Discrete choice experiment of smoking cessation behaviour in Japan

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Background: In spite of gradual increases in tobacco price and the introduction of laws supporting various anti-tobacco measures, the proportion of smokers in Japan's population is still higher than in other developed nations.

Objective: To understand what information and individual characteristics drive smokers to attempt to quit smoking. These determinants will help to realise effective tobacco control policy as a base for understanding of cessation behaviour.

Method: Discrete choice experiments on a total of 616 respondents registered at a consumer monitoring investigative company.

Results: The effect of price is greater on smokers with lower nicotine dependence. For smokers of moderate and low dependency, short term health risks and health risks caused by passive smoking have a strong impact, though the existence of penalties and long term health risks have little influence on smokers' decisions to quit. For highly dependent smokers, non-price attributes have little impact. Furthermore, the effects of age, sex and knowledge are also not uniform in accounting for smoking cessation.

Conclusion: Determinants of smoking cessation vary among levels of nicotine dependency. Therefore, how and what information is provided needs to be carefully considered when counselling smokers to help them to quit.

In Japan, the percentage of smokers in the general population is still higher than in other developed nations. In fact, the prevalence of smoking among people aged 15 years and over was 30.3% in 2003, which was higher than the average figure of 26.2% and the highest among the G7 countries.¹ Although smoking prevalence for males dropped from 53.1% in 1990 to 43.3% in 2004, that for females has actually increased from 9.4% in 1990 to 12.0% in 2004.² As in other countries, reduction of the smoking rate has been one of the central issues of public health policy. "Healthy Japan 21," a programme established by the Ministry of Health, Labour and Welfare, has promoted risk education, eradication of smoking among youth, separation of smoking areas and effective support for smoking cessation as its four main tobacco control measures.³

In Japan, the tobacco price was the lowest apart from Italy among G7 countries; this was around one-third of the price in the United Kingdom and half the price in the United States.⁴ In July 2006, the tobacco tax was raised and the price (one pack of 20 cigarettes) of common products was increased from 270 Japanese yen (£1.23, given £1 = 220 Japanese yen) to 300 Japanese yen (£1.36), though even with this price increase, the tobacco price is still low in Japan. The Health Promotion Act passed in June 2005 imposes on administrators of public places the obligation to prevent passive smoking, and there are now several municipalities that issue fines for smoking on certain streets. Furthermore, while to date the role of physicians in smoking cessation counselling has been limited,⁵ since April 2006 such counselling has been reimbursable in line with standard national health insurance practice, making access to this counselling service much easier.

Rising health expenditures and the serious state of national finances are leading to demands for more efficient tobacco control measures. Responding to these demands requires that priorities be set among different policies. Previous studies have found indicators of quit attempts, which include nicotine dependence,⁶ concern for health effects and demographic

factors such as age and education.^{7,8} These results imply that closely supervised counselling taking into account individual characteristics is needed. In this paper, we group subjects according to their level of nicotine dependence and analyse how differences in factors associated with cessation attempts among individuals can be used in formulating policies for reducing the prevalence of smoking in Japan.

The central aim of this paper is to determine what factors drive smokers' attempts to quit. Using discrete choice experiments (DCEs), we analyse the willingness of smokers to quit their habit in given hypothetical conditions. DCEs are attribute based measures of benefit. This experimental method is based on the following notions. Firstly, any good or service can be described by bundles of its attributes or characteristics. Secondly, the extent to which an individual values a good or service can be evaluated from selection of hypothetical choices mimicking the daily decision making process. This technique has been applied in healthcare settings,^{9–13} and outcomes have revealed that DCE results have internal validity and consistency.¹⁴

To the best of our knowledge, there has been little research on applying DCE to behaviour associated with attempts to quit smoking. DCE is one of stated preference methods different from revealed preference methods that use actual choice data on the existing goods or services. Furthermore, DCE enables us to predict results of tobacco control measures yet to be implemented—such as the effect of a steep increase in the cigarette price. In addition, this research uses estimation techniques that take into account individual level variation of estimated parameters. This information will be used to evaluate the uncertainty of outcomes of various tobacco control measures.

Abbreviations: DCE, discrete choice experiment; FTND, Fagerstrom test for nicotine dependence

Table 1 Sample data

	Observations	Subsample ratio	Female ratio	Average age
The first stage sampling				
Current smokers	3184	–	40%	40.6
H-type smokers	671	21%	38%	43.4
M-type smokers	1340	42%	38%	40.8
L-type smokers	1173	37%	43%	38.8
The second stage sampling				
Current smokers	616	–	23%	41.3
H-type smokers	205	33%	15%	44.2
M-type smokers	206	33%	23%	40.4
L-type smokers	205	33%	30%	39.3

METHODS

Data

We carried out a survey on adult Japanese who registered at a consumer monitoring investigative company (the total number of monitors is about 220 000). The data sampling was performed in the following two stages. Firstly, we randomly selected over 3000 current smokers from the monitors. The definition of a current smoker is somebody who has been smoking for one month or more and has smoked at least 100 cigarettes so far.¹⁵ The current smokers were classified into three types based on the Fagerstrom test for nicotine dependence (FTND).¹⁶ By aggregating the responses to the FTND, we defined respondents scoring a total of zero to three points as having low nicotine dependence (L-type), a total of four to six points as middle nicotine dependence (M-type), and a total of seven and over as displaying high nicotine dependence (H-type). The resulting ratios were 37% for L-type, 42% for M-type and 21% for H-type smokers.

Secondly, we surveyed a random sample of around 200 respondents from the three categories (H-type, M-type and L-type) and invited them to participate in the DCE described below. The percentage of women who smoked at the first stage was 40%, which was higher than the figure of adult Japanese female smokers (23%) as of 2005. Therefore, we set the female ratio of smokers at the second stage as follows, so that the female ratio of adult Japanese smokers corresponds to the national figures (23%): 30% for L-type, 23% for M-type and 15% for H-type. Note that 150 Japanese yen (£0.68) were paid to respondents who completed the FTND, and 500 Japanese yen (£2.27) were paid to respondents who replied the conjoint questionnaire for recompenses. Table 1 summarises the demographics of the sample data explained above.

Settings of the DCE

We conducted a DCE for 616 samples to analyse factors determining attempts to quit smoking. In a DCE, the choice of attributes expressing a good or service is very important. Too many attributes might impose an information processing burden on respondents, while too few prevent an accurate depiction of its characteristics. After group discussions with clinicians and pretests undertaken for smokers in which we asked about factors associated with consideration of smoking cessation, five attributes were identified as the most important factors: the price of cigarettes, fines for smoking in public places, long term health risks (mortality risk), short term health risks (risk of upper respiratory infection) and health risks to others.

In Japan, the cigarette price has been increasing gradually. To assess the impact of a substantial rise, we asked respondents the maximum price for one pack of cigarettes they would pay to continue smoking. Price levels were set within the range of the result of this question. This avoided presenting excessively high prices that would lead to individuals refusing to make a discrete choice. Smoking bans have been introduced in several countries, and these measures were found to be effective in reducing smoking.^{17 18} As mentioned in the introduction, several Japanese municipalities have adopted penalties and fines for smoking on busy streets, where a fine of 2000 Japanese yen (£9.52) is the most common. In this research, we set a smoking ban (supported by a fine) in public places—not only on streets but also on public transportation and in government offices—as an attribute. Higher cigarette prices and the existence of fines were expected to reduce the continuation of smoking and to increase quit attempts.

Table 2 Attributes and levels used in discrete choice experiments

Attributes	Levels	Level coding
Price of cigarettes (one pack, Japanese yen)	300 400 600 800	300 400 600 800
Penalty with fine for smoking in public places	Not in practice In practice	0 1
Overall mortality risk (relative risk against non-smokers)	1 2 3	0 1 2
Duration of bed rest caused by upper respiratory tract infection (per year)	The same as non-smokers 1 week longer than non-smokers 2 weeks longer than non-smokers	0 1 2
Risk of lung cancer caused by passive smoking	Not increased Significantly (around 30%) increased	0 1

Table 3 Sample question

Price of cigarettes (one pack)	600 Japanese yen
Penalty with fine for smoking in public places	In practice
Overall mortality risk	Twice as great as non-smokers
Duration of bed rest caused by upper respiratory tract infection	The same as non-smokers
Risk of lung cancer caused by passive smoking	Not increased

In the situation presented above, would you quit smoking? Or would you continue to smoke? (1) Quit smoking; (2) continue to smoke.

We considered three types of health risk. Firstly, it has been found that smoking increases overall mortality.^{19–20} This refers to a long term health risk. Secondly, smoking also causes and worsens common but usually non-fatal diseases. One example is upper respiratory tract infection.²¹ In this research, we suppose that smoking makes respondents incapable of daily life and unable to avoid bed rest. This setting refers to a short term health risk and is assumed to increase the disutility of smoking and is expected to promote smoking cessation. The third type of health risk is the one that is caused by passive smoking. For this type we considered the risk of lung cancer caused by passive smoking.²²

There are many works of epidemiological research concerning health risks caused by smoking. The magnitude of health risks depends on demographic characteristics such as sex, race, and age. Moreover, these health risks can be altered by technological innovations. Accordingly, it is meaningful to know the responses when people are presented with different risks at various levels. Table 2 summarises the attributes and levels included in the DCE.

Since the number of profiles becomes unwieldy if we consider all possible combinations, we adopted an orthogonal planning method to avoid this problem.²³ Finally we reduced the number of scenarios to 16 and divided them into two categories (eight scenarios each). Respondents were randomly assigned to one of the two. Table 3 depicts the scope of the representative question covering profiles and attributes. We used the stratified random sampling method explained above and asked eight questions per respondent, totalling 1640 samples for H-type, 1648 for M-type and 1640 samples for L-type.

Other variables

In addition, we used age, sex and knowledge about smoking as independent variables. Previous research showed that quitting smoking is closely associated with knowledge about the harms of smoking.²⁴ We asked respondents about the prevalence of smoking among Japanese males and females and its association with the following smoking related diseases: lung cancer, stomach cancer, colon cancer, coronary heart disease, lung cancer caused by passive smoking and miscarriage caused by passive smoking. Each question consisted of four choices. We defined an index of knowledge about smoking based on the total number of correct answers.

Estimation

Independent variables are level coded as shown in table 2, indicating levels for each attribute, age, sex, and knowledge about smoking. For all attributes, the utility of continuing to smoke is assumed to decrease as the level coding increases. Accordingly, the expected sign of each attribute is negative. To analyse data in which dependent variables are binary, we used the mixed logit model.^{23–25}

Among various models in the logit model family, conditional logit models that assume independent and identical distribution

of random terms have been widely used in past studies. However, independence from the irrelevant alternatives property derived from the independent and identical distribution assumption of the conditional logit model is too strict to allow for flexible substitution patterns among choices. The most prominent model is a mixed logit model that is flexible enough to obviate the limitations of conditional logit models by allowing for random taste variation,²⁶ unrestricted substitution patterns and the correlation of random terms over time.²⁷ We used here a simulation method²⁵ for estimation by setting 100 Halton draws.²³ A detailed explanation of the ML model and the simulation method is given in the appendix.

Furthermore, since each respondent repeatedly completed eight questions in the DCE, we consider the data a kind of panel data. Thus, we apply a standard random effect method in which random draws are repeatedly reused for the same respondent. We used N-Logit version 3 (Econometric Software, Inc, Plainview, NY, USA) for the estimation. Abbreviations of each variable are shown as follows.

Non-random parameters

- *Price*: price of cigarettes (one pack)
- *Age*: age
- *Sex*: sex (female dummy)
- *Knowledge*: knowledge about smoking.

Random parameters

- *Penalty*: penalty with fine for smoking in public places
- *Mortality*: overall mortality risk
- *Rest*: duration of bed rest caused by upper respiratory tract infection
- *Passive*: risk of lung cancer caused by passive smoking.

RESULTS

As table 1 shows, the proportion of females decreases and average age increases as nicotine dependency becomes more severe. Table 4 carries descriptive statistics of the samples. It indicates that respondents with higher nicotine dependence tend to be self employed, but that there is no difference in the level of education among the three groups. Also, the index of knowledge about smoking is the highest in H-type smokers. In the DCE, the proportion of sampled subjects choosing to continue to smoke is more common in those with higher nicotine dependence: 26.3% of respondents choose to continue to smoke according to the responses for all eight questions, while 13.6% choose to stop smoking, according to their responses to all eight questions, as a whole.

Table 5 shows the estimation results from the DCE. Assuming that random parameters were distributed normally, each random parameter has a mean estimate and a standard deviation (SD) estimate of each coefficient. For non-random parameters, estimates of coefficients are reported. Furthermore, estimation results are reported for the three groups of smokers (H-type, M-type and L-type). A negative sign for the average of each parameter refers to a decrease in the probability of attempting to continue to smoke and an increase in that to quit.

The cigarette price parameter “price” is negative and statistically significant for all subsamples. Here, the price elasticity of the probability of quit attempt to smoke was calculated: H-type, -0.926 ; M-type, -1.451 ; and L-type, -1.612 . This shows that smokers with lower nicotine dependence are highly responsive to price changes.

Results of non-price attributes vary among groups. In H-type smokers, all the non-price attributes are not significant, while “penalty” is significant only at the 10% level for M-type

Table 4 Descriptive statistics of samples

		Whole samples (n = 616)	H-type (n = 205)	M-type (n = 206)	L-type (n = 205)
Education	Graduate school	3.57	3.41	2.43	4.88
	University (4 years)	50.32	51.71	45.63	53.66
	University (2 years)	8.28	7.80	8.74	8.29
	Technical academy	11.20	6.83	15.05	11.71
	High school	24.84	27.8	27.18	19.51
	Junior high school	1.46	2.44	0.97	0.98
Occupation	Employed, full time	53.73	53.66	54.37	53.17
	Self employed	10.39	14.63	8.74	7.80
	Specialist	5.52	5.85	5.83	4.88
	Public servant	5.52	5.37	4.85	6.34
	Student	1.79	0.98	1.94	2.44
	Housewife	7.95	4.39	8.74	10.73
	Employed, part-time	7.47	7.80	7.28	7.32
	Unemployed	5.19	4.39	5.83	5.37
	Other	2.44	2.93	2.43	1.95
	Household income (Japanese yen)				
Household income (Japanese yen)	≤ 2 999 999	13.31	11.71	15.53	12.68
	3 000 000 to 4 999 999	28.08	28.29	34.47	21.46
	5 000 000 to 6 999 999	21.43	16.59	22.33	25.37
	7 000 000 to 9 999 999	23.05	24.88	19.42	24.88
	10 000 000 to 14 999 999	11.36	14.15	7.28	12.68
Knowledge about smoking	≥ 15 000 000	2.76	4.39	0.97	2.93
	Continue to smoke in all questions	4.22	4.27	3.97	4.05
	Quit smoking in all questions	26.30	35.12	24.76	19.02
		13.64	7.80	14.56	18.54

Note: Figures are percentages of respondents with respect to education, occupation and income. Otherwise, an average number or percentage is shown.

smokers. This indicates that the existence of a fine for smoking in public places has little impact on the decision to choose to continue smoking or to attempt to quit. As for the three types of health risk, "rest" and "passive" are negatively significant in M-type and L-type smokers, but "mortality" is negatively significant only in L-type smokers. Standard deviation estimates are statistically significant for all non-price attributes. The elevated health risks do not have significant effects on quit attempts for H-type smokers, but short term health risks and health risks for others decrease smoking by smokers with relatively low nicotine dependence. As for individual characteristics, age is positively significant except in L-type smokers, and knowledge about smoking is statistically significant only in H-type smokers. We found a higher and significant continuation rate for females only in the M-type group. The relation between individual characteristics and smoking continuation is not simple and has different patterns among levels of nicotine dependence.

Using the above estimates, we simulated the change in the probability of smoking continuation with respect to "price." Figure 1 indicates that as the cigarette price rises, the continuation rate decreases more rapidly in smokers with lower nicotine dependence. In the case of cigarettes costing less than 300 Japanese yen, which is the present price, the continuation rate is not unity. This is partly because of the effects of non-price attributes. Some smokers consider quitting even at the present price, and these "negative smokers" are more common among those with lower nicotine dependence. In contrast, around 70% of H-type smokers would continue to smoke if the current price doubled.

The cigarette price required to achieve the targeted smoking continuation rate can also be calculated using these parameters. As nicotine dependence increases, so does the price needed to reach the target. In H-type smokers, a price of 706 Japanese yen (£3.21) is needed for a 50% quitting rate and 983 Japanese yen (£4.47) for 90%. As for L-type smokers, a price of 467 Japanese

Table 5 Estimation results of the mixed logit model

Independent variables	H-type (n = 1640)			M-type (n = 1648)			L-type (n = 1640)		
	Estimates	SE	p Value	Estimates	SE	p Value	Estimates	SE	p Value
Non-random parameters									
Price	-0.0079	0.0007	<0.001	-0.0106	0.0009	<0.001	-0.0096	0.0008	<0.001
Age	0.0358	0.0130	0.006	0.0407	0.0138	0.003	0.0059	0.0122	0.627
Sex	0.0399	0.3464	0.908	0.6542	0.3282	0.046	-0.4266	0.2718	0.117
Knowledge	-0.3617	0.0958	<0.001	-0.0866	0.0976	0.375	-0.0282	0.0975	0.772
Constant	5.7602	0.8024	<0.001	5.4292	0.8083	<0.001	5.5086	0.7491	<0.001
Random parameters									
Penalty (mean)	-0.1694	0.2243	0.450	-0.3803	0.2305	0.099	-0.1888	0.1978	0.340
Mortality (mean)	0.1196	0.1884	0.526	-0.2716	0.1768	0.125	-0.4777	0.1613	0.003
Rest (mean)	-0.1642	0.1743	0.346	-0.5033	0.1600	0.002	-0.3753	0.1592	0.018
Passive (Mean)	-0.3085	0.2417	0.202	-0.7087	0.2647	0.007	-0.6689	0.2351	0.004
Penalty (SD)	1.3968	0.4400	0.001	1.5301	0.4598	<0.001	1.3547	0.3478	<0.001
Death (SD)	1.4431	0.2137	<0.001	1.8955	0.2532	<0.001	1.7529	0.2450	<0.001
Rest (SD)	1.5632	0.2744	<0.001	1.4498	0.2248	<0.001	1.5205	0.2002	<0.001
Passive (SD)	1.4736	0.3406	<0.001	2.7000	0.3884	<0.001	2.3030	0.3464	<0.001
Log likelihood	-815.526			-838.098			-843.202		
Pseudo R ²	0.283			0.266			0.258

Figure 1 Changes in smoking continuation rate with respect to cigarette price. Note: All independent variables but “price” are fixed at the sample mean. (JPY, Japanese yen.)

yen (£2.12) is needed to reach a 50% of quitting rate and 696 Japanese yen (£3.16) for 90%. For M-type smokers, the required prices are relatively close to those for L-type smokers. Since M-type and L-type smokers account for around 80% of smokers in total,²⁸ a rapid increase to 500 Japanese yen (£2.27) would be necessary to accomplish a reduction of smokers by half, which is a policy aim of the Healthy Japan 21 project.³

We assumed three different scenarios by changing non-price attributes, and simulated smoking continuation for three groups. Three scenarios are the pro-smoking scenario, the neutral scenario and the anti-smoking scenario. The desirability of smoking is different in each scenario. For example, there was assumed to be a penalty for smokers in the anti-smoking scenario but not in the pro-smoking scenario. Figure 2 depicts the results, which show that the effects of non-price attributes are greater in smokers with lower nicotine dependence. Therefore, policy measures like the supply of information about

health risks are effective in the M-type and L-type groups. On the other hand, this effect is questionable for H-type smokers.

Finally, table 6 presents a comparison of estimates of non-price attributes between males and females. The result of Welch’s *t* test indicated no significant difference in estimates of “mortality” and “passive” between males and females for all types of smokers. On the other hand, the estimates significantly differed between H-type and L-type smokers for “mortality” but not for “passive.”

DISCUSSION

Smoking is one of the most important issues yet to be solved, and analysis of smokers’ behaviour has for many years been a central theme of health economics research. In this paper, we have used a DCE to examine the effects of various attributes on the decision to continue smoking or to quit. The major findings of this research are as follows.

Figure 2 Smoking continuation rate when non-price attributes are changed. Note: For three groups, “price,” “age,” “sex and knowledge” are set at the sample mean. Non-price attributes are set as follows. In the pro-smoking scenario, (“penalty,” “mortality,” “rest,” “passive”) = (0, 0, 0). In the anti-smoking scenario, (“penalty,” “mortality,” “rest,” “passive”) = (1, 2, 1). In the neutral scenario, all non-price attributes are set to the sample mean.

Table 6 Comparison of estimates of non-price attributes between males and females

Compared estimates	Subsample	Hypothesis	Welch's <i>t</i> value	p Value
Male vs female				
Mortality	H-type	Male vs female	0.280	0.781
	M-type	Male vs female	0.321	0.749
	L-type	Male vs female	0.954	0.342
Passive	H-type	Male vs female	0.516	0.609
	M-type	Male vs female	0.982	0.330
	L-type	Male vs female	0.068	0.946
H-type vs L-type				
Mortality	Male	H-type vs L-type	3.805	0.000
	Female	H-type vs L-type	2.430	0.018
Passive	Male	H-type vs L-type	1.717	0.088
	Female	H-type vs L-type	0.492	0.624

Firstly, the price of cigarettes is a very important variable associated with the decrease of smoking, and its effect is greater in smokers with lower nicotine dependence. Secondly, the impacts of attributes other than the cigarette price differ remarkably among smokers with different levels of nicotine dependence. In particular, little effect was found in H-type smokers. Thirdly, in M-type and L-type smokers, short term health risks and health risks caused by passive smoking have a strong impact, though the existence of penalties and long term health risks have little effect on smokers' decisions to quit. Fourthly, the effects of age, sex and knowledge are not uniform in accounting for smoking cessation.

There have been only a few studies applying the DCE method to attempts to quit smoking. There is a Swedish study that lets cigarette price, subsidy to cessation treatment and smoking ban be attributes.²⁹ Their predicted effects of price and smoking bans are actually quite similar to our results. Our contribution is to reinforce previous findings by classifying samples with nicotine dependency in more detail and, more importantly, to investigate the effects of various types of health risks that were not examined.

To understand the core of socioeconomic behaviours like smoking, it is becoming increasingly important to analyse the relations between preference parameters with respect to time and risk and these behaviours.³⁰ As for time preference, it is reported that smokers are more myopic than non-smokers—namely, smokers choose early small reward over later large reward more frequently.^{30–31} Moreover, a significant positive correlation between the numbers of cigarettes smoked per day and a delay discounting rate has been found.³² It is also suggested that both the frequency of nicotine self administration and the dosage are positively associated with greater delay discounting.³³ Turning to the research on risk preference, it remains ambiguous whether smoking and impulsive probability discounting are related.^{30–34}

Looking at attributes used in the DCE, the price of cigarettes has the shortest term effect on smokers relative to other variables such as health risks and penalties—that is, our DCE results indicated that the shortest term effects are significant for all types of smokers, while the longer term effects such as health risks are usually found in smokers with lower nicotine dependence. These results are compatible with previous research findings of more myopic intertemporal choices in smokers with higher nicotine dependence.

There are also items of research pointing to the effectiveness of smoking bans in public places on reduction in tobacco consumption.³⁵ Some research has found that such a ban also reduces tobacco consumption at home.³⁶ This research finds

that penalties (for example, fines) have little effect on the decision to smoke or to quit. There are some reasons for this. Clean indoor air laws were enforced only recently in Japan, and the social acceptability of smoking may still be high. In other countries, more comprehensive smoking bans have often been undertaken, and it is reported that smoke-free workplaces are especially highly effective.³⁷ Therefore, the different types of smoking ban may have different results depending on the DCE framework.

The elasticity of the cigarette price regarding the decision to continue to smoke was relatively close to the figure of 1.07–1.21 quoted in previous literature.³⁸ To accomplish a large scale decrease in the prevalence of smoking, the price of cigarettes needs to be increased to double their present price, but a far greater price rise is necessary to discourage H-type smokers, especially. These results indicate the limitation of the present cigarette pricing policy whereby change is undertaken in a gradual manner.

Our results indicated that the effect of determinants of smoking cessation vary among levels of nicotine dependency. The effect of price change is largely influenced by the distribution of nicotine dependency. In counselling smokers, there needs to be careful designing of provision of information because the impacts of informing health risks and anti-tobacco measures are also dependent on personal characteristics such as nicotine dependency.

There remain several challenges facing this research. Firstly, our findings are based on a DCE in which the effects of attributes are evaluated based on answers from hypothetical scenarios. Thus, there is no guarantee that current smokers to answer that they will quit smoking will actually succeed. For example, potential defects of stated preference methods (including DCE) have been indicated as it only models current consumer attitudes for market forecasting. Their current intentions will become accurate reflections of future choices only if the current environment represents a future in which the choices are to be realised.³⁹ In fact, it is reported that only half of those who quit smoking will succeed in the long term after follow-up,^{40–41} and that the determinants of quit attempts and cessation are different.⁴² Those who have never intended to quit smoking may think it difficult to account for benefits and costs of smoking cessation.⁴³ In this research, 61% of the whole sample has never tried to quit smoking. These facts may result in a large discrepancy between hypothetical prediction and actual choice. Accordingly, our research may overestimate the effects, as the difference between quit attempts and actual cessation is large.

Secondly, we assume that the attributes of smoking explored are orthogonal, based on a main effects model. As a result, the

What this paper adds

- There has been little research on applying discrete choice experiment (DCE) to behaviour associated with attempts to quit smoking.
- The effects of cigarette price and health risk on cessation behaviour have wide variations according to nicotine dependence. Secondly, characteristics of health risks are also associated with these variations.

figures of pseudo R^2 are 0.258–0.283 (corresponding to 0.5–0.6 of OLS R^2), which indicate quite good fitness. Furthermore, alienating interaction effects with main effects may be justified since main effects typically account for 70% to 90% of explained variance.⁴⁴ However, we think that trying an interaction effects model is still important so as to know how the decision to smoke/quit is related to a complex interaction of factors either reinforcing or contradicting each other.

Thirdly, insignificant mean values for the parameters may result from the diversity of preferences around different values. This heterogeneity may relate to unobserved individual factors such as impulsivity and optimism. Considering risk and time preferences explicitly in the model will have good potential for future research.

Fourthly, the DCE method, in which attributes are assumed to be independent, focuses on the lone effects of attributes. However, tobacco control policies may interact with each other.⁴⁵ For example, warnings on tobacco packages may strengthen the effect of supplying information on health risks. The DCE results might ignore the potential interactions among policy measures in this way.

Finally, we should carry out an international comparison to analyse whether the conclusions in this paper still hold in different cultures and countries.

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APPENDIX

Here we explain a mixed logit model assuming that a parameter is distributed with a density function. The logit probability of decision maker n choosing alternative i is expressed as:

$$L_{ni}(\beta) = \exp(V_{ni}(\beta)) / \sum_{j=1}^J \exp(V_{nj}(\beta))$$

which is the normal logit form, given parameter β , the observable portion of utility function V_{ni} , and alternatives $j = 1, \dots, J$. Therefore, the mixed logit choice probability is a weighted average of logit probability $L_{ni}(\beta)$ evaluated at parameter β with density function $f(\beta)$, which can be written as:

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta$$

The demand elasticity of the ML model is the percentage change in the mixed logit choice probability for one alternative, given a change in the k th attribute of the same or another alternative, which can be expressed as:

$$E_{x_{knj}}^{ni} = - \int \beta_k L_{nj}(\beta) \left[\frac{L_{ni}(\beta)}{P_{ni}} \right] f(\beta) d\beta$$

where β_k is the k th coefficient. This elasticity is different for each alternative, and here the constant cross elasticity property derived from the independent and identical distribution property does not hold. In the form of linear in parameter, the utility function can be written as:

$$U_{ni} = \alpha' x_{ni} + \beta' z_{ni} + \epsilon_{ni}$$

where x_{ni} and z_{ni} , respectively, denote observable variables, α represents a fixed parameters vector, β is a random parameter

vector and ϵ_{ni} indicates an independently and identically distributed extreme value term.

Since the mixed logit choice probability is not expressed in closed form, simulations need to be performed for the mixed logit model estimation. Let θ be a deep parameter of parameter β ; in other words, the mean and (co-)variance of parameter density function $f(\beta|\theta)$. The mixed logit choice probability is approximated through the simulation method. Concretely, the simulation is carried out as follows: firstly, draw a value of β from $f(\beta|\theta)$ for any given value of θ , and repeat this process R times (labelled β^r , $r = 1 \dots R$); secondly, calculate logit formula probability $L_{ni}(\beta)$ with each draw; and thirdly, averaging $L_{ni}(\beta)$, the simulated choice probability is obtained as:

$$\hat{P}_{ni} = (1/R) \sum_{r=1}^R L_{ni}(\beta^r)$$

which is an unbiased estimator of P_{ni} whose variance decreases as R increases. The simulated log likelihood function is given as:

$$SLL = \sum_{n=1}^N \sum_{j=1}^J d_{nj} \ln \hat{P}_{ni}$$

where $d_{nj} = 1$ if decision maker n chooses alternative j , and zero otherwise. The maximum simulated likelihood estimator is the value of θ that maximises this simulated log likelihood function.

We can also calculate the estimator of the conditional mean of the distribution of the random parameters, conditioned on individual specific choice profile y_n , which is given as:

$$h(\beta|y_n) = \frac{P(y_n|\beta)f(\beta)}{\int P(y_n|\beta)f(\beta)d\beta}$$

ELECTRONIC PAGES

Tobacco Control Online: <http://tc.bmj.com>

The following electronic only article is published in conjunction with this issue of Tobacco Control.

Trends in nicotine yield in smoke and its relationship with design characteristics among popular US cigarette brands, 1997–2005

Gregory N Connolly, Hillel R Alpert, Geoffrey Ferris Wayne, Howard Koh

Objectives: To determine whether nicotine yields in the smoke of cigarettes would show an overall increase over time or an increasing trend limited to any particular market category (eg, full flavour vs light, medium (mild) or ultralight; mentholated vs non-mentholated), manufacturer, or brand family or brand style, and whether nicotine yields in smoke would be associated with measurable trends in cigarette design.

Methods: Machine-based measures of nicotine yield in smoke and measures of cigarette design features related to nicotine delivery (ventilation, nicotine content in the tobacco rod and

number of puffs), as well as market category descriptors, were obtained from annual reports filed with the Massachusetts Department of Public by tobacco manufacturers for 1997–2005. Trends in nicotine yield and its relationship with design features and market parameters were analysed with multilevel mixed-effects regression modelling procedures.

Results: A statistically significant trend was confirmed in increased nicotine yield, of 0.019 (1.1%) mg/cig/year over the period 1997–2005 and 0.029 (1.6%) mg/cig/year over the period 1998–2005. The increasing trend was observed in all major market categories (mentholated vs non-mentholated, and full flavour vs light, medium (mild) or ultralight). Nicotine yield in smoke was positively associated with nicotine concentration in the tobacco and number of puffs per cigarette, both of which showed increasing trends during the study period.

Conclusions: This study confirms increased machine-measured levels of nicotine, the addictive agent in cigarettes, in smoke, to be a result of increased nicotine in the tobacco rod and other design modifications.

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