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THE IMPACT OF VAPING AND REGULATORY ENVIRONMENT ON CIGARETTE DEMAND: BEHAVIORAL ECONOMIC PERSPECTIVE ACROSS FOUR COUNTRIES

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Abstract

Background and Aims: Government regulations of nicotine vaping products (NVP) have evolved rapidly over the past decade. The impact of NVP regulatory environment and vaping on cigarette demand in unknown. The current study aims to investigate whether or not respondents'

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Conflict of interest declaration

KMC has received funding from Pfizer to advise them on ways to improve the delivery of tobacco cessation interventions to patients in health care settings. KMC also receives funding as an expert witness in litigation filed against the tobacco industry. WKB is a principal in HealthSim, NotifiUs, Red 5 Group, BEAM Diagnostics, SoberGrid, DxRx, ProPhase, Intellipharmaceutics, Teva Branded Pharmaceutical Products. The other authors declare that they have no conflicts of interest.

Ethics approval: The survey protocols and all materials, including the survey questionnaires, were cleared for ethics by Institutional Review Board, Medical University of South Carolina; Research Ethics Office, King's College London, UK; Office of Research Ethics, University of Waterloo, Canada; and Human Research Ethics, Cancer Council Victoria, Australia.

reported cigarette demand, as measured by a hypothetical cigarette purchase task, varies with 1) smoking status, 2) vaping status, or 3) NVP regulatory environment (country used as proxy).

Participants: 10,316 adult smokers.

Setting: Australia (AU), Canada (CA), England (EN), and the Untied States (US).

Design: Cross-sectional survey data from Wave 1 of the International Tobacco Control (ITC) Four Country Smoking and Vaping (4CV) Survey (2016).

Methods: Data for this cross-sectional study were from 10,316 adult smokers who participated in Wave 1 of the International Tobacco Control (ITC) Four Country Smoking and Vaping (4CV) Survey, which was conducted in 2016 in Australia (AU), Canada (CA), England (EN), and the United States (US). The purchase task asked smokers to estimate how many cigarettes they would purchase for consumption in a single day across multiple cigarette prices. Overall sensitivity of cigarette consumption to price increases was quantified to index cigarette demand elasticity whereas estimated consumption when cigarettes are free was used to index cigarette demand intensity.

Measurements: A hypothetical purchase task asked smokers to estimate how many cigarettes they would purchase for consumption in a single day across multiple cigarette prices. Responses were used to derive measures of cigarette demand. Overall sensitivity of cigarette consumption to price increases was quantified to index cigarette demand elasticity whereas estimated consumption when cigarettes are free was used to index cigarette demand intensity.

Results: A majority of the non-daily smokers had previously smoked daily (72.3%); daily vapers were more likely to be former daily smokers (89.9%) compared to non-daily vapers (70.1%) and non-vapers (69.2%) ($p<.001$). The smoking status by vaping status interaction was significant for cigarette demand intensity ($F=4.93$; $p=.007$) and elasticity ($F=7.30$; $p=.001$): among non-daily smokers, vapers reported greater intensity but lower elasticity (i.e., greater demand) relative to non-vapers (ps<.05). Among daily smokers, daily vapers reported greater intensity relative to non-vapers ($p=.005$), but vaping status did not impact elasticity (ps>.38). Intensity was higher in AU compared with all other countries (ps<.001), but elasticity did not vary by country ($F=2.15$; $p=.09$).

Conclusions: In a hypothetical exercise, increasing the price of cigarettes was associated with less impact on reported cigarette purchases by non-daily smokers who vape regularly.

Keywords

Behavioral economics; vaping; e-cigarettes; demand; price; policy; tobacco control

INTRODUCTION

Conventional factory-made cigarette smokers have an expansive set of harm reduction options because of the increased availability of alternative nicotine products. Over the past decade, nicotine vaping products (NVPs) have become a popular and rapidly evolving class of non-combustible products that don't contain tobacco (1). Smoking-related morbidity and mortality would very likely be reduced if smokers switched completely from smoking tobacco cigarettes to vaping nicotine (2). But researchers and policy experts have engaged in

a rigorous debate on how to facilitate these transitions, and in this debate, the importance of the regulatory environment in its impact to shape behavior has been recognized (1).

Evidence is needed to inform this debate—both to identify strategies that may be promising in increasing the rate of complete switching from cigarettes to vaping products, and to ascertain whether these strategies may result in unintended adverse consequences. For example, policies designed to limit NVP availability (e.g., sales ban of nicotine-containing vaping devices or liquid) will likely hinder transitions away from cigarettes because smokers will have fewer options to substitute in place of cigarettes. The impact of NVP regulatory environment and vaping on cigarette demand, or the amount of cigarettes purchased/consumed at a given price, remain important research questions.

Behavioral economics offers a time- and cost-efficient approach to assess cigarette demand (3). Specifically, hypothetical cigarette purchase tasks ask smokers to estimate how many cigarettes they would purchase for consumption in a single day across multiple cigarette prices, allowing experimental examination of the impact of price on purchasing within subjects. The change in purchasing behavior due to increasing price can be quantified as a measure of price sensitivity or elasticity of demand (4, 5). Smokers who are less price sensitive (i.e., price has relatively low impact on amount smoked) have been found to have higher levels of nicotine dependence (6), greater difficulty quitting (7–9), and lower motivation to quit (10). No purchase task study to date has simultaneously compared cigarette demand across a broader range of smoking (i.e., daily and non-daily) and vaping (i.e., daily, non-daily, none) transition states. In addition, no purchase task study to date has examined cross-country comparisons in cigarette demand; comparisons across countries that differ in their NVP regulatory environment are needed to examine empirically whether and how regulatory environment affects demand for cigarettes.

The current study was designed to help fill these research gaps by examining the influence of 1) smoking status, 2) vaping status, and 3) NVP regulatory environment on cigarette demand among adult smokers from the Wave 1 (2016) International Tobacco Control (ITC) Four Country Smoking and Vaping (ITC 4CV) Survey. Country is used as a proxy for NVP regulatory environment because Australia (AU), Canada (CA), England (EN), and the United States (US) varied quite markedly in their regulatory approaches. In AU and CA, the sale of nicotine-containing devices and liquids was prohibited at the time of the current study, while their sale was allowed in EN and the US. In CA, the ban on NVPs was weakly enforced (11), whereas in AU it was more aggressively enforced (12). We hypothesized that higher frequency of vaping (daily<non-daily<non-vaping) and countries with less restrictive NVP policies (EN/US<CA<AU) would be associated with lower cigarette demand.

METHODS

Participants

Methodological details of the ITC 4CV1 are available via the ITC website (https://www.itcproject.org/files/4CV1_Technical_Report_20July2018.pdf). The sample in each country was designed to be as representative as possible of smokers and used either

probability-based sampling frames or non-probability quota samples (see Thompson et al., forthcoming).

Eligibility for inclusion in the current study was at least occasional smoking (i.e., daily, weekly, monthly, and occasional smoking, where smokers who smoked "monthly" or "occasionally" must have smoked at least 100 lifetime cigarettes, while daily or weekly smokers were assumed to have smoked at least 100 lifetime cigarettes), and have smoked during the past 30 days (451 excluded due to this criterion). No criteria were specified for vaping status. The final sample analyzed consisted of 10,316 adult smokers.

Procedure and Measures

Cigarette Demand (Primary Outcome)—After obtaining informed consent, participants completed the online survey, with the embedded cigarette purchase task completed by all smokers (full task available in Supplemental File 1). Instructions were based on the previously-validated Cigarette Purchase Task (5, 6, 13):

"Imagine that for the next 24 hours the only cigarettes available to you are ORDINARY FACTORY-MADE CIGARETTES. That is, you have NO ACCESS to any other type of cigarettes or nicotine products for the next 24 hours. The following questions ask how many ORDINARY FACTORY-MADE CIGARETTES you would smoke if they cost various amounts of money. The average price for an ordinary factory-made cigarette is [$0.50 (CA)/ $0.30 (US)/ £0.40 (UK)/ $0.90 (AU)]."

Respondents were asked how many cigarettes they would smoke when the price for each cigarette was: 0x (free), 0.5x, 1x, 1.5x, 2x, 5x, 10x, and 20x average market price. Demand curves (graphical depiction of consumption as a function of price) and four demand outcomes were generated from responses: 1) intensity (cigarette consumption at the lowest price; peak consumption), 2) Pmax (price at which maximum spending occurs, which is where consumption shifts from relatively low price sensitivity to relatively high price sensitivity), 3) breakpoint (price at which no cigarettes are purchased and no smoking occurs), and 4) elasticity (sensitivity of consumption to increases in cost). As depicted in the example provided in Figure 1, higher intensity, Pmax, and breakpoint, and lower elasticity estimates are indicative of higher cigarette demand (14). Multiples of average market price, instead of actual prices, were used to compute Pmax, breakpoint, and elasticity to allow for comparability across countries.

Primary Predictors—Smoking status was categorized as daily or non-daily (i.e., weekly or occasionally; see above). Vaping status groups were daily, non-daily (i.e., weekly or less than weekly but at least once a month), and non-vapers. The country variable was used as a proxy for NVP regulatory environment and had four levels (CA, US, EN, and AU).

Covariates—The survey assessed demographic variables such as age, gender, ethnicity, income, and education. Ethnicity was coded as the majority (CA/US/EN=White; AU=English speaking) or minority. Monthly household income and education were categorized into three levels (low, moderate, and high), with the tertiles roughly comparable across the four countries. Motivation to quit smoking had four levels (not at all to a lot) and

confidence to quit had five levels (very easy to very hard). Among daily smokers, cigarette dependence was measured by the heaviness of smoking index (15). Non-daily smokers were asked whether they had ever smoked daily (never vs. former daily).

Data Analyses

Purchase task data were checked for nonsystematic responding in accordance with best practice guidelines, previously described (16). Nine percent of the sample failed to meet the "bounce" criterion, which detects greater than 25% increases in consumption between pairs of ascending, contiguous prices. Five percent of the sample failed to meet the "trend" criterion (i.e., due to zero consumption at all prices), which detects negligible reductions, no change, or increases in consumption from the first to last price point. We excluded nonsystematic responders from the primary analyses (14%). Finally, 34% of the sample was excluded for responding "don't know" to at least one or more of the price points. SPSS 25 was used to fit multinomial logistic regressions that compared systematic responders to those excluded from the primary analyses due to nonsystematic responses (see Supplemental Table 1). All predictors/covariates were examined simultaneously. Among systematic responders (n=5336; 52% of those otherwise eligible), we used multinomial logistic regression to test potential group differences for participant characteristics as a function of vaping status.

GraphPad Prism version 7 software (La Jolla, CA) was used to model elasticity for systematic responders (n=5336). We derived elasticity (a), the rate of decline of consumption in standardized cost, through a modified exponential demand curve equation (17), $Q = Q_0 \times 10^{k(e^{-aQ_0C}-1)}$. For this equation, Q = consumption at a given cost, Q_0 = consumption when cost is zero, C = cost, and k = a constant that denotes the range of consumption in log powers of 10. For the current study, k=1.83, based on estimated cigarette consumption. Intensity, Pmax, and breakpoint were based on observed values. Intensity and elasticity were log transformed to correct for non-normal distributions.

ANOVAs were used to ascertain the potential impact of smoking status, vaping status, and NVP regulatory environment (i.e., country) on cigarette demand, the hypothesized factors of interest. Primary predictors were entered into the model simultaneously (smoking status, vaping status, country, smoking status by vaping status interaction term), along with all covariates and rescaled cross-sectional weights to ensure estimates were representative of smokers in each country. Significant main effects suggest that the predicted demand estimates of each level within each factor (e.g., daily vaper, non-daily vaper, non-vaper) are not equal to each other. Parameter estimates indicate the differences in the predicted estimates from the respective levels to the reference level, and are used to derive estimated marginal means used for pairwise comparisons. We also constructed models for daily smokers that included cigarette dependence and models for non-daily smokers that included past daily smoking status, thereby controlling for these potential confounds within the smoking status subgroups. Results were largely consistent with those from the more parsimonious models presented below (see Supplemental Tables 2 and 3).

RESULTS

Participant characteristics

Table 1 shows the unadjusted relationships between vaping status and participant characteristics. As shown in Table 1, smoking status, gender, motivation to quit smoking, age, and country of residence were significantly related to vaping status. Vapers were less likely to be daily smokers, from AU, and female, and were more likely to be younger and to be motivated to quit smoking (*ps*<.05). Among daily smokers, 32.2% reported low cigarette dependence, 59.8% moderate dependence, 5.7% high dependence, and 2.3% provided incomplete data (i.e., coded as don't know). A majority of the non-daily smokers had previously smoked daily (72.3%); daily vapers were more likely to be former daily smokers (89.9%) compared to non-daily vapers (70.1%) and non-vapers (69.2%) (*p*<.001).

Demand Outcomes

Figure 2 displays demand curves that depict the influence of price on estimated cigarette consumption based on unadjusted responses. Panel A shows vaping status had negligible impact on daily smokers' estimated consumption across all price points, except daily vapers reported greater smoking at the lowest price point. Panel B shows a more pronounced impact of vaping status for non-daily smokers. Non-vapers reported the lowest smoking across all price points while higher smoking was observed for non-daily vapers and then daily vapers. The modified exponential demand curve equation provided an excellent fit for the data, accounting for a large degree of the variance based on aggregated group mean values (R^2=.99) and individual fit estimates (median R^2=.88). Table 2 depicts between-subject effects from ANOVA models for all dependent variables, after adjusting for covariates and weighting. Parameter estimates from these models are indicated in Table 3. Statistics are provided in text format below for pairwise comparisons not displayed in Table 3.

Intensity.

Intensity in this context represents estimated cigarette consumption at the lowest cigarette price (i.e., amount smoked when cigarettes are free). Higher intensity (i.e., greater level of smoking) indicates greater demand. Statistically significant main effects were observed for smoking status (*F*=297.03; *p*<.001), vaping status (*F*=19.97; *p*<.001), along with a significant smoking status by vaping status interaction (*F*=4.93; *p*=.007). Figure 3 (panel A) displays the estimated marginal means for the smoking status by vaping status interaction. Among daily smokers, daily vapers reported greater smoking relative to non-vapers (*mean difference*=.07; *p*=.005; *CI*=.02 to .12), but they were not different from non-daily vapers (*p*=.20). No differences were observed between non-daily vapers and non-vapers (*p*=.08). A similar, but more pronounced, pattern was observed for non-daily smokers; daily vapers reported greater smoking than both non-daily vapers (*mean difference*=.11; *p*=.04; *CI*=.01 to .21) and non-vapers (*mean difference*=.21; *p*<.001; *CI*=.13 to .29), and non-daily vapers showed greater smoking compared to non-vapers (*mean difference*=.10; *p*=.008; *CI*=.03 to .17). Figure 4 (panel A) shows that the significant country main effect (*F*=10.81; *p*<.001) was driven by a higher level of smoking reported in AU compared to all other countries (*ps*<.001).

Covariates.—Motivation to quit did not predict intensity, whereas lower confidence to quit was associated with greater smoking. Smoking was higher (i.e., greater demand) for those who reported being male, lower income, lower education, majority ethnicity, and older age.

Pmax.

Pmax represents price at which maximum spending occurs, which is where estimated cigarette consumption shifts from relatively low price sensitivity to relatively high price sensitivity (i.e., where smoking levels begin to decline more rapidly due to price). Higher Pmax indicates greater demand. We found a significant main effect for smoking status (F=25.68; p<.001), with higher Pmax estimates for daily smokers compared to non-daily smokers. Neither vaping status (F=1.66; p=.19) nor its interaction with smoking status predicted Pmax (F=.06; p=.55). A significant main effect for country was observed (F=23.55; p<.001). Table 3 shows the average Pmax estimates were lower for smokers from AU relative to those from the US, CA, and EN (see also Figure 4, panel C). Additionally, Pmax estimates were lower for smokers from CA compared to those from the US (*mean difference*=−.82; p<.001; *CI*=−1.27 to −.38) and EN (*mean difference*=−1.08; p<.001; *CI*= −1.46 to −.70).

Covariates.—Greater motivation to quit and confidence to quit was associated with lower Pmax. Pmax did not vary by age, but higher Pmax was observed for those who reported being female, higher income, higher education, and of minority ethnicity (i.e., greater demand).

Breakpoint.

Breakpoint is the price at which cigarettes are no longer purchased (i.e., no smoking occurs), such that higher breakpoint indicates greater demand. Daily smokers reported greater breakpoint than non-daily smokers (F=59.12; p<.001), but vaping status (F=2.31; p=.10) and the smoking x vaping interaction were not significantly associated with breakpoint (F=.81; p=.45). A significant main effect for country was observed (F=23.51; p<.001). Table 3 shows the average breakpoint estimates were lower for smokers from AU relative to those from the US, CA, and EN (see Figure 4, panel D). Additionally, breakpoint estimates were lower for smokers from CA compared to those from the US (*mean difference*=−.81; p=.004; *CI*=−1.36 to −.26) and EN (*mean difference*=−.76; p=.002; *CI*=−1.23 to −.29).

Covariates.—Greater motivation to quit and confidence to quit were associated with lower breakpoint. The breakpoint did not vary by gender or education, but higher breakpoint (i.e., greater demand) was found for those who reported higher income, higher education, being a minority, and younger age.

Elasticity.

Elasticity represents the overall sensitivity of cigarette consumption to increases in price. Higher elasticity (i.e., more price sensitive) indicates lower demand. We found significant main effects for smoking status (F=268.04; p<.001) and vaping status (F=3.71; p=.02), and a significant smoking status by vaping status interaction (F=7.30; p=.001). Figure 3 (panel B) displays the estimated marginal means for the smoking status by vaping status interaction.

Elasticity did not vary by vaping status for daily smokers (*ps*>.38), but greater vaping frequency was associated with lower cigarette price elasticity within non-daily smokers. Daily vapers (*mean difference*=−.20; *p*=.001; *CI*=−.31 to −.08) and non-daily vapers (*mean difference*=−.11; *p*=.04; *CI*=−.21 to −.003) were less sensitive to cigarette prices than non-vapers. The difference between daily vapers and non-daily vapers was not statistically significant (*p*=.23). In contrast to other demand indices, elasticity did not vary by country (*F*=2.15; *p*=.09).

Covariates.—Greater motivation, and confidence, to quit were associated with higher sensitivity. Elasticity did not vary by gender or income, but those who reported higher education, being a minority, and younger age were more price sensitive (i.e., lower demand).

DISCUSSION

Our report has three principal findings. As expected, daily smokers reported they would smoke more cigarettes across a range of prices (i.e., greater demand) relative to non-daily smokers. Second, vaping status interacted with smoking status such that vaping had a larger impact for non-daily smokers than for daily smokers. Specifically, non-daily smokers who vaped estimated they would smoke more cigarettes across a range of prices (i.e., greater demand) than non-daily smokers who did not vape. Finally, we found mixed results regarding the effects of NVP regulatory environment. Smokers from AU, where nicotine-containing devices and liquid cannot be sold at retail, reported that they would smoke more cigarettes when price was irrelevant (i.e., free) but were more reactive as cigarette price increased compared to smokers in the US, EN, and CA.

Our study provides a unique contribution to the literature because of a multifactorial design which included non-daily smokers. Only daily smokers were included in the two prior cigarette purchase task studies that have examined the influence of vaping status on cigarette demand (18, 19). Results from both studies suggest that daily smokers express little variation in cigarette demand as a function of vaping status, which is similar to our findings. However, we found vaping to have a more prominent relationship for non-daily smokers. Greater vaping frequency was associated with higher cigarette demand, as indicated by intensity and elasticity. These results can be interpreted in at least two ways. First, vaping may be increasing cigarette demand among non-daily smokers and represent a risk for transitioning to daily smoking. Alternatively, vaping among non-daily smokers may represent a successful initial step towards transitioning away from exclusive daily smoking. Indeed, we found non-daily smokers who were currently vaping daily were more likely to have been former daily smokers. Vapers were also more motivated to quit smoking and were more likely to be non-daily smokers. These findings suggest non-daily smokers were vaping to replace smoking (i.e., substitution), however, cigarette demand remained intact; that is, they would revert to high, presumably pre-vape levels, if vaping was no longer a possibility. NVP availability may be especially important for keeping these smokers from relapsing back to more frequent smoking.

The current study is the first to use a cigarette purchase task to explore between-country differences of estimated cigarette demand. AU smokers required approximately a 4-fold

cigarette price increase to make smoking shift from relatively low price sensitivity to relatively high price sensitivity (i.e., Pmax) and 8-fold cigarette price increase to quit smoking (i.e., breakpoint), whereas smokers from the US, EN, and CA required even higher price increases for these outcomes. A similar pattern of results for Pmax and breakpoint was found for CA relative to US and EN. When using country as a proxy for NVP regulatory environment note that other relevant differences exist between countries. With their stronger tobacco control policies and less affordable cigarette prices in addition to more restrictive NVP regulations compared to EN and US, the lower cigarette demand observed in AU and CA (contrary to our hypothesis) may reflect smokers being more-responsive to tobacco control policies rather than vaping policies of their country. Another consideration is that smokers living in countries with more permissive NVP regulations may have had difficulty imagining how they would respond to the hypothetical scenario presented in the cigarette purchase task, where cigarettes were the only nicotine/tobacco products available. Smokers from EN and US may have overestimated their consumption, whereas smokers from AU and CA may have provided more realistic estimates. Purchase task studies that allow for purchasing of NVPs and other nicotine products, such as in the Experimental Tobacco Marketplace paradigm (20), have found that smokers begin to purchase NVPs as the price of cigarettes increases. Future studies should test the influence of manipulating instructions for the purchase task to determine the effects of product availability (i.e., other products available vs. not). Nonetheless, that the cigarette purchase task was able to detect differences in demand as a function of country suggests the task could be used across a wider range of countries to determine the relative impact of tobacco and vaping policies. Ideally, countries selected can be matched on tobacco control policies and vary only on vaping policies. Across all countries results suggest cigarette prices will need to increase substantially in order to reach a smoke-free world.

Note that the current study has several limitations. First, a sizeable portion of the sample was excluded because of nonsystematic responding or incomplete data due to reporting ‘don’t know’ on the purchase task. As reported in Supplemental Table 1, systematic responders were different than those excluded across numerous participant characteristics. Participants reporting null demand were more likely to be non-daily smokers, non-vapers, and had greater confidence to quit smoking, when compared to systematic responders. This suggests null demand responses may have been valid and indicative of a pending quit attempt. Their exclusion may have slightly inflated demand outcome estimates, but had negligible impact on the overall pattern of findings. Additionally, participants who reported don’t know were more likely to have low income and education, and were older, when compared to systematic responders. Cigarette purchase tasks presume at least a seventh grade level of literacy (21), but may be cognitively challenging because smokers typically purchase packs rather than single cigarettes. Future studies could attempt to mitigate decision complexity by presenting price per pack alongside price per cigarette. Nonetheless, this is the largest cigarette purchase task study to date and we included weighting thereby improving the generalizability of the more commonly utilized laboratory-based methods that have been used to study product demand. Second, we use 8 price points for the purchase task. Most studies include approximately 20 price points, which affords greater demand curve resolution. Nonetheless, our data fit the exponential demand equation well, was feasible

within the context of the parent study, and was sensitive to demand differences as a function of smoking status, vaping status, and country. Finally, the purchase task required estimating cigarette demand independently, assuming no other nicotine/tobacco products were available. Elasticity estimates (non-transformed means across vaping status groups ranged from .031-.035 for daily smokers and .059-.094 for non-daily smokers) were comparable to prior studies (21), but testing demand in the context of other substitutable products provides a more realistic assessment of how consumers make product choices. Further study might apply methods that allow for the measurement of cross-price elasticity, a direct test of product substitutability and a more robust test of the likely impact of having alternative products available to consumers at different price points (22–26).

Conclusions

This study shows that among non-daily smokers, cigarette demand is higher for vapers relative to non-vapers. Results suggest non-daily smokers who vape daily were formerly heavy smokers who have almost completely substituted vaping for cigarettes but still remain susceptible to relapse to heavier smoking. The same pattern was not observed for daily smokers, with negligible differences between vapers and non-vapers. A critical next step is to determine to what extent demand prospectively predicts transitions.

We also demonstrate for the first time that behavioral economic purchase tasks can be used to compare cigarette demand across countries. In general, we found cigarette demand was lower in countries with more restrictive regulatory environments for NVPs and stronger tobacco control policies. These two findings suggest regulatory policies that promote tobacco control and facilitate access to viable cigarette substitutes, such as NVPs, may reduce cigarette demand and promote transitions away from smoking.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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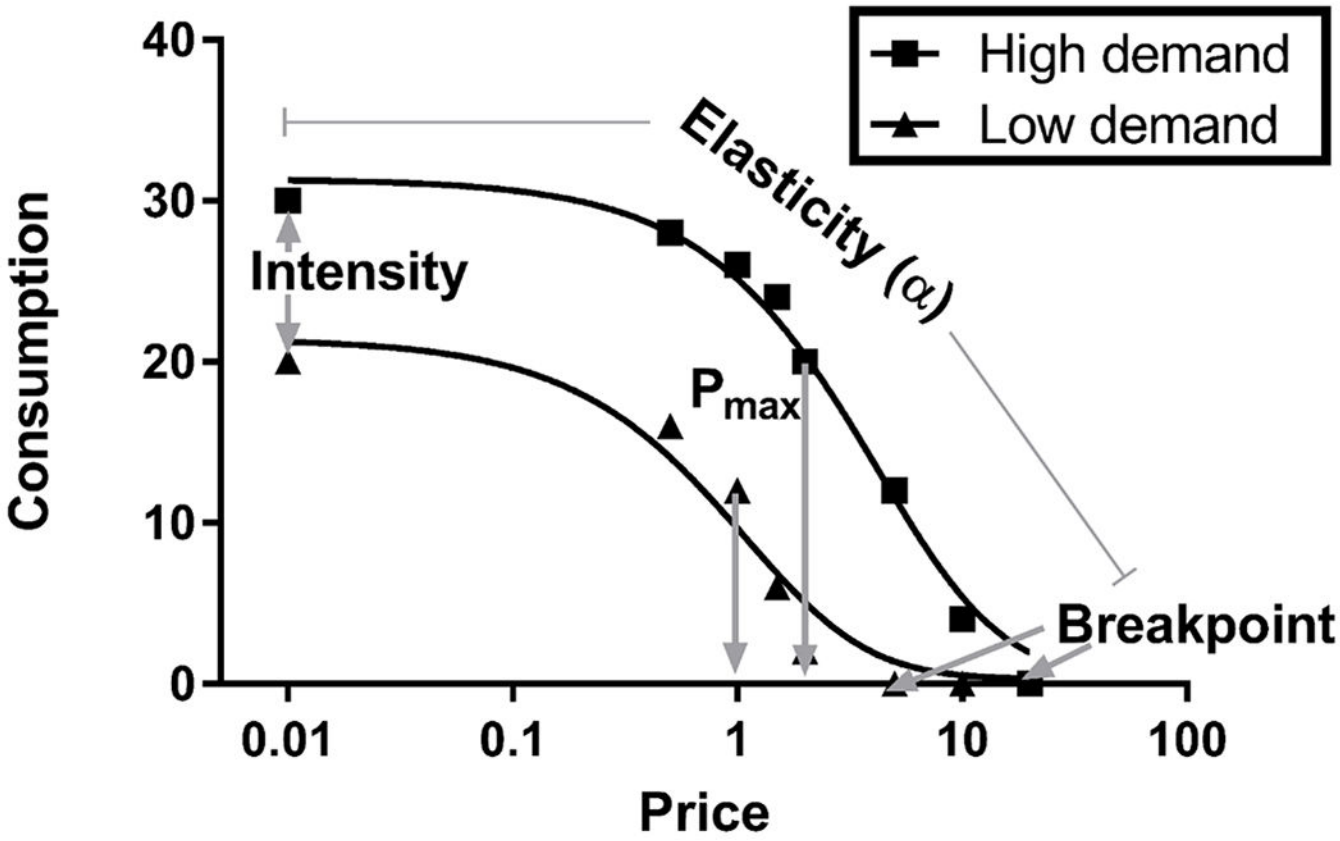

Figure 1.
Demand indices derived from the cigarette purchase task.
Note: Elasticity represents the slope of the demand curve.

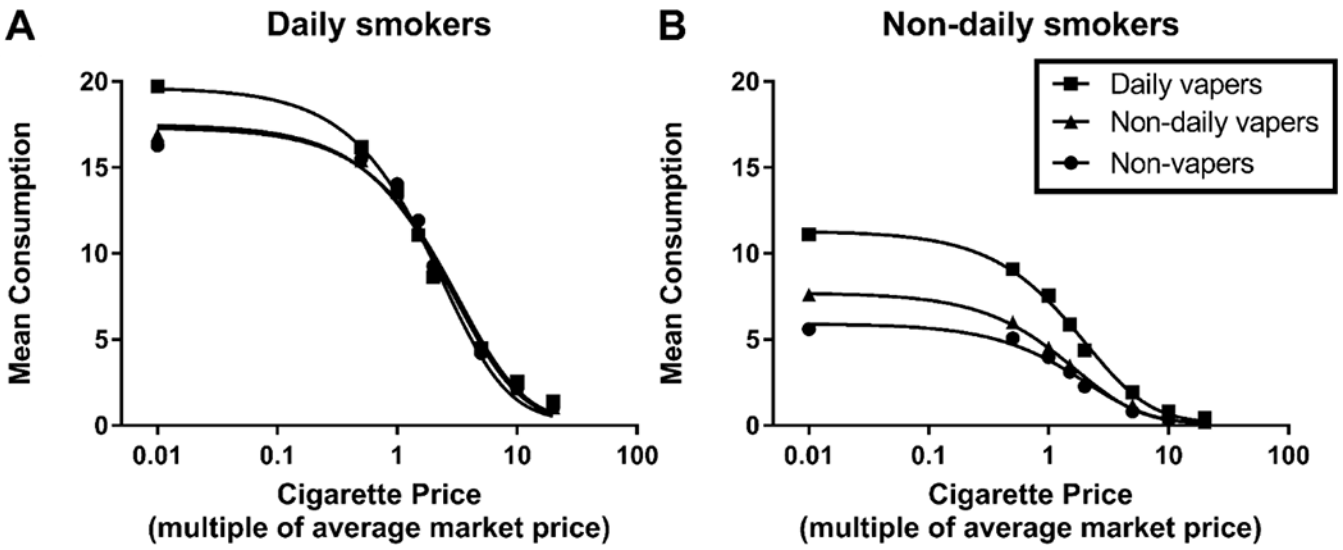

Figure 2.

Unadjusted cigarette demand curves as a function of smoking and vaping status

Note: Data from current smokers collected in 2016.

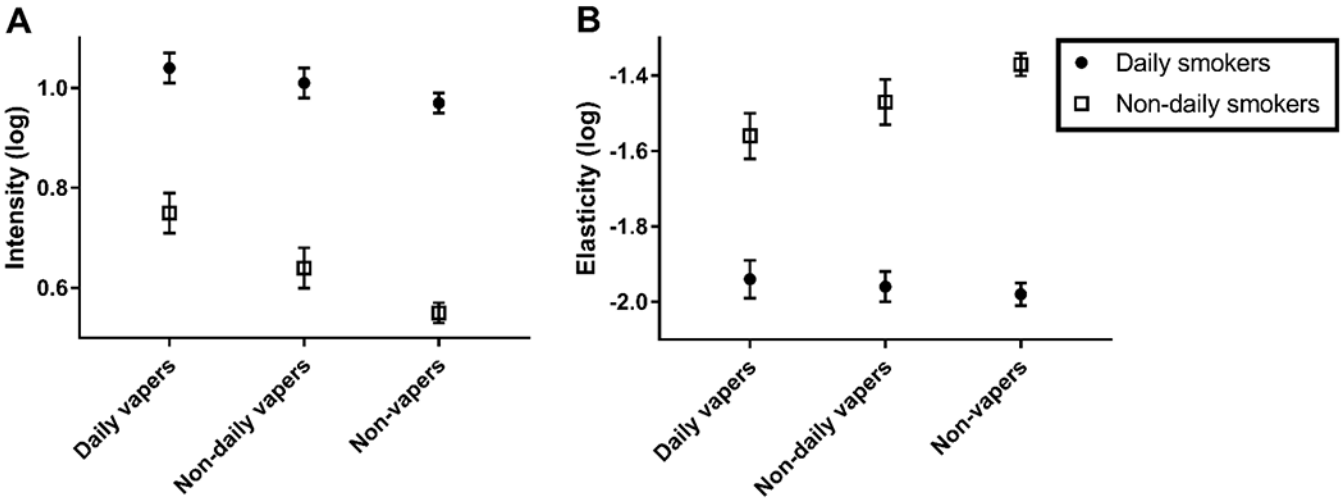

Figure 3.

Adjusted intensity and elasticity estimates (and SEs) as a function of smoking and vaping status

Note: Data from current smokers collected in 2016.

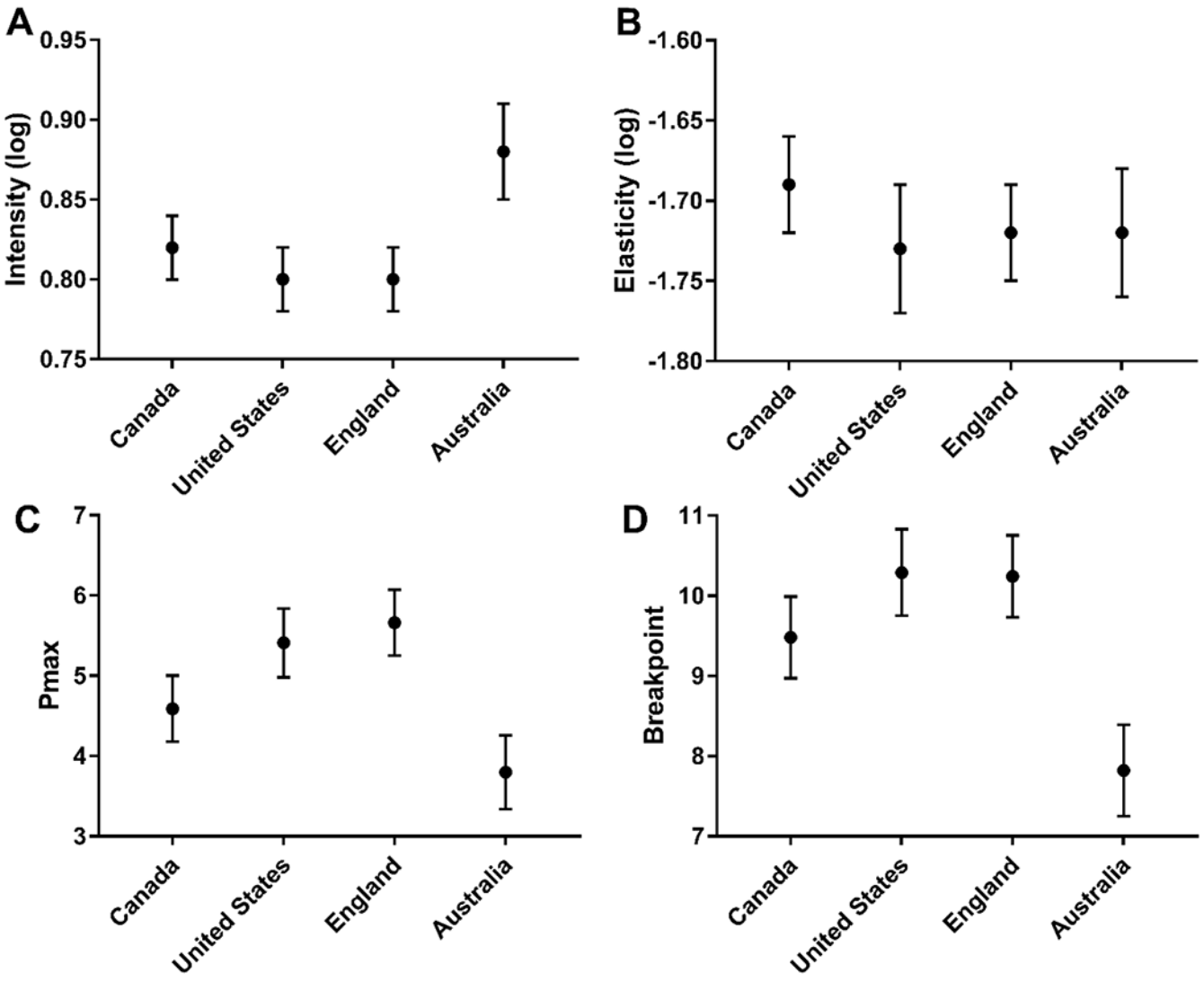

Figure 4.

Adjusted cigarette demand outcomes (and SEs) as a function of country

Note: Data from current smokers collected in 2016.

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Table 1.

Participant characteristics based on vaping status.

	Overall N=5,336	Non-vapers n=3,589	Non-daily vapers n=1,109	Daily vapers n=638	
Smoking Status					
Daily smokers	80.4%	83.2%	74.6%	75.1%	a, b
Non-daily smokers	19.6%	16.8%	25.4%	24.9%	ref
Country					
Canada	33.8%	32.4%	39.9%	30.6%	a, b
United States	20.0%	17.7%	21.6%	30.1%	a, b
England	33.9%	34.1%	33.6%	33.2%	a, b
Australia	12.4%	15.8%	4.8%	6.1%	ref
Sex					
Female	48.1%	50.0%	47.5%	37.8%	a, b
Male	51.9%	50.0%	52.5%	62.2%	ref
Income					
Don’t know	4.5%	5.2%	3.4%	2.8%	a
Low income	23.2%	23.8%	22.1%	21.9%	ns
Moderate income	29.2%	28.7%	29.1%	31.8%	ns
High income	43.1%	42.4%	45.4%	43.4%	ref
Education					
Don’t know	0.6%	0.7%	0.5%	0.2%	ns
Low education	27.8%	29.9%	22.7%	24.6%	a, b
Moderate education	42.2%	41.9%	43.9%	41.2%	ns
High education	29.4%	27.5%	32.9%	34.0%	ref
Ethnicity					
Don’t know	1.0%	1.0%	0.9%	0.9%	ns
Majority	85.1%	86.9%	81.9%	80.6%	ns
Minority	13.9%	12.1%	17.2%	18.5%	ref

	Overall N=5,336	Non-vapers n=3,589	Non-daily vapers n=1,109	Daily vapers n=638	
Age					
18-24	24.0%	19.7%	35.2%	29.0%	a, b
25-39	25.8%	22.7%	31.9%	32.4%	a, b
40-54	26.1%	28.7%	19.7%	22.3%	a, b
55 and up	24.1%	28.8%	13.3%	16.3%	ref
Motivation to quit smoking					
Don't know	1.2%	1.3%	1.3%	1.1%	ns
Not at all	8.0%	9.0%	6.0%	5.8%	a, b
A little	18.1%	18.5%	18.2%	16.0%	a, b
Somewhat	33.7%	34.5%	34.0%	28.4%	a, b
A lot	39.0%	36.8%	40.5%	48.7%	ref
Confidence to quit smoking					
Don't know	0.6%	0.7%	0.5%	0.3%	ns
Very easy	4.2%	4.2%	4.1%	4.2%	a
Somewhat easy	9.1%	9.3%	8.6%	9.1%	a
Neither easy nor hard	10.7%	10.1%	13.0%	10.2%	ns
Somewhat hard	37.9%	36.7%	39.5%	41.8%	ns
Very hard	37.6%	39.1%	34.4%	34.3%	ref

Note: Non-vaper was the reference category for the multinomial regression. The superscripts represent significant differences (*ps*<.05) between non-vaper and (a) non-daily vaper and (b) daily vaper groups. Nonsignificant differences are denoted by ns.

Table 2.

Group differences across all demand outcomes.

	Intensity		Pmax		Breakpoint		Elasticity	
	F	***p-value***	***F***	***p-value***	***F***	***p-value***	***F***	***p-value***
Smoking status	297.03	<.001	25.68	<.001	59.12	<.001	268.04	<.001
Vaping status	19.97	<.001	1.66	0.19	2.31	0.10	3.71	0.02
Country	10.81	<.001	23.55	<.001	23.51	<.001	2.15	0.09
Smoking status by vaping status	4.93	0.007	0.60	0.55	0.81	0.45	7.30	0.001
Gender	36.23	<.001	6.62	0.01	3.18	0.08	0.47	0.49
Income	3.39	0.02	3.02	0.03	5.13	0.002	1.43	0.23
Education	14.75	<.001	7.05	<.001	2.96	0.03	9.31	<.001
Ethnicity	18.71	<.001	3.60	0.03	4.74	0.009	7.47	0.001
Age	4.77	0.003	0.14	0.93	8.15	<.001	16.18	<.001
Motivation to quit smoking	1.14	0.33	9.76	<.001	11.23	<.001	8.14	<.001
Confidence to quit smoking	87.71	<.001	15.63	<.001	35.88	<.001	73.96	<.001

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Table 3.

Parameter estimates for demand indices.

	Intensity			Pmax			Breakpoint			Elasticity		
	B	***SE***	***p-value***	***B***	***SE***	***p-value***	***B***	***SE***	***p-value***	***B***	***SE***	***p-value***
Intercept	0.72	0.03	<.001	3.50	0.46	<.001	7.07	0.57	<.001	−1.59	0.04	<.001
Smoking Status												
Daily smokers	0.43	0.01	<.001	1.61	0.24	<.001	3.88	0.29	<.001	−0.61	0.02	<.001
Non-daily smokers	ref			ref			ref			ref		
Vaping Status												
Daily vapers	0.21	0.04	<.001	−0.24	0.71	0.74	0.61	0.88	0.49	−0.20	0.06	0.001
Non-daily vapers	0.10	0.04	0.008	0.74	0.63	0.24	1.43	0.79	0.07	−0.11	0.05	0.04
Non-vapers	ref			ref			ref			ref		
Country												
Canada	−0.06	0.01	<.001	0.79	0.25	0.002	1.66	0.31	<.001	0.03	0.02	0.10
United States	−0.08	0.02	<.001	1.61	0.28	<.001	2.47	0.34	<.001	−0.01	0.02	0.81
England	−0.08	0.01	<.001	1.87	0.25	<.001	2.42	0.32	<.001	0.00	0.02	0.88
Australia	ref			ref			ref			ref		
Sex												
Female	−0.05	0.01	<.001	0.04	0.01	0.001	0.40	0.16	0.01	0.01	0.01	0.49
Male	ref			ref			ref			ref		
Income												
Don’t know	0.00	0.02	0.93	−0.41	0.38	0.28	0.12	0.48	0.81	0.03	0.03	0.40
Low income	0.04	0.01	0.002	−0.61	0.21	0.004	−0.98	0.26	<.001	0.04	0.02	0.04
Moderate income	0.02	0.01	0.07	−0.36	0.19	0.06	−0.38	0.23	0.10	0.01	0.02	0.38
High income	ref			ref			ref			ref		
Education												
Don’t know	0.04	0.05	0.38	2.62	0.84	0.002	2.26	1.05	0.03	−0.29	0.07	<.001
Low education	0.09	0.01	<.001	−0.59	0.23	0.01	−0.45	0.29	0.12	−0.07	0.02	<.001

	Intensity			Pmax			Breakpoint			Elasticity		
	B	***SE***	***p-value***	***B***	***SE***	***p-value***	***B***	***SE***	***p-value***	***B***	***SE***	***p-value***
Moderate education	0.06	0.01	<.001	−0.05	0.21	0.80	−0.07	0.26	0.80	−0.06	0.02	0.001
High education	ref			ref			ref			ref		
Ethnicity												
Don’t know ethnicity	0.08	0.05	0.07	−1.26	0.80	0.12	−2.29	0.99	0.02	0.07	0.07	0.28
Majority	0.09	0.01	<.001	−0.60	0.24	0.01	−0.77	0.30	0.01	−0.07	0.02	0.001
Minority	ref			ref			ref			ref		
Age												
18-24	−0.01	0.02	0.70	0.10	0.26	0.70	1.58	0.32	<.001	0.10	0.02	<.001
25-39	−0.04	0.01	0.004	0.02	0.21	0.92	0.78	0.27	0.003	0.08	0.02	<.001
40-54	0.00	0.01	0.78	0.12	0.22	0.59	0.64	0.27	0.02	−0.01	0.02	0.54
55 and up	ref			ref			ref			ref		
Motivation to quit smoking												
Don’t know	0.02	0.04	0.52	0.28	0.66	0.67	0.46	0.81	0.57	0.04	0.05	0.43
Not at all	0.02	0.02	0.23	1.80	0.31	<.001	2.12	0.38	<.001	−0.11	0.03	<.001
A little	−0.02	0.01	0.21	0.53	0.22	0.02	0.49	0.28	0.08	0.04	0.02	0.045
Somewhat	0.00	0.01	0.73	0.68	0.18	<.001	1.14	0.22	<.001	−0.02	0.02	0.19
A lot	ref			ref			ref			ref		
Confidence to quit smoking												
Don’t know	−0.30	0.06	<.001	−0.72	0.98	0.46	−2.04	1.22	0.10	0.34	0.08	<.001
Very easy	−0.38	0.02	<.001	−2.03	0.42	<.001	−4.92	0.52	<.001	0.48	0.03	<.001
Somewhat easy	−0.25	0.02	<.001	−2.10	0.30	<.001	−3.58	0.38	<.001	0.35	0.03	<.001
Neither easy nor hard	−0.18	0.02	<.001	−1.37	0.28	<.001	−2.59	0.34	<.001	0.23	0.02	<.001
Somewhat hard	−0.13	0.01	<.001	−1.17	0.18	<.001	−2.02	0.22	<.001	0.18	0.01	<.001
Very hard	ref			ref			ref			ref		