11 (1.00, 1.23)**
Never drinker	7899	737	9.3	**1.13 (1.02, 1.26)**

* Adjusted for all listed variables.

† Tobacco price increase occurred at 1 July 2006 and 1 October 2010.

Abbreviations: GEE, generalized estimating equation; CI, confidential interval.

Bold= statistical significance of p< 0.05

Table S5. Odds ratio for relapse. Discrete-time cohorts of unweighted available-data; GEE analysis.

Characteristics	ex-smoker no.	no. who relapse	%	Adjusted odds ratio* (95%CI)	P for trend
Duration					0.105
2006-2007	6595	286	4.3	1.10 (0.90, 1.33)	
2007-2008	6441	209	3.2	0.95 (0.77, 1.17)	
2008-2009	6513	232	3.6	1 (reference)	
2009-2010†	6151	124	2.0	**0.63 (0.50, 0.80)**	
2010-2011	6398	275	4.3	1.02 (0.84, 1.24)	
2011-2012	6080	143	2.4	0.85 (0.68, 1.06)	
Sex					
Men	30309	884	2.9	1 (reference)	
Women	7869	385	4.9	**1.29 (1.11, 1.51)**	
Recent quit (within one year)					
No	34896	465	1.3	1 (reference)	
Yes	3282	804	24.5	**21.32 (18.7, 24.3)**	
Age					0.093
50-54 years-old	5476	203	3.7	1 (reference)	
55-59 years-old	18480	626	3.4	1.00 (0.84, 1.20)	
60-65 years-old	14222	440	3.1	0.94 (0.76, 1.16)	
Education					0.472
Junior high school	6245	249	4.0	1 (reference)	
High school	17566	614	3.5	0.99 (0.84, 1.17)	
Technical school or junior college	4744	179	3.8	1.10 (0.89, 1.37)	
University (4-years) or more	9623	227	2.4	0.90 (0.74, 1.11)	
Marital status					
Married	33796	1102	3.3	0.96 (0.73, 1.27)	
Divorced/widowed	2701	109	4.0	0.94 (0.67, 1.32)	
Never married	1681	58	3.5	1 (reference)	
Equivalent household income					0.068
1st quintile (Lowest)	5128	215	4.2	1 (reference)	
2nd quintile	5986	211	3.5	0.96 (0.77, 1.19)	
3rd quintile	6230	209	3.4	0.93 (0.75, 1.16)	
4th quintile	6605	196	3.0	0.89 (0.71, 1.11)	
5th quintile (Highest)	7112	203	2.9	0.85 (0.68, 1.06)	
Do not answer/ missing	7117	235	3.3	0.93 (0.75, 1.14)	
Housing tenure					
Does not own housing	4199	183	4.4	1 (reference)	
Owns housing	33979	1086	3.2	0.85 (0.71, 1.02)	
Working condition					
Working	31405	987	3.1	1 (reference)	
Retired/Home-maker/Other	3773	153	4.1	1.09 (0.89, 1.33)	
Recently unemployed (within one year)	1208	46	3.8	0.90 (0.64, 1.27)	
Other unemployed (including unknown date)	1792	83	4.6	1.21 (0.93, 1.58)	
Self-rated health					0.091
Excellent	14500	435	3.0	1 (reference)	
Good	16151	515	3.2	1.03 (0.90, 1.19)	
Poor	5812	224	3.9	1.09 (0.91, 1.30)	
Very poor	1715	95	5.5	1.26 (0.98, 1.62)	
Alcohol consumption					
Everyday drinker	13132	389	3.0	1 (reference)	
1-6 times per week drinker	10404	295	2.8	1.03 (0.88, 1.22)	
1-3 times per month drinker	2180	70	3.2	1.17 (0.88, 1.55)	

Seldom drinker	5634	229	4.1	1.12 (0.93, 1.34)
Never drinker	6828	286	4.2	1.00 (0.84, 1.20)

* Adjusted for all listed variables.

† Tobacco price increase occurred at 1 July 2006 and 1 October 2010.

Abbreviations: GEE, generalized estimating equation; CI, confidential interval.

Bold= statistical significance of p< 0.05

Figure S1. Rates of smoking cessation in various subgroups during 2008-2009 and 2009-2010. GEE results of unweighted available-data analyses.
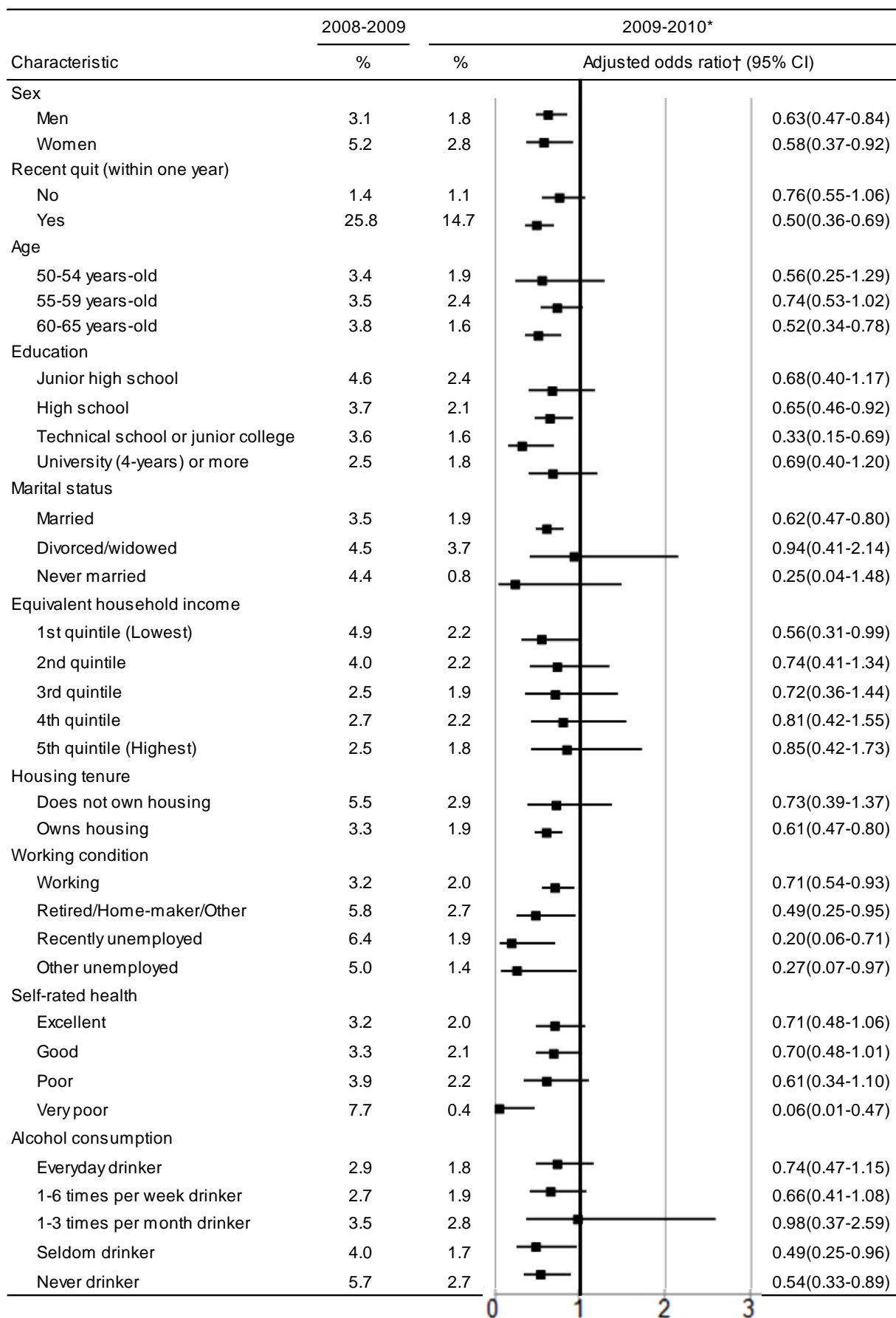
Characteristic	2008-2009 %	2009-2010* %	Adjusted odds ratio† (95% CI)
Sex			
Men	6.8	14.2	2.17(1.88-2.50)
Women	8.9	16.8	2.08(1.63-2.66)
Number of cigarettes smoked per day			
1-10	13.2	25.8	2.27(1.79-2.87)
11-20	6.3	14.1	2.39(1.98-2.88)
21-30	6.1	10.9	1.81(1.40-2.34)
31-	5.2	8.7	1.51(0.93-2.44)
Age			
50-54 years-old	6.6	12.2	1.97(1.38-2.81)
55-59 years-old	6.8	14.2	2.27(1.91-2.69)
60-65 years-old	8.5	16.1	2.08(1.69-2.55)
Education			
Junior high school	6.3	15.3	2.60(1.98-3.41)
High school	6.9	14.3	2.16(1.81-2.57)
Technical school or junior college	9.3	15.3	1.77(1.25-2.49)
University (4-years) or more	8.1	15.1	1.97(1.48-2.63)
Marital status			
Married	7.6	15.5	2.16(1.90-2.46)
Divorced/widowed	6.2	11.2	1.88(1.21-2.92)
Never married	4.5	10.7	2.41(1.32-4.38)
Equivalent household income			
1st quintile (Lowest)	8.1	15.6	1.97(1.48-2.61)
2nd quintile	6.7	13.9	2.21(1.59-3.07)
3rd quintile	7.6	14.6	2.05(1.49-2.83)
4th quintile	6.5	16.4	2.67(1.87-3.82)
5th quintile (Highest)	8.4	13.0	1.66(1.19-2.33)
Housing tenure			
Does not own housing	4.7	13.0	3.06(2.17-4.32)
Owns housing	7.8	15.1	2.03(1.78-2.32)
Working condition			
Working	6.8	14.1	2.20(1.92-2.52)
Retired/Home-maker/Other	10.5	18.0	1.88(1.27-2.78)
Recently unemployed	11.5	17.8	1.63(0.91-2.92)
Other unemployed	7.5	16.8	2.36(1.32-4.19)
Self-rated health			
Excellent	7.4	15.5	2.26(1.85-2.77)
Good	7.5	14.5	2.05(1.70-2.46)
Poor	6.7	13.4	2.01(1.45-2.78)
Very poor	6.0	16.3	3.07(1.64-5.76)
Alcohol consumption			
Everyday drinker	6.2	13.3	2.24(1.82-2.74)
1-6 times per week drinker	7.9	14.4	1.89(1.45-2.46)
1-3 times per month drinker	8.7	18.5	2.26(1.30-3.93)
Seldom drinker	7.1	17.0	2.62(1.91-3.60)
Never drinker	8.5	15.5	1.96(1.49-2.56)

* Tobacco price increase occurred at 1 October 2010. 2008-2009 was used as a reference category.

† Adjusted for all listed variables.

Abbreviations: GEE, generalized equation estimation; CI, confidential interval; NA, not applicable.

Figure S2. Rates of smoking relapse in various subgroups during 2008-2009 and 2009-2010. GEE results of unweighted available-data analyses.

Characteristic	2008-2009	2009-2010*	
	%	%	Adjusted odds ratio† (95% CI)
Sex			
Men	3.1	1.8	0.63(0.47-0.84)
Women	5.2	2.8	0.58(0.37-0.92)
Recent quit (within one year)			
No	1.4	1.1	0.76(0.55-1.06)
Yes	25.8	14.7	0.50(0.36-0.69)
Age			
50-54 years-old	3.4	1.9	0.56(0.25-1.29)
55-59 years-old	3.5	2.4	0.74(0.53-1.02)
60-65 years-old	3.8	1.6	0.52(0.34-0.78)
Education			
Junior high school	4.6	2.4	0.68(0.40-1.17)
High school	3.7	2.1	0.65(0.46-0.92)
Technical school or junior college	3.6	1.6	0.33(0.15-0.69)
University (4-years) or more	2.5	1.8	0.69(0.40-1.20)
Marital status			
Married	3.5	1.9	0.62(0.47-0.80)
Divorced/widowed	4.5	3.7	0.94(0.41-2.14)
Never married	4.4	0.8	0.25(0.04-1.48)
Equivalent household income			
1st quintile (Lowest)	4.9	2.2	0.56(0.31-0.99)
2nd quintile	4.0	2.2	0.74(0.41-1.34)
3rd quintile	2.5	1.9	0.72(0.36-1.44)
4th quintile	2.7	2.2	0.81(0.42-1.55)
5th quintile (Highest)	2.5	1.8	0.85(0.42-1.73)
Housing tenure			
Does not own housing	5.5	2.9	0.73(0.39-1.37)
Owns housing	3.3	1.9	0.61(0.47-0.80)
Working condition			
Working	3.2	2.0	0.71(0.54-0.93)
Retired/Home-maker/Other	5.8	2.7	0.49(0.25-0.95)
Recently unemployed	6.4	1.9	0.20(0.06-0.71)
Other unemployed	5.0	1.4	0.27(0.07-0.97)
Self-rated health			
Excellent	3.2	2.0	0.71(0.48-1.06)
Good	3.3	2.1	0.70(0.48-1.01)
Poor	3.9	2.2	0.61(0.34-1.10)
Very poor	7.7	0.4	0.06(0.01-0.47)
Alcohol consumption			
Everyday drinker	2.9	1.8	0.74(0.47-1.15)
1-6 times per week drinker	2.7	1.9	0.66(0.41-1.08)
1-3 times per month drinker	3.5	2.8	0.98(0.37-2.59)
Seldom drinker	4.0	1.7	0.49(0.25-0.96)
Never drinker	5.7	2.7	0.54(0.33-0.89)

* Tobacco price increase occurred at 1 October 2010. 2008-2009 was used as a reference category.

† Adjusted for all listed variables.

Abbreviations: GEE, generalized equation estimation; CI, confidential interval.