Predicting decreases in smoking with a cigarette purchase task: evidence from an excise tax rise in New Zealand

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ABSTRACT

Background Tobacco excise taxes are known to be effective in reducing smoking at the population level, but less research has examined how individual smokers respond to changes in tax policy. We ask whether price elasticities for individual smokers, derived from simulated demand curves obtained with a cigarette purchase task (CPT), can predict changes in smoking after a tax increase.

Method Smokers (N=357) were recruited from four New Zealand cities and interviewed before and after a 10% tobacco excise tax increase.

Results Simulated demand curves from the CPT were curvilinear and well described by an exponential model. Smokers reported significant reductions in cigarettes/day and addiction scores at Wave 2 (n=226). Local elasticities derived from the demand curves significantly predicted decreases in cigarettes/day after controlling for covariates.

Conclusions Elasticities from simulated demand curves can predict decreases in consumption for individual smokers after an excise tax increase. Understanding individual differences in tobacco demand curves may help to predict how different groups of smokers will respond to price increases.

Researchers have identified tax policy as the most effective way to decrease smoking,[1 2] in particular tobacco excise taxes.[3] Most of the evidence for the effectiveness of tax policy has come from population level, macroeconomic studies. For example, Gallus *et al*[4] studied the relationship between cigarette consumption per capita and price across 52 different countries in the European region. They estimated the price elasticities of −0.46 and −0.74 for local and foreign tobacco brands, respectively, consistent with a prior meta-analysis which found a price elasticity for cigarettes of −0.48.[5]

Despite the considerable support for tax policy as a tobacco control strategy from macroeconomic studies, less is known about how individual smokers respond to tax increases, although available data consistently show that consumption decreases with price. Several studies have used cross-sectional designs in which different groups of smokers were sampled repeatedly in the context of population surveys.[6 7] Fewer studies have interviewed the same smokers before and after a tax increase. Saenz-de-Miera *et al*[8] studied smokers from four Mexican cities both before and after an increase in the ad valorem tax of 110–140% of the price to the retailer. Average reported prices increased by 12.7% and heavy smokers (>5 cigarettes/day) reported a significant reduction in cigarettes smoked per day, although the reduction for lighter smokers was not significant. Walton *et al*[9] found that a sample of New Zealand (NZ) smokers was more likely to have recently made a smoking-related change (eg, cut back or attempted to quit) after an excise tax increase in 2012 than before.

However, to our knowledge, no prior study has examined whether it is possible to predict individual smokers' response to an excise tax increase. Understanding the demographic and other variables associated with smokers' response to a tax increase is important for legislators and policy makers responsible for designing equitable and effective tobacco control strategies. We asked if measures of individual price elasticities, obtained from a simulated demand curve for tobacco, had predictive validity for changes in smoking after a tax increase. Of particular interest was whether elasticities could predict decreases in consumption after controlling for demographics, smoking habits and level of addiction, which would suggest that simulated demand curves can provide additional and potentially unique information about how individuals respond to increases in cigarette price.

We used a cigarette purchase task (CPT) based on MacKillop *et al*.[10] In their study, smokers from three US states indicated how many cigarettes/day would be purchased at 64 prices that increased from zero (free) to \$1.00/cigarette in small step increments. MacKillop *et al* found that the overall demand curve was curvilinear with relatively inelastic and elastic regions. They calculated the estimated increases in tax revenue and reductions in healthcare costs and lost productivity for representative tax increases, showing how the CPT could be used to inform tax policy. Other studies have found that demand indices obtained from CPTs can discriminate between smokers depending on the level of addiction[11 12] and have good test–retest reliability.[13]

We administered a CPT to a sample of NZ smokers both before and after the 10% tobacco excise tax increase (inflation-adjusted) that took effect on 1 January 2013. With an adult smoking prevalence of 18% in 2012, NZ represents a different cultural and economic context than the USA, where most previous studies employing CPTs have been conducted. Government has announced the goal of a smoke-free society by 2025,[14] and in addition to other tobacco control initiatives has committed to annual excise tax increases from 2010 through 2016. The average price of a packet of 20 cigarettes in November 2012 was NZ$14.50 (NZ$0.725/cigarette), and increased by 12% after the tax rise[15] to NZ$16.24 (NZ$0.812/cigarette). Because the exchange rate at the time was NZ$1.00=US$0.82, these prices are considerably higher than the USA, where the average pack price was US$5.51 in 2012.[16]

METHOD

Participants

The participants were 357 adult smokers recruited by newspaper, community and internet advertisements from four major NZ cities: Auckland (n=72), Wellington (n=151), Christchurch (n=71) and Dunedin (n=63). They needed to be daily smokers, >18 years, who purchased their own tobacco and with no intention to quit prior to 1 January 2013. All received a NZ$15 shopping mall voucher and a chance to win a NZ$250 tablet computer in return for completing each interview.

Procedure

All aspects of the study were approved by the University of Canterbury and Victoria University of Wellington Human Ethics Committees, and participants provided written informed consent. Participants were first interviewed between November and December 2012 (Wave 1), contacted again in February 2013, and those that agreed were re-interviewed in February–March 2013 (Wave 2).

In each session, participants first completed a demographic questionnaire, which in addition to age, ethnicity, employment, marital status, education and income, asked how many cigarettes/day they smoked, what type (factory-made or roll-your-own (RYO)), and the size of tobacco packets they typically purchased (20, 25 or 30 cigarettes/pack for factory-made, or 30, 40 or 50 g for RYO). They then completed several addiction questionnaires, including the Autonomy Over Smoking Scale (AUTOS[17]), the Fagerstrom Test of Nicotine Dependence (FTND[18]), the Glover-Nilsson Smoking Behavior Questionnaire (GNSBQ[19]) and the CPT.

Cigarette purchase task

The CPT[10] is used to measure demand for tobacco over a wide range of prices. The CPT was adapted from that used by MacKillop *et al* for price ranges that would be suitable for the New Zealand market. We used different versions of the CPT, both with 64 prices, depending on whether the participant indicated that they typically smoked factory-made or RYO tobacco.

For the factory-made smokers, the prices per cigarette ranged from NZ$0 to NZ$5.00. Prices increased by NZ$0.05 from NZ$0 to NZ$2.50/cigarette, by NZ$0.20 from NZ$2.50 to NZ$4.90/cigarette, and by from NZ$0.10 to NZ$5.00/cigarette. Depending on the participants' usual choice of tobacco packet, the price per pack was displayed to the right of each price per cigarette. The instructions were:

> Imagine a TYPICAL DAY during which you smoke. The following questions ask how many cigarettes you would consume if they cost various amounts of money. The available cigarettes are your favorite brand. Assume that you have the same income/savings that you have now and NO ACCESS to any cigarettes or nicotine products other than those offered at these prices. In addition, assume that you would consume cigarettes that you request on that day; that is, you cannot save or stockpile cigarettes for a later date. Be sure to consider each price increment carefully.

For RYO smokers the prices were listed in terms of cost per package of 30 or 50 g tobacco. To generate prices that were comparable to those used for the factory-made version of the CPT, prices for the latter were expressed relative to the current market price for cigarettes in November 2012 (NZ$0.70/cigarette), multiplied by the price per package of 30 or 50 g tobacco (which was approximately NZ$30.00 and NZ$50.00 at the time), and rounded to whole dollar amounts. Thus the minimum non-zero and maximum prices per pouch were NZ $2.00 and NZ$214.00 for 30 g pouches and NZ$4.00 and NZ $357.00 for 50 g pouches, with the average current market price (NZ$30.00 and NZ$50.00/pouch) at the same ordinal position among the prices in the scale as the NZ$0.70/cigarette on the factory-made CPT (14th item). In this way, the prices for both factory-made and RYO questionnaires covered approximately two orders of magnitude, with current market price at the same position, and changes in price relative to current market price were constant across all versions of the questionnaires. The instructions for the RYO smokers also noted that they should assume they would use the same amount of tobacco when rolling cigarettes.

RESULTS

Demographic information is shown in table 1. For the Wave 2 assessment in February–March 2013, 63.6% of participants (227/357) agreed to be re-interviewed. Of these 227, 7.0% (n=16) indicated that they had quit smoking.

Table 2 shows the average cigarettes/day smoked and scores on the addiction questionnaires at Wave 1 and for those who continued to smoke at Wave 2. Overall, cigarettes/day at Wave 2 (M=12.31) were significantly less than at Wave 1 (M=14.42), t (184)=4.58, p<0.001, d=0.24, indicating a 14.6% decrease in smoking after excluding quitters. At Wave 2, 62.5% (125/200) of the sample said they smoked fewer cigarettes/day than at Wave 1; 20.5% (75/200) reported the same cigarettes/day at Wave 2; and 17% (34/200) said they smoked more cigarettes/day at Wave 2. Significant reductions were also reported for

Table 1 Demographic and cigarette preference data for Waves 1 and 2

	Wave 1 (N=357)	Wave 2 (N=211)
Gender		
Male	46.6% (n=162)	41.6% (n=87)
Female	53.4% (n=186)	58.4% (n=122)
Cigarette preference		
Factory-made (FM)	68.3% (n=244)	65.4% (n=138)
Roll-your-own (RYO)	31.7% (n=113)	34.6% (n=73)
Ethnicity		
European (includes other)	70.0% (n=242)	69.4% (n=143)
Māori/Pacific	30.0% (n=104)	30.6% (n=63)
Age (years)		
18–24	23.0% (n=79)	17.7% (n=35)
25–34	30.2% (n=104)	27.8% (n=55)
35–44	17.2% (n=59)	17.2% (n=34)
45–54	18.0% (n=62)	23.7% (n=47)
55+	11.6% (n=40)	13.6% (n=27)
Income (NZ$)		
<20 000	25.6% (n=99)	27.0% (n=55)
20 000 ≤ x <30 000	12.4% (n=48)	13.2% (n=27)
30 000 ≤ x <40 000	8.5% (n=33)	11.3% (n=33)
40 000 ≤ x <50 000	8.5% (n=33)	10.3% (n=33)
50 000 ≤ x <60 000	9.6% (n=37)	10.8% (n=22)
60 000 ≤ x <70 000	7.0% (n=27)	8.8% (n=18)
≥70 000	18.1% (n=70)	18.6% (n=38)

Table 2 Average reported smoking habits (cigarettes/day) and addiction questionnaires (Fagerstrom Test of Nicotine Dependence (FTND[18]); Autonomy Over Smoking Scale (AUTOS[17]) total score, and subscales: withdrawal symptoms, psychological dependence, cue-induced craving; and Glover-Nilsson Smoking Behavior Questionnaire (GNSBQ[19])), for Wave 1 and for participants who still smoked at Wave 2

	Wave 1 November–December 2012 (N=357)	Wave 2 February–March 2013 (N=211)	d
Cigarettes/day	14.76 (8.62)	12.31 (8.72)	0.24***
FTND	4.18 (2.20)	3.88 (2.18)	0.16**
AUTOS (total)	18.33 (8.15)	17.77 (8.12)	0.15**
Withdrawal symptoms	5.51 (3.43)	5.22 (3.48)	0.1
Psychological dependence	5.50 (2.90)	5.33 (2.92)	0.13*
Cue-induced craving	7.33 (2.96)	6.70 (3.13)	0.28***
GNSBQ	16.97 (7.85)	15.49 (8.02)	0.24***

SD are listed in parentheses. Effect sizes (Cohen's d) for dependent-means t tests are also shown.

addiction scores at Wave 2: FTND: 3.88 (Wave 2) versus 4.22 (Wave 1), $t(205)=3.09$, $p<0.01$, $d=0.16$; AUTOS total: 17.77 (Wave 2) versus 18.92 (Wave 1), $t(204)=2.63$, $p<0.01$, $d=0.15$; and GNSBQ: 15.49 (Wave 2) versus 17.36 (Wave 1), $t(205)=3.54$, $p<0.001$. Of the AUTOS subscales, the largest reduction was reported for cue-induced craving, $t(220)=4.78$, $p<0.001$, $d=0.28$, followed by Psychological Dependence, $t(220)=2.00$, $p<0.05$, $d=0.13$, while the reduction in Withdrawal Symptoms approached significance, $t(220)=1.89$, $p=0.06$, $d=0.10$.

We conducted several analyses to characterise CPT demand curves at both the individual and group level. Both measures obtained directly from CPT responses and derived from fits of Hursh and Silberberg's[20] exponential model. For direct measures, we calculated the maximum consumption (Q_o) as the demand when cigarettes were free, O_{max} as the maximum amount of money spent per day, and the breakpoint (BP) as the first price for which consumption was zero. The equation for Hush and Silberberg's model is:

$$\log_{10}Q = \log_{10}Q_o + k(e^{-\alpha Q_o C} - 1), \qquad (1)$$

where Q is the demand at price C, Q_o is maximum consumption (ie, demand when cigarettes are free), k a constant which specifies the range of possible values in orders of magnitude (here set equal to 4, as in previous applications with CPT data[10]), and α the elasticity, a fitted parameter which determines how quickly demand falls with increases in price (higher values of α indicate that demand is more elastic, ie, falls more rapidly).

Figure 1 shows the average CPT data for Wave 1, plotted on logarithmic coordinates, including fits of Equation 1. For plotting on logarithmic scales, the price for NZ$0.00 was changed to NZ$0.025. Results were characteristic of demand curves for inelastic commodities: Over a range of low to medium prices, tobacco consumption remained high and decreased sharply at relatively high prices. On average, participants said they would smoke 18.55 cigarettes/day if they were free (Q_o), would quit smoking when cigarettes cost NZ$1.45 each (BP), and would spend a maximum of NZ$18.19 per day on tobacco (O_{max}). Equation 1 provided an excellent description of the average data, accounting for 90% of the variance with $\alpha=0.0056$. As expected, the quality of fits to the individual data was more variable, but the model still described results reasonably well, accounting for an average of 73% of the variance.

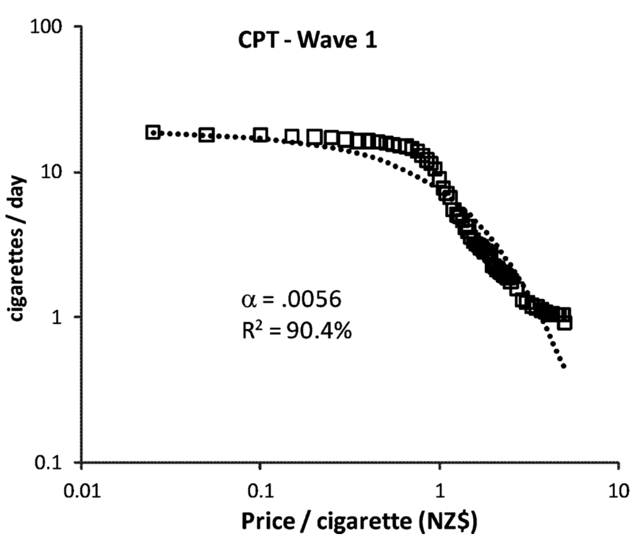

Figure 1 Average cigarette purchase task (CPT) results from Wave 1 plotted on logarithmic axes. Fits of equation 1 are shown by dotted lines.

Correlations between CPT-based demand measures, addiction scores at Wave 1, and smoking habit (cigarettes/day at Waves 1 and 2) are shown in table 3. Overall, greater intensity of demand was associated with increased addiction scores. Elasticity at Wave 1 (α) was negatively correlated with measures of addiction, rs=−0.28, −0.31 and −0.26, respectively, for FTND, AUTOS and GNSBQ, $p<0.001$. Conversely, O_{max} and Q_o were both positively correlated with the addiction measures, rs=0.35, 0.26, 0.18, and 0.45, 0.37, 0.37, $p<0.001$, respectively. This supports the convergent validity of the CPT, as lower elasticity and higher demand measures should be associated with higher levels of addiction.

Our major goal was to determine if simulated demand at Wave 1, as measured by the CPT, would predict decreases in tobacco consumption after the excise tax rise. Specifically, we conducted hierarchical multiple regressions in which the decrease in cigarettes/day from Waves 1 to 2 was the dependent variable. Results are shown in table 4. First we evaluated a covariate model in which smoking habit (cigarettes/day at Wave 1, cigarette preference (FM/RYO)), income level and addiction measures (FTND, AUTOS, GNSBQ) served as predictors. The model accounted for 14.6% of the variance, but cigarettes/day at Wave 1 was the only significant predictor, $\beta=0.46$, $p<0.00001$. Next, we tested whether measures derived from fits of equation 1 to the CPT—specifically α, Q_o and O_{max}, predicted decreases in smoking at Wave 2 after controlling for cigarettes/day at Wave 1. However, none of these variables accounted for significant additional variance, $\Delta R^2=0.001$, 0.001 and 0.000 for α, Q_o and O_{max}, respectively, all $p>0.63$.

Although we anticipated that α would predict changes in smoking, one concern is that it is based on fits to the full range of CPT responses, and might be a less effective predictor than a measure of elasticity based on a more limited range of prices that included those before and after the excise tax rise. To provide this, we computed the regression slopes between CPT responses for five prices ranging from NZ$0.65 to NZ$0.85/

Table 3 Correlation matrix for measures of smoking habit (cigarettes/day (W1,W2)=cigarettes/day at Waves 1,2; Δ cigarettes/day=difference in cigarettes/day (W1−W2); addiction measures at Wave 1 (Fagerstom Test of Nicotine Dependence (FTND[18]), Autonomy Over Smoking Scale (AUTOS[17]), Glover–Nilsson Smoking Behavior Questionnaire (GNSBQ[19]), and measures of demand derived from the cigarette purchase task at Wave 1 (Q_o, O_{max}, P_{max}, BP, α, local elasticity)

	Cigarettes/day W1	Cigerettes/day W2	Δ Cigarettes/ day	FTND	AUTOS	GNSBQ	Q_o	Q_{max}	P_{max}	BP	α
Cigerettes/day W2	0.71***										
	(n=200)										
Δ Cigerettes/ day	0.33***	−0.42***									
	(n=199)	(n=200)									
FTND	0.68***	0.58***	0.11								
	(n=323)	(n=224)	(n=200)								
AUTOS	0.46***	0.39***	0.06	0.55***							
	(n=322)	(n=223)	(n=199)	(n=356)							
GNSBQ	0.43***	0.40***	−0.01	0.52***	0.76***						
	(n=323)	(n=224)	(n=200)	(n=357)	(n=356)						
Q_o	0.68***	0.52***	0.22**	0.45**	0.37***	0.37***					
	(n=323)	(n=222)	(n=200)	(n=354)	(n=353)	(n=354)					
O_{max}	0.55***	0.40***	0.24**	0.35***	0.26***	0.18**	0.36***				
	(n=323)	(n=224)	(n=200)	(n=357)	(n=356)	(n=357)	(n=354)				
P_{max}	−0.01	0.04	0.03	0.00	−0.02	−0.05	−0.08	0.61***			
	(n=323)	(n=224)	(n=200)	(n=357)	(n=356)	(n=357)	(n=354)	(n=357)			
BP	−0.01	0.08	−0.07	−0.02	0.06	0.08	−0.03	0.18**	0.28***		
	(n=284)	(n=201)	(n=180)	(n=315)	(n=314)	(n=315)	(n=312)	(n=315)	(n=315)		
α	−0.52***	−0.39***	−0.17*	−0.36***	−0.37***	−0.32***	−0.49***	−0.51***	−0.39***	−0.25***	
	(n=323)	(n=224)	(n=200)	(n=357)	(n=356)	(n=357)	(n=354)	(n=357)	(n=357)	(n=315)	
Local elasticity	−0.22***	−0.01	−0.22**	−0.19***	−0.14**	−0.14**	−0.23***	0.10*	0.26***	0.23***	0.02
	(n=323)	(n=222)	(n=200)	(n=354)	(n=353)	(n=354)	(n=354)	(n=354)	(n=354)	(n=312)	(n=354)

*p<0.05, **p<0.01, ***p<0.001.

cigarette as a measure of local elasticity. When added to the regression, local elasticity accounted for a significant increase in variance beyond cigarettes/day at Wave 1, $\Delta R^2=0.024$, $F(1, 176)=4.89$, $p=0.03$. Importantly, the coefficient for local elasticity was negative, $\beta=-0.16$, $p=0.03$, indicating that those participants whose demand for tobacco was relatively more elastic at Wave 1 (ie, more negative slopes) were likely to show greater reductions in cigarettes/day at Wave 2.

Table 4 Beta weights (β), SE and obtained p values from multiple regressions to predict decreases in smoking at Wave 2 (Δcigarettes/day=cigarettes/day W1−cigarettes/day W2)

Covariate model	β	SE	p Value
Cigarettes/day W1	0.46	0.10	<0.00001
Income	−0.08	0.07	0.28
FM/RYO	−0.14	0.08	0.07
FTND	−0.09	0.11	0.41
AUTOS	0.05	0.11	0.63
GNSBQ	−0.18	0.11	0.09
Hierarchical models			
Cigarettes/day W1	0.33	0.08	<0.001
α	0.03	0.08	0.72
Cigarettes/day W1	0.35	0.11	<0.001
Q_o	−0.05	0.10	0.63
Cigarettes/day W1	0.31	0.09	0.001
O_{max}	0.002	0.09	0.99
Cigarettes/day W1	0.27	0.07	<0.0001
Local elasticity	−0.16	0.07	0.03

Cigarettes/day W1,W2=cigarettes/day at Waves 1,2; FM/RYO=cigarette preference (factory-made=1; roll-your-own tobacco=2); FTND, Fagerstrom Test of Nicotine Dependence[18]; AUTOS, Autonomy Over Smoking Scale[17]; GNSBQ, Glover-Nilsson Smoking Behaviour Questionnaire.[19]

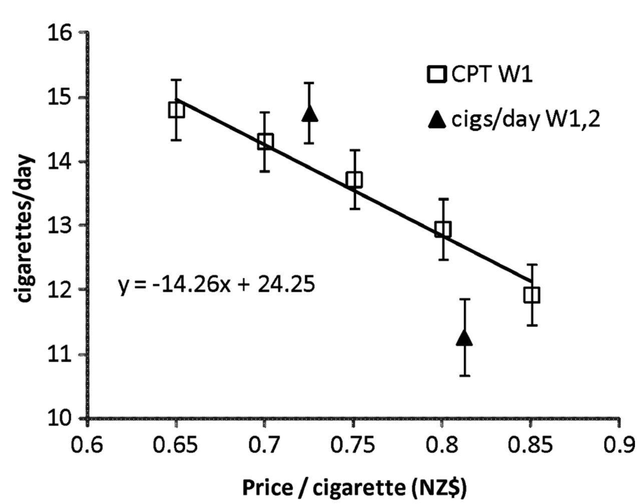

Figure 2 Average simulated demand for cigarettes/day from the cigarette purchase task (CPT) for prices between NZ$0.65 and NZ$0.85 are shown by unfilled squares. The line (and equation) represents the regression of these points on price. The average reported cigarettes/day at Wave 1 (price=NZ$0.725) and Wave 2 (price=NZ$0.812) are shown by filled triangles. Bars indicate 1 SE.

Results in table 4 show that individual differences in local elasticity predicted decreases in smoking (see also table 3), but they do not indicate whether the magnitude of change from Waves 1 to 2 was consistent with the CPT results. Figure 2 shows the average CPT responses for the five prices used to calculate the local elasticities (NZ$0.65–NZ$0.85/cigarette; unfilled squares), and reported cigarettes/day at Waves 1 and 2 (filled triangles; with prices of NZ$0.725 and NZ$0.812/cigarette, respectively). The regression line for the CPT data is also shown (slope=local elasticity). Based on the regression, the CPT predicted that there should have been a decrease of 1.24 cigarettes/day from Waves 1 to 2, which is less than obtained (M=2.76). We also calculated predicted decreases in cigarettes/day based on the local elasticities for individual participants. The average predicted decrease (M=1.16) was significantly less than the obtained decrease, $t(199)=-3.45$, $p=0.0007$.

We calculated price elasticities implied by the relative change in demand as prices changed from NZ$0.725 to NZ$0.812/cigarette in figure 2—that is, [(Δ cigarettes/day)/(cigarettes/day W1)]/[(Δ price)/(price W1)]. Based on the CPT results, the elasticity was −0.74, whereas the elasticity implied by change in cigarettes/day was −1.97. Together with the results in the previous paragraph, this suggests that participants reported larger reductions in smoking at Wave 2 than were predicted by their simulated demand curves at Wave 1.

We conducted analyses to check if participants who agreed or declined to be interviewed at Wave 2 were different in terms of smoking habits (cigarettes/day, factory-made vs RYO), CPT and addiction scores. No significant or systematic differences were found.

DISCUSSION

We developed a CPT for New Zealand smokers and used it to assess simulated demand for cigarettes before a 10% tobacco excise tax increase. Similar to previous studies,[10 11 13 21] simulated demand was a decreasing, positively accelerated function of price, and was well-described by Hursh and Silberberg's[20] exponential model. After the tax increase, participants reported a significant reduction in smoking habits (cigarettes/day) as well as levels of addiction as measured by the FTND[18], Autonomy Over Smoking Scale (AUTOS[17]) and the Glover-Nilsson Smoking Behavior Questionnaire (GNSBQ[19]). After controlling for cigarettes/day at Wave 1, reductions in smoking at Wave 2 were predicted by a local elasticity measure derived from the CPT—specifically, regression slopes based on a limited range of prices that included those actually in effect at Waves 1 and 2 (see figure 2). This result confirms our primary hypothesis that individual differences in price sensitivity could predict changes in cigarette consumption following a tax increase.

Although the regression slopes from the CPT predicted individual differences in changes in cigarette consumption, the magnitude of the reported reduction in cigarettes/day at Wave 2 (2.76 cigarettes/day) was more than twice that predicted by the CPT (1.24 cigarettes/day). The implied elasticity of the regression slope fit to the average CPT data was −0.74, which was less than half, in terms of absolute value, of the elasticity based on reported cigarettes/day (−1.97). Notably, the reduction in smoking predicted by the CPT was more consistent with macroeconomic studies on demand for cigarettes, which have typically found elasticities for tobacco in the range of −0.4 to −0.7.[4 22 23] Although reasons for this discrepancy are unclear, one possibility is that the reduction in cigarettes/day may have been affected by left-digit bias. Previous studies using similar global self-reports of smoking have found that participants are likely to round up or down to the nearest factor of 10.[24 25] We examined our data and found that values of 10, 15 and 20 cigarettes/day were indeed over-represented at both Waves 1 and 2. If participants were likely to round down at Wave 1—for example, one who smoked 20 cigarettes/day at Wave 1 but knows that he or she has cut back and reports smoking 15 or 10 cigarettes/day at Wave 2, the difference could be inflated.

It is interesting to compare the CPT results for NZ smokers with those of previous studies, which have been based mostly on US samples. To increase comparability, we used the same number of prices and the same ratio between minimum and maximum prices as MacKillop *et al*,[10] although the prices were in different currencies. In addition, in both cases the minimum price was the smallest unit available for the respective currency (NZ$0.05, US$0.01). The value of the elasticity parameter (α) from equation 1 estimated from the average Wave 1 data, 0.0056 (see figure 1), was lower than that reported by MacKillop *et al*[10] in their large sample of adult US smokers (0.02), suggesting that simulated demand for tobacco is less elastic in NZ than in the USA. However, the intensity of demand (cigarettes/day when price is free) was lower in the present data (M=18.55) compared to MacKillop *et al* (M=23.62). Despite these differences, the overall similarity in the shapes of the NZ and USA demand curves suggests that the present results are generalisable.

Understanding individual differences in elasticity, and demand curves for tobacco in general, is important for policy makers to ensure the equity and effectiveness of excise taxes as a tobacco control strategy. One concern about tobacco excise taxes is that they can disproportionately affect low-income smokers, who spend a greater proportion of their available household income on cigarettes.[26] Low-income smokers would be particularly disadvantaged if they reported less of a decrease in smoking habits after a tax rise than high-income smokers. We found no significant correlations between income level and smoking habit, reduction in cigarettes/day, elasticity (α), and addiction scores (FTND, AUTOS, GNSBQ), all $p>0.30$. Thus the tax rise appeared to affect smokers similarly regardless of income level, although this result should be interpreted cautiously because of limited sample size.

Notably, we found that Māori/Pacific smokers reported significantly greater reductions in cigarettes/day at Wave 2 (M=4.96) than European/other (M=1.95). This contrasts with a recent report,[9] which found that Māori smokers were less likely than non-Māori to report a change in smoking behaviour after the 2012 excise tax rise. Reasons for the discrepancy are unclear, but our results are encouraging because Māori and Pacific Island groups are economically disadvantaged and with higher smoking prevalence than average, and an important priority in New Zealand's tobacco control strategy.

Previous studies[11 27] have provided evidence for the convergent validity of the CPT because derived indices of demand such as elasticity, breakpoint (BP), intensity (Q_o) and maximum expenditure (O_{max}) have been correlated with scores on the FTND,[18] which is one of the most widely used measures of smoking-related addiction. In addition to the FTND, we found that CPT-related demand measures were also similarly correlated with the AUTOS[17] and GNSBQ,[19] which measure psychological aspects of addiction (eg, loss of autonomy) and behavioural symptoms, respectively. This provides additional evidence of the convergent validity of the CPT.

Some limitations of the present study should be acknowledged. We relied on global self-report for smoking habit and did not use a biochemical measure of nicotine dependence (eg, cotinine). Thus, as noted above, our measure of reduction in smoking could have been inflated by left-digit bias. As an alternative measure, we calculated the difference between CPT responses for the prices that were closest to those in effect at Waves 1 and 2 (NZ$0.70 and NZ$0.80/cigarette, respectively). This measure was highly correlated (r=0.75) with the difference in global self-reports and was similarly predicted by the local elasticity measure in the regression analysis (table 4). We also had some attrition in the sample, when 36.7% of participants declined to be re-interviewed at Wave 2. However there were no significant differences in smoking habit, addiction levels and CPT-derived demand indices between those who did or did not participate in Wave 2.

The present results add to the growing literature on the assessment of simulated demand for tobacco using purchase tasks like the CPT, and suggest that measures of elasticity from these tasks can be useful for predicting individual responses to changes in prices. Results of our study complement prior investigations which have examined the effect of excise tax increases on tobacco consumption, which have typically adopted a macroeconomic perspective.[3] The CPT provides a rich source of information about sensitivity to cigarette prices that contributes to a fuller understanding of the psychological and economic factors that determine nicotine addiction.

What this paper adds

- Tobacco excise taxes are known to be effective in reducing smoking at the population level, but little is known about how individual smokers respond to tax increases.
- Cigarette purchase tasks (CPTs) can be used to obtain simulated demand curves—smokers' intentions to purchase tobacco at various prices—but their predictive validity is unknown.
- We interviewed smokers both before and after an excise tax rise in New Zealand and found that elasticities from the CPT demand curves predicted decreases in smoking for individual smokers, after controlling for covariates including smoking habit, income, addiction level and cigarette preference.
- Simulated demand curves provide an important and possibly unique source of information about how individual smokers' behaviour will change after a tax increase.

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Contributors RCG and ML designed the study; RCG, BMK and ML acquired and analysed the data; and RCG drafted the manuscript with revision by BMK and ML. All authors approved the final submission.

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Competing interests None.

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