Just What the Doctor Ordered?

The Benefits and Costs of E-Cigarette Regulation in Australia

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ABSTRACT

Australia had adopted a novel approach to e-cigarette policy by requiring a physician's prescription to lawfully obtain nicotine e-cigarettes. We conducted an online discrete choice experiment to gauge how adult Australian smokers made hypothetical choices between cigarettes, prescription e-cigarettes, non-prescription e-cigarettes, and quitting. We estimate a mixed logit model, which allows us to predict the market shares under different policy scenarios. The mixed logit model also provides estimates of consumer willingness to pay for the benefits from the prescription status of e-cigarettes and the costs of illegal e-cigarette markets. We estimate that the average utility loss from an illegal retail market is worth AU$7.90 per pack-equivalent. We use the corresponding estimates of the compensating variations in income to conduct cost-benefit analyses of possible reforms to Australian e-cigarette regulation. In aggregate, we estimate that the benefits of allowing but not requiring prescriptions of e-cigarettes are AU$1.8 billion per year. Our paper provides a novel contribution to research on e-cigarette regulation and provides a case-study for the policy implementation in Australia. Our paper is also part of our research agenda to explore and develop methods to conduct policy analysis and cost-benefit analysis of regulatory policies that might create illegal markets.

1. Introduction

Between 1991 and 2023, daily smoking rates among Australians aged 14 and older decreased from 24 to 8 percent (Australian Institute of Health and Welfare 2024a). However, smoking remains the leading cause of preventable death in Australia. Tobacco use contributed to almost 20,500 deaths (13 percent of all deaths) in 2018 alone. Recent reductions in smoking rates have been largest among younger age groups. In 2022-2023, only 3.4 of Australian secondary school students aged 12 to 17 reported smoking in the past month (Scully et al. 2023). Between 2019 and 2022-2023, the rates of smoking among people aged 25 to 39 dropped below 10 percent. However, smoking rates among people 60 and over have not fallen. Based on the recent data, the Australian Institute of Health and Welfare (2024a) observes that "while fewer young people are taking up smoking in the first place, the proportion of older people quitting smoking has not shifted substantially and may require additional support to see declines in future years."

Almost 50 years ago, one of the pioneering researchers in smoking cessation argued in the *British Medical Journal* that "People smoke for the nicotine but die from the tar." (Russell 1976). Building on Russell's and others' research, pharmaceutical manufacturers developed and launched nicotine replacement therapies, like nicotine gum and nicotine patches. The nicotine replacement therapies provided consumers with an accessible, evidence-based pharmaceutical product to help them quit smoking. E-cigarettes are a newer consumer product that provides nicotine via inhalation but "unlike cigarettes…do not deliver combustion-generated toxicants that are linked to cancer, chronic lung disease and cardiovascular disease." (Hajek et al. 2014, p. 6). A systematic review of evidence from randomized clinical trials concludes that there is high certainty evidence that e-cigarettes increase quit rates compared to pharmaceutical nicotine replacement therapies (Lindson, Butler, McRobbie et al. 2024). While health authorities in many

countries including the U.K. and the U.S. recognize the potential for e-cigarettes to help adult smokers to quit, they have also expressed concerns that e-cigarettes might attract youth to become new users of nicotine. As concerns over the high rates of youth e-cigarette users has grown, countries, like the U.S. and the U.K., have implemented policies aimed at reducing the appeal of e-cigarettes to youths (Perrone 2023).

Compared to other countries where e-cigarettes can easily be purchased from physical retailers, Australia has historically restricted consumer access, effectively banning the sale of nicotine containing e-cigarettes (Morphette et al. 2023). As of October 1st, 2021, Australia, once again, became an outlier in its approach to e-cigarette policy by requiring a prescription from a medical doctor to lawfully obtain nicotine-containing e-cigarettes, pods, or 'juice'.

Australia's prescription requirement attempts to address the public health tradeoff between allowing e-cigarettes as a smoking cessation product for current smokers while maintaining a barrier to entry for new users, especially youth who would otherwise not have smoked. However, the welfare economic analyses of optimal e-cigarette regulation focus on somewhat different tradeoffs than the public health tradeoff. Neoclassical welfare economic analysis focuses on the tradeoff between the opportunity costs e-cigarette regulations create for consumers versus uninternalized externalities. Behavioral welfare economics extends the analysis to include internalities smokers and vapers impose on their future selves (Allcott and Rafkin 2022).

In this paper we explore how Australian smokers react to and navigate the e-cigarette market structure created by the e-cigarette prescription requirement. A potential unintended consequence of the prescription requirement is the creation of an illegal e-cigarette market due to demand from users who are unable or unwilling to get a prescription. We conducted an online

discrete choice experiment (DCE) to gauge how adult Australian smokers made hypothetical choices between cigarettes, prescription e-cigarettes, non-prescription e-cigarettes, and quitting. We use the DCE data to estimate a mixed logit model, which allows us to predict the market shares under different policy scenarios. The mixed logit model also provides estimates of consumer willingness to pay for the benefits they perceive from the prescription status of e-cigarettes and the perceived costs of illegal e-cigarette markets. We use the corresponding estimates of the compensating variations in income to conduct cost-benefit analyses of possible reforms to Australian e-cigarette regulation.

Our paper provides a novel contribution to research on e-cigarette regulation and provides a case-study for the policy implementation in Australia. Our paper is also part of our research agenda to explore and develop DCE methods to conduct policy analysis and cost-benefit analysis of regulatory policies that might create illegal markets (Kenkel et al. 2024). DCEs are commonly used in marketing research and economics to provide predictions of consumer demand in scenarios that are not yet observed in actual markets. There is a broad consensus that stated preference (SP) data collected through DCEs and the related contingent valuation method can provide valuable information (Carson 2014). In a narrative review of discrete choice experiments, McFadden (2017) concludes that: "Forecasts that are comparable in accuracy to [revealed preference] forecasts can be obtained from well-designed SP studies for familiar, relatively simple goods that are similar to market goods purchased by consumers…." Penn and Hu (2018) report a meta-analysis that provides quantitative evidence consistent with McFadden's (2017) conclusion that SP data are more reliable for familiar market goods. Our DCE asked smokers to make choices about nicotine products which are similar to the real-world purchases they make on a weekly or even more frequent basis.

From the background survey included in our DCE, we are able to learn about current smokers' knowledge about and reported compliance with the October 2021 policy. We find that the prescription requirement was not well known and had poor compliance. Only 28 percent of the full sample of current smokers and 40 percent of the sub-sample of current vapers, correctly responded that a prescription is currently required to purchase nicotine e-cigarettes. 85 percent of current vapers reported that they did not have an e-cigarette prescription. These findings were especially striking across age groups, with very few older subjects reporting knowledge about the e-cigarette prescription requirement. There is also some evidence of schooling- and income-gradients which suggests that disadvantaged smokers tend to be less likely to know about and comply with the prescription requirement.

Our estimated mixed logit model using the DCE data implies that holding other factors constant, consumers receive more utility from choosing e-cigarettes with a prescription, perhaps because prescription status is a useful signal of safety and efficacy. We estimate that on average the estimated willingness to pay for prescription status is AU$6.32 per pack-equivalent of e-cigarettes. We also find that illegality of non-prescription e-cigarettes imposes substantial utility losses. We estimate that the average utility loss from an illegal retail market is worth AU$7.90 per pack and the average utility loss from an illegal street market is worth AU$8.56 per pack. The benefits of prescription status and the costs of illegal markets points to a better policy alternative – make prescriptions voluntary but not required for e-cigarette purchases. In aggregate, we estimate that the benefits of allowing but not requiring prescriptions of e-cigarettes are AU$1.8 billion per year.

2. Background

Prior to the October 2021 prescription requirement, nicotine-containing e-cigarettes were illegal to sell in Australia. Nicotine used for e-cigarettes was classified as Schedule 7 "dangerous poison", which made the sale or supply of nicotine e-cigarettes illegal (Morphett et al. 2023). However, with a prescription or permit, individuals could import a limited quantity of nicotine e-cigarettes for personal use as an unapproved therapeutic good (Hall 2024). E-cigarettes without nicotine were legal in most places in Australia (Morphett et al. 2023).

The 2021 policy change reclassified nicotine-containing e-cigarettes as Schedule 4 "prescription only medicine" creating a legal supply-side in the Australian nicotine e-cigarette market. With a physician's prescription, consumers can legally purchase nicotine e-cigarettes from pharmacies or directly import up to three months' supply for their personal use (Australian Boarder Force 2021, Australian Therapeutic Goods Administration nd). E-cigarettes can only be prescribed as unapproved therapeutic goods because the Australian Therapeutic Goods Administration (TGA) has not assessed them for safety and efficacy. As a result, e-cigarettes are not covered by the Australian Pharmaceutical Benefits Scheme, a public sector program that makes many other prescription drugs available to patients with only a modest copayment.

Given the restrictions on the Australian nicotine e-cigarette market, it is notable that e-cigarette use has been growing, especially among young adults and youth. Repeated cross-section data from the Australian National Drug Strategy Household Survey show that current e-cigarette use among people aged 14 and over grew rapidly from 1.2 percent in 2016 to 2.5 percent in 2019 to 7 percent in 2022-2023 (Australian Institute of Health and Welfare 2024b). In 2022-2023, the prevalence of current e-cigarette use was highest among people aged 18 to 24, at 21 percent. At ages above 24, current e-cigarette use rates steadily decline with age, reaching 1.6 percent of people aged 60 to 69 and under 1 percent among people over 70. Repeated cross-

section data from the Australian Secondary Students' Alcohol and Drug survey show that past-month vaping among youth increased from 4.2 percent to 15.7 percent in 2022/2023 (Scully, et al. 2023). The pattern of higher use among youth and low use among older adults is the reverse of the desired public health tradeoff to limit youth use while making e-cigarettes available to help adult smokers quit.

Observers of Australian e-cigarette markets agree that compliance with the prescription requirement is low. The legality of e-cigarettes without nicotine has made it difficult to enforce the prescription requirement for nicotine e-cigarettes. Because there are no domestic e-cigarette device manufacturers, all e-cigarette devices in Australia are imported. E-cigarette importers are not required to prove that their products do not contain nicotine; as a result, "importers have flooded Australia with [nicotine e-cigarettes] simply by not declaring the nicotine content present." (Jenkins, et al. 2024). After importation, state-level enforcement is also difficult because laboratory testing is required to determine whether an e-cigarette contains nicotine.

Given the difficulties in enforcement, it is unsurprising that recent survey data suggest that the majority of nicotine e-cigarettes consumption is non-compliant with the prescription requirement. In the 2022-2023 National Drug Strategy Household Survey, 73 percent of current e-cigarette users report that their e-cigarettes contained nicotine and 13 percent of users of nicotine-containing e-cigarettes report that they had an e-cigarette prescription (Australian Institute of Health and Welfare 2024b). An impact analysis of new legislation to improve compliance reviews evidence from several recent surveys and concludes that between 3 to 12 percent of the market for nicotine e-cigarettes is legally supplied to vapers with a prescription (Therapeutic Goods Administration, 2023a).

Effective January 1, 2024, Australia adopted e-cigarette policy reforms including a ban on importing disposable e-cigarettes irrespective of nicotine content or therapeutic claims (Therapeutic Goods Administration 2023b). In March 2024, the TGA implemented a further ban on the imports of all vapes without an import license and required a permit from the Office of Drug Control. Further reforms were proposed including restrictions that will make it illegal for tobacconists, vape shops and convenience stores to lawfully supply any type of e-cigarettes (Therapeutic Goods Administration 2024). These reforms will close the loophole created by the legality of non-nicotine e-cigarettes and might dramatically change the nicotine e-cigarette market. Our study explores the impact and benefits and costs of the cigarette regulatory policies in place between October 1, 2021 and January 1, 2024. In the concluding section we discuss possible implications for the 2024 regulatory reforms.

3. Data and Empirical Strategy

3.1 The Discrete Choice Experiment

From January 25 to February 7, 2023, we conducted an online discrete choice experiment (DCE) with Australian subjects. This was part of a set of cross-country DCEs conducted between 2021 and 2023 across eight countries to study how smokers choose between nicotine consumer products in differently regulated markets. In the 2023 Australia DCE, subjects made hypothetical choices between cigarettes, e-cigarettes with a prescription, e-cigarettes without a prescription, and quitting. A novel feature of our DCE is that it presented subjects with choice tasks where e-cigarettes without a prescription are described as either legal, prohibited but available under-the-counter and online from retailers who continue to sell them, or prohibited and strictly enforced and only available from illegal dealers. The experimental variation in legality as a product attribute allows us to explore the impact of different possible illegal supply-sides in the

Australian e-cigarette market. The prices of cigarettes and e-cigarettes were also experimentally varied across the choice tasks presented to subjects.

Product prices and the legality of e-cigarettes without a prescription were experimentally varied across three levels: a 3 (cigarette price) by 3 (prescription e-cigarette price) by 3 (non-prescription e-cigarette price) by 3 (non-prescription e-cigarette legality conditions) experimental design, for a total of 81 combinations. Because 81 choice tasks would be too demanding, each subject was presented with 12 choice tasks. Different subjects were assigned different sets of choice tasks; across all subjects the DCE presented 41 of the 81 possibilities. The number of products, attribute levels, and choice tasks follow good practice guidelines for DCEs (Johnson et al. 2013). The assignment of choice tasks to subjects was designed to maximize statistical efficiency to identify the parameters of interest.

In each choice task, subjects are asked to state their "immediate choice today" between cigarettes, prescription e-cigarettes, non-prescription e-cigarettes, or quitting the use of both products. After subjects make their immediate choice, the choice task re-appears, and subjects are asked to state the choice that they would make 6 months in the future. This process is repeated 12 times for a total of 24 choice observations per subject.

Figure 1 provides an example of the choice task screen. Before the first task, subjects are shown a set of instructions (Figure 2). Subjects are told that in some questions they will be asked to imagine that nicotine e-cigarettes can be purchased without a prescription while in other questions they will be asked to imagine that nicotine e-cigarettes require a prescription to be legally purchased but might be available from illegal retail or street markets. They are told that when making choices that should not consider the price of buying the startup kit for reusable e-cigarettes, or the price of obtaining a doctor's prescription. The background survey questions

before the DCE choice tasks and the instructions for the choice tasks used the wording "nicotine e-cigarettes" to avoid any confusion with e-cigarettes that do not contain nicotine.

Before the experiment, the online survey asked respondents about their current smoking and e-cigarette use and other background information including the price they paid for their last purchase of cigarettes. The respondent's price paid for a pack of cigarettes is used as the medium price level in the DCE, which helps improve the realism of the choices provided. To identify the effect of cigarette prices on choices, the cigarette price was experimentally varied as 0.5p, p, and 2p where p was calculated from the cigarette price paid. Because not all subjects had used or vaped e-cigarettes, we use online sources to calculate 10.00 AUD as the median price of an e-cigarette product which would be equivalent to a pack of cigarettes, taking into consideration the nicotine content. In the DCE choice tasks we again use 0.5p, p, and 2p (i.e. AU$5, AU$10, and AU$20) as the prices for both e-cigarettes with a prescription and e-cigarettes without a prescription.

3.2 The Sample

Our sample consists of 644 Australian adult smokers from an opt-in non-probability online survey administered by the survey firm SSRS. Using information we provided, the survey firm recruited a sample that "simulates" the population of interest – adult Australian smokers. Our analysis of the price paid for cigarettes identified outliers with extremely low or high prices. Because we use the cigarette price paid as the basis for the cigarette prices shown in the DCE choice tasks, price outliers potentially can have undue influence on parameter estimates. After trimming the observations with price outliers, our sample of analysis is 611 subjects, who provided 7,332 observations of immediate choices and 7,332 observations of 6-months-from-now choices.

Table 1a and 1b provides descriptive statistics about the sample demographic characteristics and smoking behaviors. In our sample 66 percent of respondents smoked cigarettes every day, while the remaining 34 percent smoked some days. On average, they paid 28.62 AU$ for a pack of 20 cigarettes. Of the 611 respondents, 54 percent had ever used e-cigarettes, but only 39 percent of them were current users (i.e., 12 percent were daily e-cigarette users and 27 percent were some day e-cigarette users). The remaining 15 percent were former vapers.

3.3 Empirical Model

We use our DCE data to estimate a random coefficients mixed logit model of consumer tobacco product choices. Mixed logit is a highly flexible model that allows individual heterogeneity to interact with product characteristics. It relaxes the independence of irrelevant alternatives assumption of McFadden's conditional logit model. Our mixed logit model is based on a random utility model, where individual i's indirect utility from product j at time (choice task) t is linear and additively separable in an alternative specific constant (ASC), the tobacco product's price, and the legal availability of the tobacco product:

$$\boldsymbol{U_{ijt} = ASC_{ijt} + \alpha_i p_{ijt} + \beta_i' Legal\ Availability_{ijt} + \epsilon_{ijt}}$$

The ASCs capture the baseline utility from each tobacco product or the alternative of quitting; the alternative of quitting is the omitted category. The ASCs are assumed to have normal distributions. The coefficients α_i and β_i are assumed to have lognormal distributions, which restricts the signs of the effects of these attributes on consumer utility. The variables measuring cigarette and e-cigarette prices are linearized versions of the experimentally assigned price levels. Legal availability takes three levels: legal and available where the subject usually buys cigarettes, prohibited and available under-the-counter and online from some retailers who

continue to sell nicotine e-cigarettes without a prescription, and a strictly enforced prohibition where nicotine e-cigarettes are only available from illegal dealers, e.g., street sellers. For convenience we will refer to the legal availability conditions as: legal, illegal retail market, and illegal street market. In the empirical model, legal is the omitted baseline category. ϵ is the idiosyncratic error term.

4. Descriptive Results: Knowledge and Compliance with the Prescription Requirement

In this section we report descriptive results from the background survey about the e-cigarette prescriptions requirement. The background survey questions were asked before the DCE choice tasks.

All subjects were asked whether a doctor's prescription is currently required to get or buy e-cigarettes with nicotine (Table 2a). Only 28 percent of the full sample of current smokers responded yes. Almost as many – 26 percent – responded no, and the remaining 47 percent of the sample responded that they were unsure. Awareness of the prescription requirement was higher in the sub-sample of current vapers, at 40 percent. But the fraction of the sub-sample of current vapers who responded that a prescription is not currently required is also higher, at 35 percent, with the remaining 25 percent of the sub-sample unsure.

The background survey included several questions about compliance with the e-cigarette prescription requirement. We used responses to these questions to create five measures of compliance (Table 2b). The first measure is whether the subject has a prescription. 15 percent of the sub-sample of current vapers reported that they had a prescription, while 85 percent reported that they had not tried to get a prescription or had tried but were unable to get one. The second measure of compliance is based on whether the subject reported having obtained nicotine e-cigarettes without a doctor's prescription at least once since October 1, 2021 (when the

prescription requirement took effect). By this measure, 8 percent of current vapers were compliant with the requirement while 92 percent of current vapers reporting having obtained an e-cigarette without a prescription at least once after the requirement took effect. The third measure of compliance is based on where current vapers reported purchasing nicotine e-cigarettes. The only legal sources of nicotine e-cigarettes are pharmacies and online retailers (although online purchases are not necessarily legal if the retailers did not comply with the prescription requirement). 10 percent of current vapers reported only purchasing e-cigarettes from a pharmacy or online, while 88 percent reported at least one illegal supplier (retailers such as supermarkets, convenience stores, petrol stations, tobacconists or vape shops, news agents/newsstands, people selling tobacco independently, or from a friend/relative or through social media). The fourth measure of compliance is based on responses to a question about whether current vapers' recent purchase seemed like a normal, recorded purchase. 24 percent of current vapers responded that their purchase seemed like a normal, recorded purchase while 76 percent of current vapers responded either that their recent purchase seemed like an under-the-counter, unrecorded purchase or that they were not sure, but it might have been an under-the-counter, unrecorded purchase. The fifth measure of compliance combines the first measure of whether current vapers had a prescription and the third measure about whether the location of their recent purchase was from a source other than a pharmacy or online. By this measure, only 3 percent of current vapers were compliant.

By the measures presented in Table 2, between 3 and 24 percent of current vapers in our sample were compliant with the prescription requirement. This range is comparable to the Therapeutic Goods Administration (2023) estimates that between 3 to 12 percent of the market for nicotine e-cigarettes is legally supplied to vapers with a prescription. Hall (2024) also reports

similar estimates. Looking across our different measures of compliance, we find that some subjects in our sample who reported that they had an e-cigarette prescription also reported non-compliant behaviors including at least one purchase without a prescription, purchases from retailers where prescription e-cigarettes are not legally sold, and purchases that seemed to be unreported, under-the-counter sales.

We next explore how knowledge about the prescription requirement and compliance varies in our sample by socio-demographics. Table 3 presents descriptive linear probability models of the probability of knowing about the prescription requirement (column 1 for the full sample and column 2 for the sub-sample of current vapers) and compliance with the prescription requirement among current vapers (column 3, where we use the first measure of compliance based on whether the subject has a prescription). The explanatory variables in these models include measures of the subject's schooling, household income, employment status, age, gender, and race.

The descriptive linear probability model for the full sample (column 1) shows that older subjects are less likely to know that an e-cigarette prescription is required. Compared to 18- to 24-year-olds, almost all age groups 35 and older are estimated to be 21 to 25 percentage points less likely to know that a prescription is required. The full sample mean is 28 percent, so the estimates in column (1) suggest that very few older subjects know that an e-cigarette prescription is required. When the model is estimated for the sub-sample of current vapers, we still find evidence that older vapers are less likely to know that a prescription is required but the magnitude and statistical significance of some of the estimates are weaker (column 2). In the column (3) model of whether current vapers comply with the requirement and have a

prescription, we find some weak evidence that older vapers are less likely to comply. However, the estimated coefficients are statistically insignificant.

The descriptive linear probability models in columns (1) and (2) of Table 3 provide some evidence of modestly positive schooling-knowledge and income-knowledge gradients. The gradients are not always monotonic. For example, in the full sample model reported in column (1), compared to subjects who had not completed high school, subjects with some college are estimated to be 12 percentage points more likely to know that an e-cigarette prescription is required, college graduates are 2.4 percentage points more likely, and subjects with post-college schooling are 7.8 percentage points more likely. These estimates are not statistically significantly different from zero or from each other. We find somewhat stronger evidence of an income-knowledge gradient, but again it is not always monotonic and many of the estimated coefficients are not statistically significant.

In the column (3) model of whether current vapers comply with the requirement and have a prescription, we find evidence of a schooling-compliance gradient. Compared to vapers who had not graduated high school, vapers who are college graduates are 12.9 percentage points more likely to have an e-cigarette prescription and vapers with post-college schooling are 31.4 percentage points more likely. The estimated differences are large compared to the sub-sample mean of 15 percent compliance.

Overall, the descriptive results in Table 3 show some potentially important socio-demographic heterogeneity in knowledge about and compliance with the prescription requirement. As noted in the introduction, the recent trends since 2019 suggest that to improve public health, more needs to be done to encourage older Australian smokers to quit. The 2021 prescription requirement created a legal supply-side in the nicotine e-cigarette market. But the

Table 3 results show that in our sample of smokers, very few older subjects know that e-cigarette prescriptions are required. There is also some evidence of schooling- and income-gradient which suggest that disadvantaged smokers are less likely to know about and comply with the prescription requirement.

5. Mixed Logit Results about Product Choices in the Discrete Choice Experiment

Table 4 presents the estimated mixed logit model of consumer nicotine product choices in the DCE. The sizes of the ASCs show that in our sample of smokers, the most preferred option is cigarettes, followed by e-cigarettes with a prescription, e-cigarettes without a prescription, and quitting (the omitted reference category). The price coefficient shows that higher product prices statistically significantly reduce consumer utility from the corresponding product choice. The legality condition coefficients show statistically significant consumer disutility from the illegality of e-cigarettes without a prescription; illegal street markets impose more disutility than illegal retail markets.

The estimated ASC for e-cigarettes with a prescription is greater than the estimated ASC for e-cigarettes without a prescription. The difference in these estimated ASCs reflects the utility consumers receive from prescription status, holding the other attributes constant. To verify that the difference is not an artifact of the assumptions required for structural estimation of the utility function, we looked at the raw data on choices when e-cigarettes without a prescription are legal and at the same price as e-cigarettes with a prescription. In the raw data, subjects were more likely to choose e-cigarettes with prescription even when the alternatives have the same legality and price attributes.

In the mixed logit model of the consumer's indirect utility function, the coefficient on price, α, is an estimate of the marginal utility of income. Therefore, the ratios ASC/α and β/α

convert the estimated impacts from a utility-metric to a dollar-metric, which are more intuitively interpretable. Dividing the estimated ASCs by α implies that on average consumers are willing to pay AU$6.32 per pack-equivalent for e-cigarettes with prescription status. The column (1) results for today's choices imply that the utility costs of obtaining e-cigarettes without a prescription from an illegal retail market are worth about AU$7.90 per pack-equivalent and from an illegal street market are worth about AU$8.57 equivalent. Put differently, in terms of the impact on consumer choices, a tax of about AU$7.90 [AU$8.57] per pack-equivalent of e-cigarettes that is fully passed through to consumer prices is equivalent to an illegal retail [street] market. For context, the average price paid for cigarettes in our analysis sample was almost AU$30 per pack, which reflects Australia's high excise tax on cigarettes; the medium price level for e-cigarettes in the choice tasks was AU$10.00 per pack-equivalent.

Next, we use the estimated mixed logit model to predict consumer choices under the status quo market conditions and two policy scenarios (Table 4). For the status quo market condition, we predict choices when e-cigarettes without a prescription are illegal but available in retail markets, the price of cigarettes is the price the subject reported paying for their last pack, and the prices of e-cigarettes without or with a prescription are at the market price as determined by our online research. The first policy scenario is a strict prohibition where e-cigarettes without a prescription are only available in illegal street markets. The second policy scenario is the repeal of the prescription requirement where e-cigarettes are legal. In this scenario, we assume that e-cigarettes with a prescription are still available; the scenario can be described as a voluntary prescription policy. In the policy scenarios we assume that the stricter or looser regulations do not change any product prices.

Before turning to the policy scenarios, to shed light on the external validity of our model predictions we compare the model predictions under status quo market conditions to the observational data collected from our subjects in the background survey. The predictions roughly match some of the moments from the observational data. The model predictions for immediate choices under status quo conditions are that 58.1 percent of subjects will choose cigarettes, 25.2 percent will choose e-cigarettes with a prescription, 7.7 percent will choose e-cigarettes without a prescription, and 9 percent will attempt to quit both cigarettes and e-cigarettes. The model prediction that under status quo conditions 32.9 percent of choices will be for e-cigarettes (either with or without a prescription) is not too far from the observational data on dual use of cigarettes and e-cigarettes. In the observational data from our sample, dual use of cigarettes and e-cigarettes is common. Everyone in the sample is a smoker, with 66 percent daily smokers and 34 percent someday smokers. 28 percent of our sample report using e-cigarettes in the past 30 days, with 13.5 percent daily vapers and 14.5 percent someday vapers. The background survey does not provide observational data directly comparable to the predicted 9 percent share of subjects who will attempt to quit. The immediate choice situation corresponds to the subject's next tobacco product choices, which will often be within a week. In U.S. data from the Population Assessment of Tobacco and Health, 7 percent of smokers plan to quit using tobacco products for good within the next seven days.

However, the predicted shares of e-cigarettes with and without a prescription under status quo conditions do not match the observational data discussed above that around 85 percent of the e-cigarette market is non-compliant with the prescription requirement. After the completion of the 12 choice tasks, our survey included a set of questions to determine if the subjects correctly noticed which attributes varied across the tasks. Subjects' responses were often incorrect about

the variation in both the price and legality attributes. However, the pattern of responses does not provide any clues as to why many more subjects chose e-cigarettes with a prescription in the hypothetical choice tasks than in the observational data on these same subjects. This is an important area for future research.

With the caveat in mind that the predicted shares of e-cigarettes with and without a prescription might be unreliable, we turn now to a discussion of the predictions for the policy scenarios. Our model predicts that under strict enforcement where e-cigarettes without a prescription are only available in illegal street markets, there is a slight shifting towards e-cigarettes with a prescription. However, the combined share of the e-cigarette options and the shares of cigarette choices and choices to quit do not change much from the predicted shares under status quo conditions. In contrast, if e-cigarette prescriptions are not required but remain available, our model predicts that the combined share of the e-cigarette options increases to 37.1 percent, 4.2 percentage points higher than the 32.9 percent predicted under status quo conditions. The predicted share of cigarette choices falls by 2.7 percentage points and the predicted share of quit choices falls by 1.5 percentage points. These results are mixed in terms of their public health implications. The shift from cigarettes to lower-risk e-cigarettes would improve public health, but the reduction in quit attempts worsens public health.

In the neoclassical model of the consumer, a policy that allows but does not require e-cigarette prescriptions expands consumer options and unambiguously improves consumer welfare. Specifically, making e-cigarettes without a prescription legal improves the welfare of consumers who would purchase e-cigarettes without a prescription when they are illegal, as well as consumers who were deterred from that choice by the illegality costs. To calculate the compensating variation (CV) in income for the welfare improvement, we use the Small and

Rosen (1981) expression for the CV which weights the utility associated with each alternative by the probability of selecting that alternative. We calculate that the CV is -AU$3.14 per choice; i.e. AU$3.14 is the maximum amount that the average consumer would be willing to pay for the repeal of the e-cigarette prescription requirement while allowing voluntary prescriptions. In contrast, the policy of strict enforcement where e-cigarettes without a prescription are only available in illegal street markets reduces consumer welfare; we calculate that the CV for the extra constraint is AU$0.54 per choice. To aggregate the CVs, we assume that 1.6 million Australian smokers make 365 choices per year (one pack of cigarettes or one pack-equivalent of e-cigarettes per day). The aggregate benefits of repealing the e-cigarette prescription requirement are AU$1.8 billion per year. The aggregate costs to consumers of strict enforcement of the prescription requirement are AU$0.3 billion per year. These calculations of benefits and costs do not include the impact of the policies on consumers, including youth, who are not neoclassical utility maximizers and impose internalities on their future selves.

6. Willingness to Pay for an E-cigarette Prescription

After the DCE choice tasks, our survey also included a dichotomous choice experiment of willingness to pay for an e-cigarette prescription. The question explained to subjects that under current law, purchase and possession of nicotine e-cigarettes without a doctor's prescription is illegal and punishable by fines (in all states) and/or imprisonment (in some states). Subjects were then asked if they would be willing to pay a certain price for an appointment to obtain a physician's 12-month prescription for e-cigarettes with nicotine. Subjects were randomly assigned a price of AU$40, AU$80, or AU$160. Each subject was only asked about one of these prices. The question clarified that the price would be in addition to the cost of buying e-cigarettes with nicotine.

The results of the dichotomous choice experiment are presented in Figure 3. The results plot out a downward sloping demand/willingness-to-pay curve. At the highest price of AU$160, 26 percent of the sample stated that they were willing to obtain an e-cigarette prescription. At the price of AU$80, 39 percent stated a willingness to obtain an e-cigarette prescription. At the lowest price of AU$40, 43 percent stated a willingness to obtain an e-cigarette prescription. These results complement our estimates of willingness to pay from the DCE data, because in the DCE, subjects were told not to consider the price of obtaining a prescription for legal e-cigarettes.

7. Conclusions

In this paper we explore Australia's novel approach to regulate e-cigarettes by requiring a physician's prescription for legal purchases. Descriptive analysis of our survey data supports the existing evidence that there is widespread non-compliance with this policy. Many Australians are vaping nicotine e-cigarettes without a prescription. Nevertheless, based on our econometric analysis of stated preference data collected through a discrete choice experiment we estimate that making e-cigarettes without a prescription illegal imposes utility costs on consumers equivalent to a tax of AU$7.90. At the same time, we estimate that consumers value prescription status, perhaps because as a signal of safety and efficacy. Results from a dichotomous choice experiment provide additional evidence that many Australians are willing to pay for e-cigarette prescriptions. We estimate that eliminating the prescription requirement but still allowing consumers to voluntarily get prescriptions yields aggregate benefits of $1.8 billion per year.

Australian e-cigarette regulatory policy is instead moving in the opposite direction. In January and March 2024, the Australian Therapeutic Goods Administration announced two stages of regulatory reforms design to improve enforcement of the e-cigarette prescription

requirement (Hall 2024). These reforms will close the enforcement loophole created by the legality of non-nicotine e-cigarettes and might dramatically change the Australian nicotine e-cigarette market. Our DCE was designed to provide evidence about consumer choices when strict enforcement makes e-cigarettes without a prescription only available from illegal street markets. Our estimated model predicts strict enforcement will have a very modest impact on consumer choices and welfare relative to the pre-2024 reforms status quo. We estimate that strict enforcement will impose modest aggregate costs of about AU$0.3 billion. However, there are important caveats to these estimates, including the inherent challenges of predicting consumer behavior in illegal markets. Further research on the demand-sides of illegal markets is an important part of our research agenda.

Different approaches to evaluate e-cigarette regulatory policy emphasize different tradeoffs which sometimes leads to different policy recommendations. We use established methods from neoclassical welfare economics to develop our estimate that a voluntary prescription policy yields benefits of AU$1.8 billion per year. However, the public health implications of our estimates are more mixed; the predicted increase in vaping partly comes from less smoking, but it also partly comes from less quitting. The net benefits or costs of a voluntary prescription policy would be different to the extent that vapers, especially youth, are not neoclassical utility maximizers but instead impose internalities on their future selves. Another direction for future work is to conduct behavioral welfare economic analysis of Australian e-cigarette regulation.

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Figure 1: Example of a Choice Task

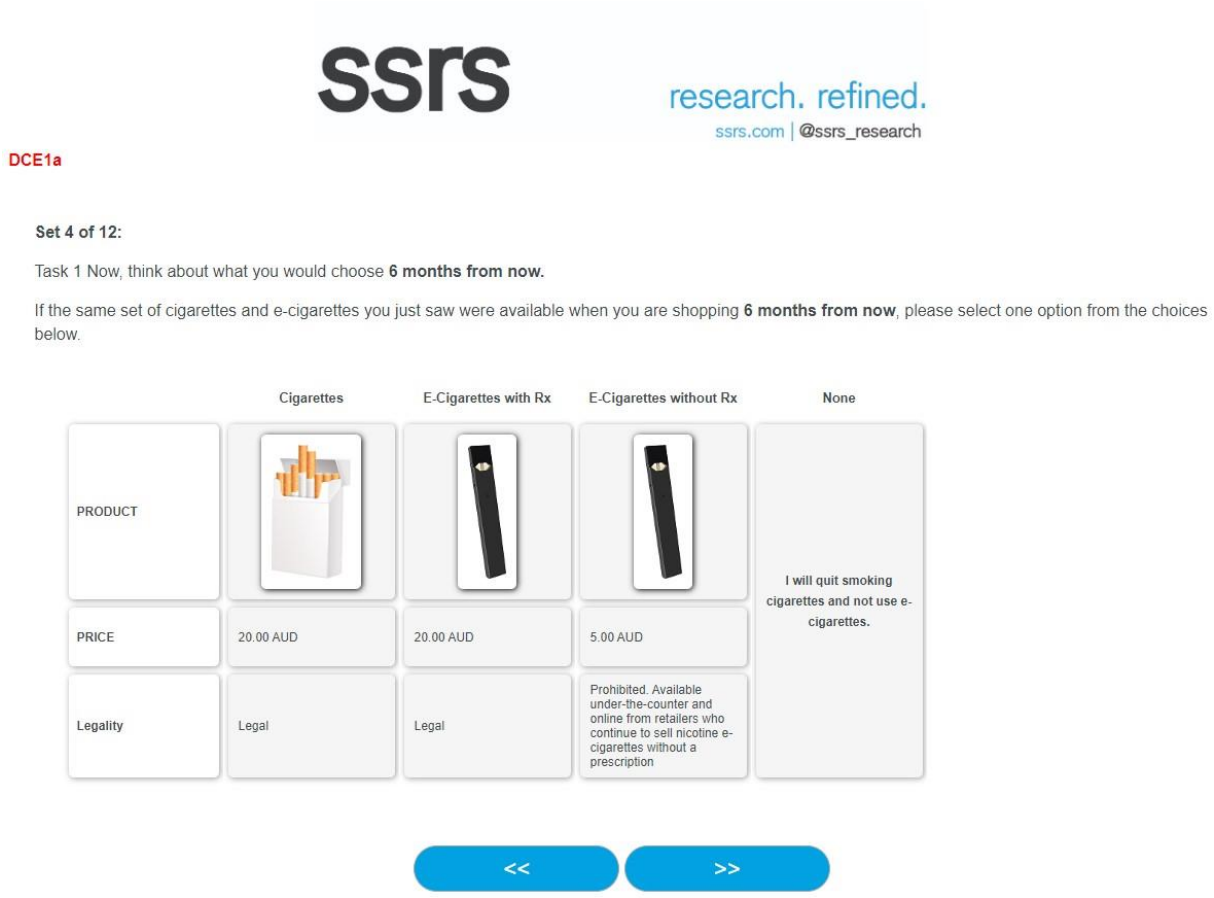

Figure 2: Choice Task Instructions

We are interested in smokers' choices between cigarettes, e-cigarettes which contain nicotine, or quitting. We want to you imagine that you are shopping to buy cigarettes and/or e-cigarettes. In some questions, we will ask you to imagine that nicotine e-cigarettes can be purchased without a doctor's prescription and available where you usually buy your cigarettes. In other questions, we will ask you to imagine that nicotine e-cigarettes require a prescription to legally purchase from a pharmacist/chemist or from online retailers. However, nicotine e-cigarettes might still be available under-the-counter from retailers and online from retailers who continue to sell them without a prescription, or from street dealers. When a nicotine e-cigarette without a prescription is described as prohibited, you should assume that the purchase and possession of nicotine e-cigarettes without a doctor's prescription is illegal and punishable by fines (in all states) and/or imprisonment (in some states).

In what follows you will see different scenarios each with different combinations of the price of your cigarette brand, the price of an e-cigarette, along with descriptions of the legal status of purchasing e-cigarettes with nicotine without a prescription.

E-cigarettes with nicotine are sold in various quantities with different types of devices. Although some e-cigarettes with nicotine last shorter or longer than a pack of cigarettes, we will be asking you about e-cigarettes with nicotine that are equivalent to one pack of cigarettes. For the purposes of your choices, please do not consider the price of buying the startup kit for reusable e-cigarettes, or the price of obtaining a doctor's prescription.

Please answer all the questions that you are able to. All your responses will be kept confidential and anonymous. Although the 12 scenarios appearing on your screen may look similar to each other, each shows a different combination of cigarette prices, e-cigarette prices, and situations that describe the ability to obtain e-cigarettes with nicotine without a prescription - so please read each carefully.

Let's begin!

Figure 3: Results of the Dichotomous Choice Experiment

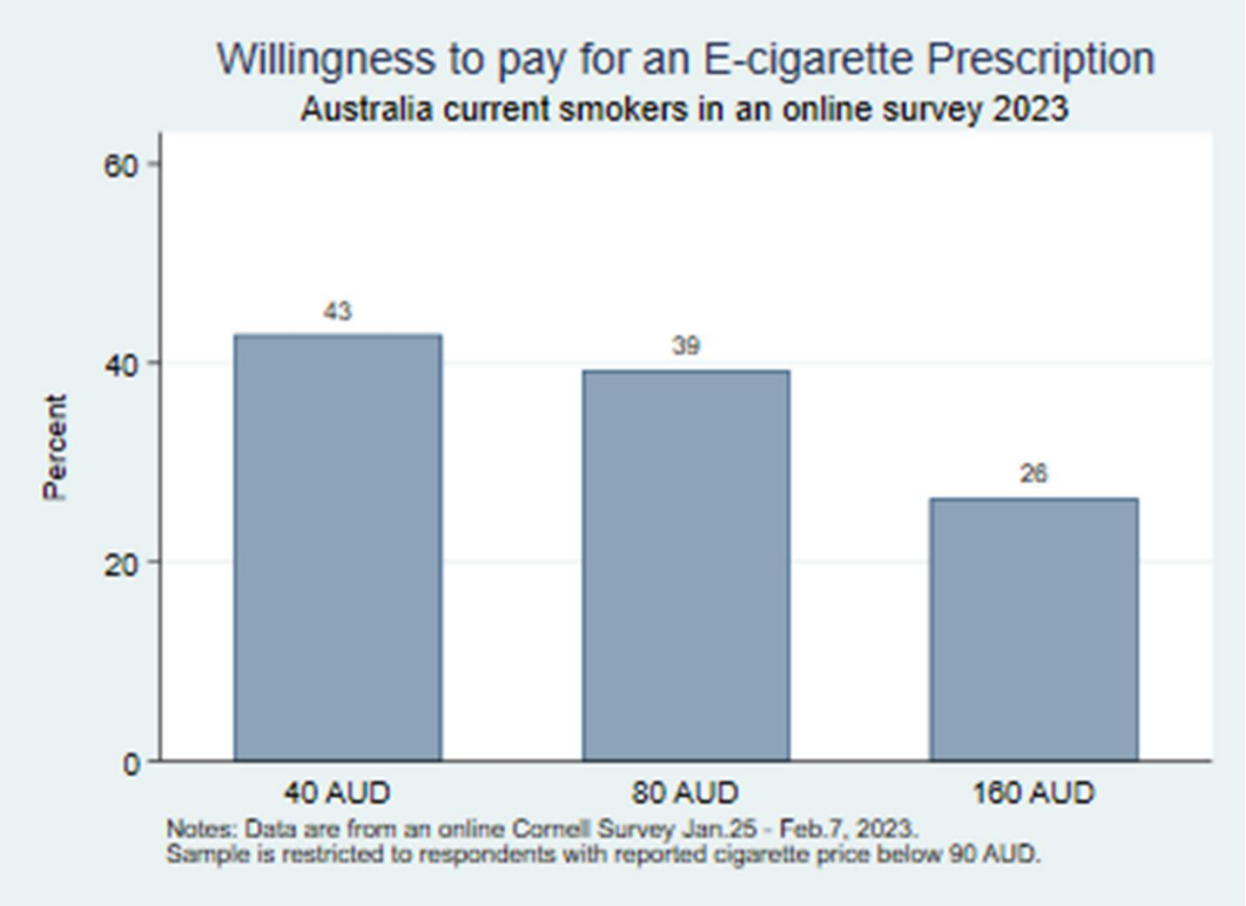

Table 1a: Socio-Economic Descriptive Statistics

	All	Current Vaper	Former Vaper	Aware Rx Law	Unaware Rx Law	Rx	No Rx
Less than High School	0.10	0.07	0.13	0.07	0.11	0.00	0.10
	(0.30)	(0.25)	(0.34)	(0.25)	(0.31)	0.00	(0.31)
High School	0.23	0.22	0.21	0.20	0.25	0.17	0.24
	(0.42)	(0.42)	(0.41)	(0.40)	(0.43)	(0.38)	(0.43)
Trade or Vocational	0.26	0.23	0.30	0.27	0.26	0.20	0.27
	(0.44)	(0.42)	(0.46)	(0.44)	(0.44)	(0.40)	(0.44)
Some College	0.08	0.08	0.14	0.11	0.07	0.05	0.09
	(0.28)	(0.26)	(0.35)	(0.31)	(0.26)	(0.22)	(0.28)
College	0.24	0.30	0.18	0.25	0.23	0.37	0.23
	(0.43)	(0.46)	(0.38)	(0.44)	(0.42)	(0.49)	(0.42)
Grad. or Prof. School	0.09	0.10	0.04	0.11	0.08	0.22	0.08
	(0.28)	(0.31)	(0.21)	(0.31)	(0.27)	(0.42)	(0.26)
Full time	0.57	0.70	0.47	0.68	0.52	0.81	0.55
	(0.50)	(0.46)	(0.50)	(0.47)	(0.50)	(0.40)	(0.50)
Part time	0.16	0.18	0.15	0.15	0.16	0.15	0.16
	(0.37)	(0.38)	(0.36)	(0.36)	(0.37)	(0.36)	(0.37)
Not in Labor Force	0.18	0.08	0.20	0.11	0.21	0.02	0.19
	(0.39)	(0.26)	(0.40)	(0.32)	(0.41)	(0.16)	(0.40)
Unemployed	0.09	0.05	0.18	0.07	0.11	0.02	0.10
	(0.29)	(0.23)	(0.38)	(0.25)	(0.31)	(0.16)	(0.30)
Yearly Income (AUD)							
0-19,999	0.05	0.04	0.05	0.02	0.05	0.02	0.05
	(0.21)	(0.20)	(0.21)	(0.15)	(0.23)	(0.16)	(0.21)
20,000-34,999	0.13	0.08	0.19	0.10	0.15	0.05	0.14
	(0.34)	(0.27)	(0.40)	(0.30)	(0.35)	(0.22)	(0.35)
35,000-49,999	0.10	0.10	0.07	0.08	0.11	0.12	0.10
	(0.30)	(0.30)	(0.25)	(0.27)	(0.31)	(0.33)	(0.30)
0,000-59,999	0.08	0.07	0.13	0.06	0.09	0.07	0.08
	(0.27)	(0.25)	(0.33)	(0.24)	(0.28)	(0.26)	(0.27)
60,000-79,999	0.18	0.19	0.21	0.20	0.17	0.07	0.19
	(0.38)	(0.39)	(0.41)	(0.40)	(0.38)	(0.26)	(0.39)
80,000-99,999	0.11	0.14	0.06	0.17	0.09	0.22	0.10
	(0.31)	(0.35)	(0.23)	(0.37)	(0.28)	(0.42)	(0.30)
100,000-149,999	0.21	0.20	0.21	0.18	0.22	0.17	0.22
	(0.41)	(0.40)	(0.41)	(0.39)	(0.42)	(0.38)	(0.41)
150,000-199,999	0.10	0.12	0.09	0.14	0.08	0.20	0.09
	(0.29)	(0.33)	(0.29)	(0.34)	(0.27)	(0.40)	(0.28)
200,000 plus	0.05	0.07	0.01	0.05	0.04	0.07	0.04
	(0.21)	(0.25)	(0.11)	(0.23)	(0.20)	(0.26)	(0.21)
Observations	611	240	91	169	442	41	570

Table 1b: Demographic and Smoking Behavior Descriptive Statistics

	All	Current Vaper	Former Vaper	Aware Rx Law	Not Aware Rx Law	Rx	No Rx
Age							
18-24	0.11	0.19	0.12	0.17	0.09	0.17	0.11
	(0.32)	(0.39)	(0.33)	(0.38)	(0.28)	(0.38)	(0.31)
25-34	0.23	0.33	0.23	0.27	0.22	0.34	0.23
	(0.42)	(0.47)	(0.42)	(0.44)	(0.42)	(0.48)	(0.42)
35-44	0.20	0.26	0.19	0.21	0.20	0.32	0.20
	(0.40)	(0.44)	(0.39)	(0.41)	(0.40)	(0.47)	(0.40)
45-54	0.18	0.11	0.24	0.15	0.20	0.07	0.19
	(0.39)	(0.31)	(0.43)	(0.36)	(0.40)	(0.26)	(0.39)
55-64	0.17	0.09	0.12	0.12	0.18	0.05	0.17
	(0.37)	(0.28)	(0.33)	(0.32)	(0.39)	(0.22)	(0.38)
65-74	0.09	0.02	0.09	0.08	0.09	0.05	0.09
	(0.29)	(0.14)	(0.29)	(0.28)	(0.29)	(0.22)	(0.29)
75 plus	0.01	0.00	0.01	0.01	0.02	0.00	0.02
	(0.12)	0.00	(0.11)	(0.08)	(0.13)	0.00	(0.13)
Male	0.59	0.67	0.57	0.63	0.58	0.73	0.58
	(0.49)	(0.47)	(0.50)	(0.49)	(0.49)	(0.45)	(0.49)
White	0.85	0.79	0.91	0.80	0.87	0.68	0.86
	(0.36)	(0.41)	(0.29)	(0.40)	(0.34)	(0.47)	(0.35)
Smoker Characteristics							
Everyday Smoker	0.66	0.58	0.73	0.67	0.66	0.59	0.67
	(0.47)	(0.50)	(0.45)	(0.47)	(0.47)	(0.50)	(0.47)
Some Days Smoker	0.34	0.42	0.28	0.33	0.34	0.42	0.33
	(0.47)	(0.50)	(0.45)	(0.47)	(0.47)	(0.50)	(0.47)
Price Paid for a Pack	28.62	29.08	26.54	29.05	28.46	30.30	28.50
	(12.1)	(12.9)	(10.8)	(12.3)	(12.1)	(13.4)	(12.0)
Ever Vape	0.54	1.00	1.00	0.75	0.46	1.00	0.51
	(0.50)	0.00	0.00	(0.44)	(0.50)	0.00	(0.50)
Everyday Vaper	0.12	0.31		0.21	0.09	0.39	0.10
	(0.33)	(0.46)		(0.41)	(0.29)	(0.49)	(0.31)
Some Days Vaper	0.27	0.69		0.36	0.24	0.51	0.25
	(0.44)	(0.46)		(0.48)	(0.43)	(0.51)	(0.44)
Former Vaper	0.15		1.00	0.18	0.14	0.10	0.15
	(0.36)		0.00	(0.39)	(0.34)	(0.30)	(0.36)
Observations	611	240	91	169	442	41	570

Table 2a: Knowledge of E-cigarette Prescription Requirement

Is a doctor's prescription currently required to get or buy e-cigarettes with nicotine?	All	Current Vapers	Former Vapers
Yes	0.28	0.40	0.34
	(0.45)	(0.49)	(0.48)
No	0.26	0.35	0.17
	(0.44)	(0.48)	(0.37)
Unsure	0.47	0.26	0.50
	(0.50)	(0.44)	(0.50)
Observations	611	240	91

Table 2b: Measures of Compliance with the E-cigarette Prescription Requirement

	Current Vapers
Compliance Measure 1	
Has an Rx for E-Cigs	0.15
	(0.36)
Tried, but failed to obtain an Rx for E-Cigs	0.05
	(0.22)
Compliance Measure 2	
Obtained e-cigs without an Rx since Oct 1, 2021	0.92
	(0.28)
Compliance Measure 3	
Purchased e-cigs from a pharmacy or online	0.27
	(0.44)
Only purchased e-cigs from a pharmacy or online	0.10
	(0.31)
Obtained e-cigs from a non-licensed or illegal seller	0.88
	(0.32)
Compliance Measure 4	
Most Recent e-cig purchase was or may have been under the counter	0.76
	(0.43)
Compliance Measure 5	
Obtained any e-cigs without an Rx or from a non-licensed or illegal seller	0.96
	(0.19)
Only obtained e-cigs using Rx at a Pharmacy or Online	0.03
	(0.17)
Observations	240

Table 3: Linear Probability Models of Prescription Requirement Knowledge and Compliance

	1	2	3
	Aware of Rx Law Full Sample	Aware of Rx Law Current Vaper	Has Rx Current Vaper
Less than High School	0.019	-0.018	0.079
	(0.072)	(0.150)	(0.050)
High School	0.072	0.019	0.069
	(0.070)	(0.152)	(0.058)
Trade or Vocational	0.120	0.095	0.036
	(0.088)	(0.181)	(0.086)
Some College	0.024	0.005	0.129**
	(0.075)	(0.152)	(0.059)
College	0.078	0.159	0.314***
	(0.090)	(0.176)	(0.110)
Not in Labor Force	-0.021	-0.195	0.002
	(0.074)	(0.185)	(0.090)
Part time Work	0.006	-0.058	0.053
	(0.078)	(0.184)	(0.093)
Full time Work	0.092	-0.006	0.043
	(0.074)	(0.190)	(0.110)
20,000-34,999 yearly income AUD	0.082	0.207	0.004
	(0.082)	(0.168)	(0.097)
35,000-49,999 yearly income AUD	0.033	0.206	0.033
	(0.092)	(0.171)	(0.108)
50,000-59,999 yearly income AUD	0.025	0.074	-0.048
	(0.098)	(0.187)	(0.135)
60,000-79,999 yearly income AUD	0.100	0.176	-0.128
	(0.088)	(0.166)	(0.097)
80,000-99,999 yearly income AUD	0.216**	0.345*	0.041
	(0.102)	(0.181)	(0.121)
100,000-149,999 yearly income AUD	0.022	0.100	-0.040
	(0.091)	(0.167)	(0.111)
150,000-199,999 yearly income AUD	0.178*	0.251	0.030
	(0.108)	(0.187)	(0.130)
200,000 plus yearly income AUD	0.119	0.114	-0.065
	(0.125)	(0.193)	(0.136)
Age 25-34	-0.168**	-0.170*	-0.039
	(0.073)	(0.098)	(0.077)
Age 35-44	-0.207***	-0.166	-0.015

	(0.075)	(0.104)	(0.082)
Age 45-54	-0.209***	-0.077	-0.085
	(0.076)	(0.123)	(0.084)
Age 55-4	-0.234***	-0.342***	-0.053
	(0.075)	(0.116)	(0.092)
Age 65-74	-0.108	0.134	0.200
	(0.097)	(0.238)	(0.217)
Age 75 plus	-0.253**		
	(0.118)		
Male	-0.004	-0.011	0.003
	(0.041)	(0.074)	(0.056)
White	-0.062	-0.147*	-0.119
	(0.056)	(0.084)	(0.072)
Constant	0.333***	0.481**	0.153
	(0.116)	(0.208)	(0.133)
Observations	589	237	237
Adjusted R-squared	0.032	0.025	0.018

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

***** Omitted Categories: Unemployed, Less than a High School Degree, Income 0-19,999, and age 18-24.

Table 4: Mixed Logit Model of Consumer Choices of Nicotine Products

Variables		Immediate choice today		Choice of 6 months from now	
		Mean	**SD**	**Mean**	**SD**
Alternative specific constant	Cigarette	7.520***	3.785***	7.836***	4.765***
		(0.281)	(0.188)	(0.297)	(0.293)
	E-cigarette with Rx	2.580***	4.216***	3.029***	3.876***
		(0.189)	(0.342)	(0.248)	(0.305)
	E-cigarette without Rx	1.708***	3.192***	1.390***	3.370***
		(0.229)	(0.180)	(0.266)	(0.217)
Price	Price in AUD	-0.138***	0.251***	-0.278***	1.050
		(0.011)	(0.049)	(0.044)	(1.153)
Legality of E-cigarettes without Rx	Prohibited, available under the counter and online	-1.090***	0.800*	-1.076***	0.750*
		(0.264)	(0.458)	(0.266)	(0.439)
	Prohibited, strictly enforced, only available from illegal dealers	-1.183***	0.616*	-1.122***	0.047
		(0.230)	(0.366)	(0.144)	(0.267)
Log-likelihood at convergence		-4575		-4607	

Note: ASCs are assumed to follow normal distributions, and price and legality are assumed to follow log-normal distributions. Coefficients are assumed to be correlated. 500 shifted and shuffled Halton draws are used for simulation.

Table 4: Policy Scenarios: Compensating Variations and Predicted Choice Shares

Policy Scenario	CV (AU$)	Share of Cigarettes	Share of E-cigarettes with Rx	Share of E-cigarettes without Rx	Share of Quitting
Status Quo		0.581	0.252	0.077	0.090
Strict Prohibition	0.535	0.587	0.257	0.061	0.095
Repeal of Prohibition	-3.136	0.554	0.236	0.135	0.075