RISK BELIEFS AND PREFERENCES FOR E-CIGARETTES

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ABSTRACT

Drawing on evidence from a new nationally representative survey, this article examines several measures of risk beliefs for e-cigarettes. For both lung cancer mortality risks and total smoking mortality risks, respondents believe that e-cigarettes pose risks that are lower than the risks of conventional tobacco cigarettes. However, people greatly overestimate the risk levels of e-cigarettes compared with the actual risk levels. Risk beliefs for conventional cigarettes receive at least a two-thirds informational weight in the formation of e-cigarette risk beliefs. Public perceptions of nicotine levels of e-cigarettes are closer to the beliefs for conventional cigarettes than are their health risk perceptions. Consumers' desired uses of e-cigarettes are more strongly related to health risk perceptions than perceived e-cigarette nicotine levels. The overestimation of e-cigarette risks establishes a potential role for informational policies.

KEYWORDS: e-cigarettes, cigarettes, smoking, risk, Bayesian
JEL CLASSIFICATION: D80, I12, I18, K32

I. Introduction

The health risks associated with cigarettes and the stringent regulation of cigarettes have led to the emergence of alternative cigarette products. Although earlier reduced-risk products such as the Premier and Eclipse cigarettes marketed by R. J. Reynolds were not successful in the marketplace, electronic cigarettes known as e-cigarettes have made substantial inroads. These e-cigarettes are battery-powered devices that vaporize a propylene glycol/nicotine fluid, enabling the user to inhale a nicotine vapor. Because they do not burn tobacco, they have not yet been subject to cigarette taxes and regulations. This favorable regulatory status may be short-lived, as both the US Food and Drug Administration (FDA) and the World Health Organization (WHO) are scrutinizing the product and considering possible regulatory proposals.[1] In addition, three states have prohibited the use of e-cigarettes in private worksites, restaurants, and bars, and thus far 40 states have prohibited the sale of e-cigarettes to minors, usually those below age 18 but in four states below age 19 (Centers for Disease Control and Prevention 2014b).

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1 The WHO has gone further with a proposal that there be regulation of e-cigarettes. See Esterl and Evans (2014). Also, see the proposed rule by the US Food and Drug Administration (2014) and US Department of Health and Human Services (2014a). Some tobacco companies have instituted voluntary warnings for their e-cigarette brands. Marlow (2014) reviews many of the economic issues pertaining to regulation of e-cigarettes.

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A pivotal impetus for there to be an economic rationale for regulation is the existence of some market failure with respect to the product. The focus of this article is on potential market failures associated with individual choice, in particular, on how consumers perceive the product's risks and how these risk beliefs are linked to decisions to use the product. Survey evidence for a nationally representative sample provides insight into the public's assessment of two principal classes of product attributes—those that relate to the health risks posed by e-cigarettes and the nicotine levels of e-cigarettes. Are the levels of these risk beliefs accurate? Do people understand the nature and extent of the differences between e-cigarettes and conventional cigarettes? The different measures of the risk considered here provide insight into the beliefs underlying current and prospective use of e-cigarettes. The consumer rationality test entails whether people have accurate assessments of the properties of e-cigarettes as well as the risks of the principal product alternative, conventional cigarettes that burn tobacco. The nature of the market failure may be an overestimation of a product's riskiness, which in turn has implications for the appropriate role of government policy.

Cigarette products have been a primary target of informational regulations for the past five decades. Risk beliefs with respect to e-cigarettes are of pivotal concern as well, both with respect to the choice to use e-cigarettes and the potential use of e-cigarettes either as an alternative to conventional cigarettes or as a smoking cessation aid. Influencing these risk beliefs through hazard warnings can serve a productive economic function of informing consumers of pertinent product risks. Although most regulatory efforts have been directed at boosting risk perceptions, if consumers systematically overestimate risks, fostering informed consumer choice may entail conveying risk information that lowers risk beliefs. Examination of the level of various health risk beliefs for e-cigarettes consequently is a prerequisite for understanding the role that informational policies can play.

The organization of the paper is as follows. Section II introduces the nationally representative sample and Section III describes the Bayesian learning model for analyzing smoking risk beliefs. Section IV examines the level of risk beliefs and nicotine perceptions. People generally believe that e-cigarettes are safer than conventional cigarettes, but the absolute levels of risk beliefs exceed current estimates of the risk levels. There is also a belief that e-cigarettes contain less nicotine than conventional cigarettes. The analysis of current and prospective e-cigarette usage decisions in Section V finds that risk beliefs are influential and are strongly correlated with e-cigarette usage, but perceptions of nicotine levels are not. Section VI concludes with a discussion of implications for informational policies.

II. Sample Characteristics

The data used in this study are drawn from an original survey undertaken for this research project in June and July 2014 using the GfK KnowledgePanel, formerly known as Knowledge Networks. This company maintains a nationally representative web-based panel in which participants are recruited based on a random probability sampling approach,

TABLE 1. Sample characteristics

Continuous variables	Mean [std. dev.]
Age (years)	50.77 [17.27]
Education (years)	14.77 [2.66]
Income (household, $ thousands)	63.12 [43.35]
Children (number minor children)	0.43 [0.89]
Total excise tax ($/pack)	2.57 [1.05]
Binary variables (0–1)	**Mean**
Male	0.50
Nonwhite	0.26
Married	0.56
Current smoker	0.13
Former smoker	0.32
Never smoker	0.53
Nonsmoker	0.87
Tried e-cigarettes	0.12
Top-coded income (above $175,000)	0.05
Did not indicate smoking status	0.02
Did not indicate cigarette lung cancer risk	0.16
Did not indicate cigarette mortality risk	0.15
Did not indicate e-cigarette lung cancer risk	0.26
Did not indicate e-cigarette mortality risk	0.26
$N = 1{,}041$	

yielding the highest-quality panel of its type.[2] To ensure representativeness, the company provides potential respondents with web access and computers if needed. The sample size for this study consists of 1,041 adults in the United States, age 18 and over. Online Appendix Table 1 (http://www.mitpressjournals.org/doi/suppl/10.1162/AJHE_a_00042) provides a comparison of the sample with the adult US population. The sample is broadly representative in terms of the demographic characteristics, but the smoking population is

2 See www.knowledgenetworks.com/knpanel/docs/knowledgepanel(R)-design-summary-description.pdf, archived at https://perma.cc/X3MQ-K6WQ (last accessed March 23, 2016). The author's prior use of this panel was approved for policy analysis purposes by the US Office of Management and Budget, Office of Information and Regulatory Affairs. It was the first web-based panel to receive this approval.

somewhat underrepresented.[3] Table 1 summarizes the characteristics of the main variables used in the empirical analysis.

To provide comparability with some previous research on cigarette risk beliefs, the survey included risk belief questions for both conventional cigarettes and e-cigarettes patterned on the wording in Viscusi (1990, 1992, 2002) and Viscusi and Hakes (2008).[4] After indicating that the respondent should "assume that a typical smoker smokes a pack a day, or 20 cigarettes,"[5] respondents were asked to assess the risk of conventional cigarettes out of a denominator of 100 smokers, which is a readily understood mechanism for eliciting probability judgments.[6] Although risk rating scales such as 0 to 10 yield risk perception results for conventional cigarettes similar to the risk out of 100 smokers format, when respondents are rating the lower risks of e-cigarettes, the risk out of 100 smokers format provides a greater opportunity to give positive but low risk assessments. The lung cancer mortality question was the following: "Out of 100 smokers, how many of them do you think will die of lung cancer because they smoke?" The comparable total mortality risk question was the following: "And out of every 100 cigarette smokers, how many of them do you think will die from lung cancer, heart disease, throat cancer, or any other illness because they smoke?" The survey then asked respondents to assess these absolute risk questions for e-cigarettes.

In addition to the absolute questions, the survey asked respondents to assess whether e-cigarettes were more or less risky than conventional cigarettes: "How would you compare

3 The national average adult smoking rate in 2014 was 16.8 percent based on estimates by the Centers for Disease Control, www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm, archived at https://perma.cc/RKV7-VBSW (last accessed March 23, 2016). The smoking rate in this survey is 13.3 percent, with an additional 2.2 percent not indicating smoking status. The smoking status question followed a series of cigarette risk belief questions, which may have made responding to that question more sensitive. The smokers in the sample are similar to smokers nationally, as they are disproportionately white males, with only 10.9 percent having a bachelor's degree or higher, as compared with 30.5 percent for the full sample.

4 Variants of this format have also been analyzed in Liu and Hsieh (1995), Antoñanzas et al. (2000), Rovira et al. (2000), Viscusi et al. (2000), Sloan, Smith, and Taylor (2003), Lundborg and Lindgren (2004), Lundborg (2007), Lundborg and Andersson (2008), Khwaja et al. (2009), and Gerking and Khaddaria (2012).

5 The average number of cigarettes smoked per day dropped to 14.2 cigarettes in 2013 after having previously been at 20 cigarettes per day or more during the period affecting the smokers whose illnesses generate the current scientific estimates of the risk of smoking (see Centers for Disease Control and Prevention 2014a). If risks of smoking follow a linear dose-response relationship, the risks faced by an average smoker today are 71 percent of the risks that would be incurred by smoking a pack a day.

6 Other risk belief question formats that have been analyzed are 0–10 in Smith et al. (2001) and Khwaja, Sloan, and Chung (2006, 2007), and 1–10 as in Khwaja et al. (2009). The risk out of 100 smokers permits more refined responses but appears to yield similar results for conventional cigarettes. Khwaja et al. (2009) report identical mean lung cancer risk beliefs of 0.43 for the 1–10 question and the risk out of 100 smokers question based on their smoking survey results using both question formats. They also found that asking the risk out of 100 smokers question in the third person led to reported risk beliefs of 0.43 when asked in the third person, as was done in my survey above, and a very similar answer of 0.40 when asked in the second person. Focal responses, such as 50 out of 100, also did not substantially affect the previous results (Viscusi 2002; Khwaja, Sloan, and Chung 2007).

the risks of smoking a typical e-cigarette to smoking a conventional cigarette, assuming that the person smokes just as often?" The five qualitative responses ranged from "much less risky than conventional cigarettes" to "much more risky than conventional cigarettes."

The survey also included two different questions pertaining to the potential addictiveness of e-cigarettes. In the absence of a well-defined objective reference point for the addictive properties of cigarettes, each question format involved a comparison with conventional cigarettes. The nicotine question was the following: "How would you compare the levels of nicotine in e-cigarettes to conventional cigarettes?" Respondents rated nicotine on five levels from "much less nicotine than conventional cigarettes" to "much more nicotine than conventional cigarettes." The ease of quitting question took the following form: "How hard is it to quit e-cigarettes as compared to conventional cigarettes?" The five qualitative responses ranged from "much less difficult to quit than conventional cigarettes" to "much more difficult to quit than conventional cigarettes."

The survey also elicited detailed smoking-related information. Excluding e-cigarettes, was the respondent a current smoker, a former cigarette smoker, or has never smoked cigarettes? The survey also ascertained whether the respondent had also smoked e-cigarettes and whether the respondent was a current e-cigarette smoker, either smoking e-cigarettes alone or in conjunction with conventional cigarettes. For those who have smoked e-cigarettes, the survey examined which of the following reasons the respondent thought was influential in the decision to smoke e-cigarettes: "trying to quit conventional cigarettes," "trying to reduce amount of conventional cigarettes I smoke," "convenience, e-cigarettes can be smoked in more places," "prefer not to expose people nearby to smoke," "better flavor than conventional cigarettes," and "less expensive than conventional cigarettes."

The survey included detailed demographic information on the respondent's gender (male = 1), race (nonwhite = 1),[7] education (responses converted to years of schooling), household income (in thousands of dollars), top-coded income (for income levels at or above $175,000), age, marital status (married = 1), and number of minor children living in the household. The survey also included information on respondents' US Census region, which were divided into four groups, and state of residence. The state information provided the basis for constructing a cigarette excise tax variable reflecting the level of state plus federal excise taxes per pack in 2014.[8]

III. Models of Risk Perceptions and Preferences

The empirical analysis considers two closely related components—risk beliefs and product use preferences. The basic analytic framework to be applied to structuring individual risk beliefs is that the beliefs adhere to a rational Bayesian learning framework. In addition

7 The nonwhite variable includes African Americans, Asians, Hispanics, and other races.

8 State excise tax rate information is found in Orzechowski and Walker (2014). Similar data is found at the Tax Foundation website, http://taxfoundation.org/blog/state-cigarette-tax-rates-2014/, archived at https://perma.cc/R7MD-6NPM (last accessed March 23, 2016).

to analyzing absolute risk beliefs for conventional cigarettes and e-cigarettes, the survey elicited a comparison of the risks of e-cigarettes relative to the risks conventional cigarettes. These various results can then be used to examine the relationship of these risk beliefs to decisions to smoke e-cigarettes. If people are expected utility maximizers, then increases in the assessed probability of adverse health outcomes from e-cigarettes should discourage smoking of e-cigarettes. Such a negative relationship would also follow from many other behavioral models of risky decisions as well.

The model of individuals' probabilistic beliefs utilizes a beta distribution, which is quite flexible and can take on a variety of skewed and symmetric shapes. The beta distribution is ideally suited to analyzing the types of Bernoulli trials underlying the health risk lotteries associated with different types of cigarettes.[9] The cigarette probability assessments to be analyzed are the assessed probabilities of death or fatal lung cancer attributable to smoking. For simplicity, the model is framed in terms of the probability of death. Let the individual's assessed probability of death associated with conventional cigarettes be p, and let s be the assessed probability of death for e-cigarettes. The perceived e-cigarette risk s is a function of the assessed risk of cigarettes p and the risk q implied by other information and beliefs that the person might have. Let the value of p serve as the prior risk assessment, as the assessed risk of conventional cigarettes may serve as the initial frame of reference for assessing the risks of e-cigarettes. The value of q is the risk implied by information not included in p, such as news reports about e-cigarettes.

Based on the beta distribution formulation, the posterior risk s is a linear function of the prior p and the risk q implied by other information. Let the informational weight on p be ψ_0 and the weight on q be γ_0, where ψ_0 and γ_0 are equivalent to the number of draws from a Bernoulli urn corresponding to the total amount of information the person has about the relation of conventional cigarette risks to e-cigarette risks and the other information relating to the risk q implied by other available information. The perceived risk s from e-cigarettes consequently equals

$$s = \frac{\psi_0 p + \gamma_0 q}{\psi_0 + \gamma_0} \tag{1}.$$

The fraction of the total informational content associated with p and q is given by $\psi = \psi_0/(\psi_0 + \gamma_0)$ and $\gamma_0 = \gamma_0/(\psi_0 + \gamma_0)$. Equation 1 can be rewritten as

$$s = \psi p + \gamma q \tag{2}.$$

The e-cigarette risk belief s is consequently a weighted average of the assessed risk of cigarettes and the implied risk based on other risk information, where the weights are the fractions of the total information used in forming the risk judgment s associated with

9 The particular formulation was introduced in Viscusi and O'Connor (1984) to analyze processing of warning information and has been adopted in smoking-related studies by Viscusi (1991, 1992), Smith et al. (2001), Lundborg and Lindgren (2004), and Lundborg and Andersson (2008), among others.

p and q. The risk of e-cigarettes is less than that of conventional cigarettes if

$$s = \psi p + \gamma q < p \quad (3),$$

or if $q < p$.

Unlike the value of p, which is elicited for each respondent in the survey, the value of q is not observed. Rather, it is a function of a set of individual characteristics and experiences. The value of x_{ij} for the jth variable for person i affects person i's value of q_i following

$$q_i = \sum_{j=1}^{m} \beta_j x_{ij} \quad (4),$$

where the β_j terms are the coefficients that weight the x_{ij} values in the calculation of q_i. Note that in estimates of an equation for s that the coefficients of the variables in such an equation will reflect the combined influence of β_j and the relative informational weight γ on this component of risk beliefs.

The personal characteristic variables that lead respondents to be better informed about the risk of e-cigarettes should affect q in a manner that reduces the assessed value of s given that the available evidence suggests that e-cigarettes pose lower risks than conventional cigarettes. One would expect current smokers, younger consumers, and better-educated consumers to have more access to such information, increasing the information weight that they place on the low risk evidence and consequently reducing their assessed s values.

Whether a person will choose to smoke an e-cigarette depends not just on the respective risks, but also on the expected utility associated with the different options. Consider a choice between smoking an e-cigarette or a conventional cigarette, and let the risk outcome be death, which can be assigned a utility level of zero with no loss of generality. Let u be the utility of smoking conventional cigarettes and v be the utility of smoking e-cigarettes. The individual will prefer e-cigarettes if

$$(1 - s)v > (1 - p)u \quad (5),$$

or

$$\frac{u}{v} < \frac{(1 - s)}{(1 - p)} \quad (6).$$

The values of $(1 - p)$ and $(1 - s)$ are the associated probabilities of survival for cigarettes and e-cigarettes. So long as the relative utility of conventional cigarettes compared with e-cigarettes is less than the relative probabilities of survival, e-cigarettes will be preferred. For $(1 - s)$ values that are always greater than the values of $(1 - p)$, e-cigarettes will always be preferred when v is equal to or greater than u. If e-cigarettes provide lower utility levels v, perhaps because of less desirable taste or a somewhat different smoking experience, then to be attractive to consumers the risk level s must be below p. For analogous reasons,

increasing the relative product price of conventional cigarettes through excise taxes should make e-cigarettes more attractive.

IV. Beliefs for Health Risks, Nicotine Levels, and Ease of Quitting

A. THE RISK AND ADDICTION PROPERTIES OF E-CIGARETTES

Unlike conventional cigarettes for which there is an extensive epidemiological literature that can be used to assess the risk levels, there is more limited evidence regarding e-cigarettes, which are comparatively new products. It is useful to distinguish the health risks of e-cigarettes, such as the mortality risks of smoking, from the role of nicotine addiction since e-cigarettes have quite different properties on these two dimensions.

The available evidence with respect to the health risks of e-cigarettes suggests that they are dramatically safer than conventional cigarettes.[10] Chemical studies have found that different brands of conventional cigarettes have levels of nitrosamines that range from 971 to 1,806 times as great as electronic cigarettes. The levels of toxic chemicals such as heavy metals are very low, with e-cigarettes having a toxic emissions score of 0 as compared with 100–134 for different conventional cigarettes tested. Toxicological studies such as those involving human embryonic stem cells have found only marginal levels of toxicity in one e-cigarette sample, with cigarette smoke having very potent toxicity levels. Clinical studies have found that e-cigarettes lead to elevation of systolic and diastolic blood pressure but to a much lower degree than conventional cigarettes. Based on their systematic review of the pertinent scientific literature, Farsalinos and Polosa (2014, 81) concluded: "It is obvious that some residual risk associated with EC (electronic cigarette) use may be present, but this is probably trivial compared with the devastating consequences of smoking." Similarly, Cahn and Siegel's (2011, 18) review of the scientific evidence concluded that the level of toxins in conventional cigarettes is several orders of magnitude greater than the level for e-cigarettes. They find that "a preponderance of the available evidence shows them to be much safer than tobacco cigarettes and comparable in toxicity to conventional nicotine products."

Similarly, the risks posed by secondhand exposure to e-cigarettes are also dramatically less (McAuley et al. 2012). This difference arises for two reasons. First, the toxicity of e-cigarette vapors is less. Second, there is considerably less passive exposure as the vapor is only produced when the device is activated and puffs are being taken. The result is that "the effects of EC (electronic cigarette) use on bystanders are minimal compared with conventional cigarettes (Farsalinos and Polosa 2014, 79)."

E-cigarettes also have nicotine, which contributes to the addiction aspect of smoking. However, contrary to many popular misconceptions, nicotine is not a contributor to the principal mortality risks of smoking. Nicotine is not listed as a carcinogen by the International Agency for Research on Cancer and has not been found to promote obstructive lung disease, cardiovascular disease, or other life-threatening effects (Farsalinos

10 Unless indicated otherwise, all information in the paragraph is drawn from the systematic review by Farsalinos and Polosa (2014).

and Polosa 2014). Nicotine has, however, been found to affect brain development in adolescents as well as having effects during pregnancy on both maternal and infant health (US Department of Health and Human Services 2014b, 8). The average nicotine levels per puff are lower for e-cigarettes, but "experienced users may achieve systematic nicotine concentrations akin to traditional users (Schroeder and Hoffman 2014, ii33)." The level of nicotine in e-cigarettes may differ from the labeled amounts and is variable across different e-cigarette products (Trehy et al. 2011). On balance, e-cigarettes deliver nicotine levels and the associated addictive properties of smoking that on average may be less than those of cigarettes, but any such difference will not be stark since the function of the e-cigarettes is to provide the nicotine and a smoking experience that substitutes for that of cigarettes.

Some analysts view e-cigarettes as serving as a form of nicotine replacement therapy. E-cigarettes have been found to serve a beneficial role in assisting in smoking cessation (Bullen et al. 2013) or fostering both smoking cessation and a reduction in the number of cigarettes smoked (Polosa et al. 2011). E-cigarettes also have been found to decrease smoking among smokers not intending to quit (Caponnetto et al. 2013). The relative efficacy of e-cigarettes in promoting smoking cessation is greater than that of nicotine replacement therapies (Brown et al. 2014). As a result of such studies, many perceive e-cigarettes as being a potentially useful smoking cessation tool (Siegel, Tanwan, and Wood 2011; Wagener et al. 2014).

Switching from cigarettes to e-cigarettes will generate a clear-cut public health benefit. But what if e-cigarettes discourage some smokers from quitting altogether as they switch from conventional cigarettes to e-cigarettes rather than giving up smoking? Also the availability of e-cigarettes may lead some current nonsmokers to smoke e-cigarettes. Given the current estimates of toxicity levels, the difference in product riskiness between conventional cigarettes and e-cigarettes is so great that even if conventional cigarette smoking rates declined by only 1 percent and the entire population smoked e-cigarettes, there would be a net public health benefit from e-cigarettes.

For the purposes of assessing the adequacy of risk beliefs, it is useful to have a sense of the order of magnitude of the current risks to smokers. The risks of conventional cigarettes have been well established, but the lifetime probabilities of lung cancer and mortality are not included in reports by the US Surgeon General. We can, however, calculate these risks to smokers using recent estimates for smokers age 35 and over of 130,659 smoking-attributable lung cancer deaths annually and 437,400 total smoking-attributable deaths to smokers per year.[11] Because of the existence of a latency period for the most serious smoking-related diseases, let us use the 1985 US smoking population to estimate the size of exposed population associated with current mortality statistics.[12] If people incur the

11 These statistics are from the US Department of Health and Human Services (2014b, Table 12.4, 660). The mortality estimates are for adults 35 years of age and older. There are additional deaths from secondhand smoke (41,280), prenatal conditions (1,013), and fires (620). Including these deaths leads to the widely cited total attributable death number of 480,320. The focus of the survey question being analyzed here is on the private risk to the smoker so these other deaths are excluded from the calculations. New evidence in 2015 of additional smoking-related risks would boost these estimates somewhat.

12 The total adult smoking population was 50.4 million in 1985 and ranged from 48 million to 52 million from 1965 to 1985. See American Lung Association (http://www.lung.org), Research and Program Services,

annual rates of death above in each of the years in the 30-year period from age 35 to 64, then the lifetime risks of death to smokers are 0.08 for lung cancer and 0.26 for total smoking mortality.[13] The risk-related empirical issue to be examined is whether respondents perceive e-cigarettes to be safer than conventional cigarettes and whether the absolute perceived risk levels for lung cancer mortality and total smoking-related mortality are adequate. If the risks of e-cigarettes relative to those of conventional cigarettes are consistent with the findings of chemical studies, the risks of e-cigarettes would be at least a factor of 1,000 below the estimated risks for conventional cigarettes. If the relative risk levels are consistent with toxic emission studies cited above, the risks of e-cigarettes would be a factor of at least 100 less than conventional cigarettes. If these estimates are accurate, then the best estimate of the risks of smoking-attributable lung cancer and total mortality out of 100 smokers based on currently available scientific estimates would be below 1 out of 100.

B. ABSOLUTE HEALTH RISK BELIEFS FOR E-CIGARETTES

The survey was structured so that respondents first assessed the risks of lung cancer and total mortality risk for cigarettes, and then assessed these risks for e-cigarettes. The survey question permitted an "I don't know" response, and there were some respondents who chose not to indicate a response.[14] These two nonresponse categories are pooled in the empirical analysis and will be addressed in the regression analysis to account for potential selection effects. Other risk assessment questions in the survey posed fewer problems and had a higher response rate. Table 2 summarizes the four sets of risk beliefs of cigarette-related lung cancer deaths and total deaths out of 100 smokers for the full sample, smokers, and nonsmokers. For cigarettes, the mean risk belief probabilities for the full sample are 0.410 for lung cancer and 0.503 for total smoking-related mortality. These results, which indicate an overestimation of the risks, are very similar to estimates reported in previous surveys so that the availability of e-cigarettes does not appear to have influenced these

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Epidemiology and Statistics Unit, Trends in Tobacco Use, July 2011. The estimate of the total number of adult smokers for 2012 is 42.1 million, which will generate lower smoking mortality numbers in the future. See the Centers for Disease Control and Prevention (2014a), Adult Cigarette Smoking in the United States: Current Estimates.

13 The risk levels change proportionally with the number of years after age 35 that the annual number of deaths occurs. For example, if the smoking population incurred these total mortality risks over 50 years of smoking from age 35 to 84, then the lifetime total mortality risk rises to 0.13 for lung cancer and 0.43 for total smoking mortality. Earlier 30-year estimates of 0.06 for lung cancer mortality and 0.18 for total smoking mortality from Viscusi (1992, 2002) are lower than the 30-year estimates above, as they are based on previous studies by the US Surgeon General and were used to analyze earlier smoking surveys.

14 As a result, the sample sizes for the objective risk belief questions ranged from 696 for e-cigarette lung cancer risks to 880 for tobacco cigarette mortality risks. In contrast, 1,012 respondents answered the risk question comparing the risk levels of e-cigarettes and tobacco cigarettes. The web-based format led to more "I don't know" responses than previous surveys in which telephone interviewers prompted those surveyed for a response. Three percent of the respondents skipped the different objective risk belief questions rather than specifically indicating an "I don't know" response.

TABLE 2. Risk perceptions out of 100 smokers for cigarettes and e-cigarettes

	Mean (standard error of the mean)		
	Full sample	Smokers	Nonsmokers
Cigarette risk beliefs:			
Lung cancer ($N = 870$)	41.0 (0.9)	35.7 (2.5)	41.8 (1.0)
Total mortality ($N = 886$)	50.3 (1.0)	42.6 (2.6)	51.4 (1.0)
E-cigarette risk beliefs:			
Lung cancer ($N = 766$)	27.3 (0.9)	20.9 (2.5)	28.2 (1.0)
Total mortality ($N = 776$)	33.3 (1.0)	23.2 (2.4)	34.7 (1.1)

beliefs.[15] The perceived risk levels for e-cigarettes are lower than those for conventional cigarettes, as the lung cancer risk belief for e-cigarettes is 0.273 and the total mortality risk belief is 0.333. Similar relative discrepancies are observed for both smokers and nonsmokers. Smokers have lower risk beliefs than nonsmokers for conventional cigarettes, which one would expect given their self-selection into smoking behavior. Smokers also have lower risk beliefs than nonsmokers for e-cigarettes.

The patterns of risk beliefs are not very sensitive to the respondents giving focal responses to the questions, as indicated by the results reported in Online Appendix Table 2. For example, in the case of cigarette risk beliefs for lung cancer, the overall mean cigarette risk belief out of 100 smokers is 41.0 for the full sample, 39.2 excluding responses of 50, and 37.9 excluding responses of 0, 50, and 100. These focal responses also could be quite legitimate expressions of risk beliefs. Consequently, all responses will be included in the analysis.

A regression analysis is instructive in exploring the influence on e-cigarette risk beliefs of the respondent's conventional cigarette-related beliefs, which are framed here as being governed by the individual's prior risk beliefs. The equations for both the lung cancer and total mortality e-cigarette risk belief questions take on a similar form. To account for possible sample selection effects of respondents choosing to respond to the cigarette risk belief questions, one of the equations also includes an inverse Mills' ratio term $lambda_i$.[16]

15 Earlier results reported in Viscusi (2002, 147) indicate lung cancer risk beliefs from four different surveys ranging from 0.43 to 0.48 and a total mortality risk range from three surveys ranging from 0.50 to 0.54. Khwaja et al. (2009) found a lung cancer risk estimate of 0.43 using this third-person wording as above and similar results using other question formats. See footnote 6, supra.

16 The regression was estimated using the Stata Heckman maximum likelihood estimator.

TABLE 3a. E-cigarette lung cancer risk belief regressions

	OLS	OLS with selection correction	Double-bounded Tobit	Two-stage least squares
Cigarette risk beliefs	0.676[a]	0.674[b]	0.716[a]	0.701[a]
	(0.030)	(0.030)	(0.032)	(0.169)
Current smoker	−3.266	−3.129	−4.085[c]	−3.081
	(2.170)	(2.128)	(2.433)	(2.382)
Male	−5.036[a]	−5.042[a]	−5.620[a]	−4.935[a]
	(1.312)	(1.297)	(1.441)	(1.445)
Age	0.099[b]	0.100[b]	0.125[a]	0.099[b]
	(0.043)	(0.042)	(0.046)	(0.043)
Education	−0.722[b]	−0.692[b]	−0.807[a]	−0.709[b]
	(0.282)	(0.277)	(0.310)	(0.282)
Children	−0.185	−0.186	−0.111	−0.204
	(0.675)	(0.669)	(0.724)	(0.743)
Married	0.503	0.574	0.738	0.393
	(1.462)	(1.470)	(1.598)	(1.594)
R^2	0.55	–	–	0.54
Log likelihood	–	−3,829.8	–	–

Notes: $N = 1{,}041$ for column 2; 766 otherwise. Equations also included variables for former smokers, did not indicate smoking status, nonwhite, income, top-coded income, and three regional variables. First-stage selection equations are in Online Appendix Table 2. Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

The assessed risk levels for electronic cigarettes are consequently

$$\text{e-cigarette risk}_i = \alpha_0 + \alpha_1 \text{cigarette risk}_i + \alpha_2 \text{lambda}_i + \sum_{j=3}^{m} \alpha_j x_j + u_i \qquad (7),$$

where α_1 is the value of ψ in equation 2, and the α_j coefficients reflect the product $\gamma\beta_j$ in the Bayesian formulation above.

Tables 3a and 3b report four sets of estimates of lung cancer and total mortality risk belief equations: an OLS equation, an OLS equation with a selection correction term, a double-bounded Tobit equation since the responses are bounded from below by zero and above by 100, and two-stage least squares estimates in which the cigarette risk beliefs variable is permitted to be endogenous. The results are very similar across all specifications.

Achieving identification for the sample selection term was facilitated using results from other parts of the survey dealing with household recycling behavior. The number of times that the respondent selected the "I don't know" response to the recycling questions was not significantly correlated with smoking risk beliefs but was strongly predictive of nonresponses to the smoking risk belief questions. A related variable included in the selection equations was a zero-one binary variable for whether the respondent skipped

TABLE 3b. E-cigarette total mortality risk belief regressions

	OLS	OLS with selection correction	Double-bounded Tobit	Two-stage least squares
Cigarette risk beliefs	0.698[a]	0.698[a]	0.738[a]	0.992[a]
	(0.026)	(0.025)	(0.028)	(0.177)
Current smoker	−4.355[b]	−4.262[b]	−4.873[b]	−0.879
	(2.130)	(2.097)	(2.404)	(3.184)
Male	−6.482[a]	−6.480[a]	−6.913[a]	−5.136[a]
	(1.434)	(1.418)	(1.558)	(1.711)
Age	0.100[b]	0.101[b]	0.111[b]	0.123[b]
	(0.047)	(0.046)	(0.050)	(0.053)
Education	−0.632[b]	−0.606[b]	−0.658[b]	−0.409
	(0.308)	(0.305)	(0.331)	(0.350)
Children	−0.160	−0.164	−0.128	−0.160
	(0.807)	(0.800)	(0.854)	(0.865)
Married	1.250	1.316	1.571	−0.122
	(1.556)	(1.553)	(1.697)	(1.862)
R^2	0.56	–	–	0.47
Log likelihood	–	−3,924.5	–	–

Notes: $N = 1{,}041$ for column 2; 766 otherwise. Equations also included variables for former smokers, did not indicate smoking status, nonwhite, income, top-coded income, and three regional variables. First-stage selection equations are in Online Appendix Table 2. Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

and gave no answer to any of the recycling questions, as opposed to specifically indicating "I don't know." Also included in the selection equation were the respondent's income and the top-coded income variable. The lambda sample selection variable is not statistically significant in the smoking risk belief equations so one cannot reject the hypothesis of no selection bias. The first-stage results for the selection equation are reported in Online Appendix Table 3.

The results for the estimation of cigarette risk beliefs in the first stage of the two-stage least squares results reported in Online Appendix Table 4 indicate that the instruments are reasonably strong. Neither the recycling variable nor the household head variable is significantly related to e-cigarette risk beliefs. Respondents with a strong attachment to the environment believe cigarettes are riskier than those who do not. Conventional cigarette risk beliefs are higher for individuals who are diligent recyclers, which is an ordinal variable scaled from zero to five. Household heads have lower cigarette risk beliefs which, given the mean risk beliefs for the sample, implies that their risk beliefs are more accurate.

The four sets of regression results in Tables 3a and 3b for the objective e-cigarette risk assessments indicate the dominant influence of cigarette risk beliefs on the counterpart risk beliefs for e-cigarettes. The cigarette risk belief explanatory variable in the e-cigarette lung cancer risk equation is the respondent's cigarette risk beliefs for lung cancer, while

the cigarette risk belief explanatory variable in the total mortality risk equation is the total mortality risk belief for cigarettes. For both e-cigarette lung cancer mortality beliefs and e-cigarette total mortality risk beliefs, there is a powerful influence of prior risk beliefs for conventional cigarettes. The relative informational weight on the cigarette risk belief ranges from 0.68 to 0.72 for the different lung cancer equations and from 0.70 to 0.99 for total smoking mortality. These coefficients have a direct interpretation in terms of the information weights in equation 2. At least two-thirds of the information that the respondents use to assess the risks associated with e-cigarettes is based on the counterpart cigarette risk belief estimates. At most one-third of the information comes from all other sources.

This weight on cigarette risk beliefs accounts for most of the risk assessment for e-cigarettes. Consider the risk belief for the full sample values in Table 2, where the lung cancer risk belief for e-cigarettes is 67 percent of the counterpart value for conventional cigarettes, and the total mortality risk beliefs for e-cigarettes is 66 percent of the counterpart value for conventional cigarettes. These proportional relationships closely parallel the informational weights on the conventional cigarette risk belief variables in Tables 3a and 3b to make conventional cigarette risk beliefs almost perfect predictors of mean e-cigarette risk beliefs. Thus, the mean e-cigarette risk beliefs that one would predict based on the risk beliefs for conventional cigarettes coupled with the estimated weight on these beliefs from Tables 3a and 3b are similar to the actual mean observed values.

Since available evidence suggests that e-cigarettes pose lower risk levels than conventional cigarettes, one would expect variables that reflect the degree to which the respondent is informed of this evidence would reduce the level of the person's risk beliefs for e-cigarettes. These predictions are borne out. Smokers should be more attuned to the properties of different types of cigarette products. For the Tobit results in Table 3a and the first three columns of results in Table 3b, the negative coefficient for current smoker is statistically significant, with the effects implying risk beliefs 0.04 to 0.05 lower. This result takes into account smokers' risk beliefs regarding conventional tobacco cigarettes, which is also included in the equations.

The demographic variables accord with patterns reflective of individual knowledge of smoking risks. Older consumers are likely to be less well informed about risks of new cigarette products, and they consequently have significantly higher risk beliefs as they are more likely to overestimate the risks of e-cigarettes. This result mirrors a similar age-related pattern of perception of risks of conventional cigarettes for which younger people, who have been raised in a stronger antismoking environment, have higher risk beliefs for cigarettes than do older people (Viscusi 1991, 1992). More education reduces risk beliefs for the lung cancer risks for e-cigarettes for all but one of the equations in Tables 3a and 3b. Men also have lower risk beliefs for e-cigarettes even controlling for current smoking status and smoking risk beliefs. Whether this relationship is because they are better informed or tend to not be as concerned with risk generally is unclear.

C. COMPARATIVE HEALTH RISK BELIEFS FOR E-CIGARETTES

The survey also asked respondents to compare several characteristics of e-cigarettes to those of conventional cigarettes. These questions did not require an objective risk

TABLE 4. Risk beliefs and perceptions of nicotine and quitting difficulty of e-cigarettes compared with conventional cigarettes

Fraction of sample in category				
Panel A. Risk beliefs for e-cigarettes compared with conventional cigarettes				
Much less risky	Less risky	Just as risky	More risky	Much more risky
0.139	0.380	0.438	0.022	0.021
$N = 1{,}012$				
Panel B. Nicotine levels compared with conventional cigarettes				
Much less nicotine	Less nicotine	Just as much nicotine	More nicotine	Much more nicotine
0.089	0.287	0.533	0.074	0.017
$N = 992$				
Panel C. Difficulty of quitting compared with conventional cigarettes				
Much less difficult to quit	Less difficult to quit	Just as difficult to quit	More difficult to quit	Much more difficult to quit
0.089	0.231	0.644	0.020	0.015
$N = 984$				

assessment but only a comparative judgment. Presenting these statistics serves as a robustness test with respect to risk beliefs and will also provide question wording parallel to those used in the survey for the nicotine component.[17] However, unlike the objective risk assessment questions, qualitative risk ratings and categorical scales are subject to personal differences with respect to how the scales are interpreted (Gaba and Viscusi 1998; Rice, Robone, and Smith 2012). The survey questions used the risk of conventional cigarettes as the respondent's reference point, which will diminish the problem, but differences will still remain in terms of, for example, how much risk is "more risky" or "much more risky." The regression analysis below will explore a series of different specifications to explore the sensitivity of the results to different coding of the qualitative response variables.

Panel A of Table 4 reports the results for the comparative questions involving the riskiness of cigarettes and e-cigarettes. The most common response, which was indicated by 44 percent of the sample, was that the products were just as risky. The majority of the sample, or 52 percent, thought that e-cigarettes posed lower risk levels in that they were either less risky (38 percent) or much less risky (14 percent).[18] A combined total of only

17 Qualitative questions also have played a role in other economic studies of smoking. Lin and Sloan (2015) analyze whether respondents believe that smoking probably or definitely increases the risk of lung cancer.

18 A US survey analyzed by Tan and Bigman (2014) found that 77 percent of respondents were not aware of e-cigarettes, but for those who were aware of this product 51 percent believed that they were less harmful

TABLE 5a. Regression results for e-cigarette risks compared with cigarette risks: Lung cancer models

	Probit regression results			
	Ordered 5 to 1	Binary top two categories	Binary top three categories	Binary top four categories
Cigarette risk beliefs: Lung cancer	−0.012[a]	−2.5 E-4	−0.005[a]	−2.2 E-3[a]
	(0.002)	(2.5 E-4)	(0.001)	(0.4 E-3)
Did not indicate cigarette risk beliefs: Lung cancer	−0.454[a]	−0.029[a]	−0.116	−0.161[a]
	(0.159)	(0.008)	(0.072)	(0.064)
E-cigarette risk beliefs: Lung cancer	0.030[a]	7.1 E-4[a]	0.014[a]	7.0 E-3[a]
	(0.003)	(2.6 E-4)	(0.001)	(0.6 E-3)
Did not indicate e-cigarette risk beliefs: Lung cancer	1.057[a]	0.054[a]	0.415[a]	0.120[a]
	(0.130)	(0.024)	(0.047)	(0.018)
Current smoker	−0.276[b]	0.018	−0.135[b]	−0.043[c]
	(0.121)	(0.017)	(0.052)	(0.029)
Male	−0.219[a]	−0.024[b]	−0.056	−0.033[b]
	(0.072)	(0.010)	(0.035)	(0.017)
Age	0.002	5.5 E-4[c]	2.7 E-4	3.4 E-5
	(0.002)	(3.1 E-4)	(11.5 E-4)	(50.2 E-5)
Education	−0.018	−0.002	−0.011	0.001
	(0.014)	(0.002)	(0.007)	(0.003)
Children	0.079[b]	3.6 E-5	0.024	0.024[b]
	(0.039)	(490.3 E-5)	(0.021)	(0.011)
Married	0.026	−0.004	0.033	−0.004
	(0.081)	(0.010)	(0.039)	(0.017)
Pseudo R^2	0.11	0.14	0.16	0.20
N	1,012	1,006	1,012	1,006

Notes: Each equation also includes nonwhite, income, top-coded income, former smoker, did not indicate smoking status, and three regional variables. Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

4 percent of the respondents indicated that they thought that e-cigarettes were more risky or much more risky, where 2 percent of the respondents were in each of these two above risk categories. The general implication of these results is that respondents tend to be split between thinking e-cigarettes pose a lower risk or the same risk as conventional cigarettes, with only a tiny minority believing that e-cigarettes are more risky.

To analyze the relationship of these comparative risk belief responses to the different risk perception variables, Table 5a reports probit regressions for the comparative risk

than conventional cigarettes. The percentage believing the risk of e-cigarettes is lower is below the worldwide survey result reported by Farsalinos et al. (2014) that 88 percent of respondents thought e-cigarettes were "less harmful than tobacco cigarettes."

TABLE 5b. Regression results for e-cigarette risks compared with cigarette risks: Total mortality risk models

	Probit regression results			
	Ordered 5 to 1	Binary top two categories	Binary top three categories	Binary top four categories
Cigarette risk beliefs: Total mortality risk	−0.014[a] (0.002)	−5.6 E-4[b] (2.7 E-4)	−0.006[a] (0.001)	−2.3 E-3[a] (0.4 E-3)
Did not indicate cigarette risk beliefs: Total mortality risk	−0.666[a] (0.185)	−0.029[a] (0.008)	−0.186[b] (0.074)	−0.209[a] (0.081)
E-cigarette risk beliefs: Total mortality risk	0.030[a] (0.002)	9.1 E-4[a] (2.7 E-4)	0.013[a] (0.001)	0.006[a] (0.001)
Did not indicate e-cigarette risk beliefs: Total mortality risk	1.237[a] (0.143)	0.073[a] (0.030)	0.468[a] (0.045)	0.133[a] (0.018)
Current smoker	−0.240[a] (0.121)	0.019 (0.018)	−0.123[b] (0.051)	−0.052[c] (0.032)
Male	−0.184[b] (0.073)	−0.020[b] (0.009)	−0.045 (0.035)	−0.031[c] (0.019)
Age	0.003 (0.002)	5.0 E-4[c] (3.0 E-4)	8.4 E-4 (11.7 E-4)	5.4 E-5 (57.6 E-5)
Education	−0.018 (0.014)	−0.002 (0.002)	−0.010 (0.007)	7.2 E-4 (37.0 E-4)
Children	0.083[b] (0.038)	−0.001 (0.005)	0.031 (0.021)	0.028[b] (0.012)
Married	0.004 (0.081)	−0.003 (0.010)	0.018 (0.040)	−0.006 (0.020)
Pseudo R^2	0.12	0.14	0.18	0.18
N	1,012	1,006	1,012	1,006

Notes: Each equation also includes nonwhite, income, top-coded income, former smoker, did not indicate smoking status, and three regional variables. Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

belief question including the lung cancer risk beliefs for cigarettes and e-cigarettes as key explanatory variables. Table 5b repeats the analysis using the total mortality risk beliefs for cigarettes and e-cigarettes. The dependent variable for the ordered probit regression in the first column of both Table 5a and 5b is the relative overall comparative lung cancer risk of e-cigarettes for the categories in panel A of Table 4, with the risk perception values ranging from one for much less risky to five for much more risky. The next three columns of results in Table 5a and 5b are binary probit regressions in which the values coded as one are only for the top two categories (much more risky and more risky), the top three categories (much more risky, more risky, just as risky), and the top four risk categories (much more risky, more risky, just as risky, and less risky). Each of these equations

formulates the comparative risk belief of e-cigarettes as being a function of the absolute level of either lung cancer or total mortality risk beliefs for cigarettes and e-cigarettes and a series of personal characteristic variables.

The key set of variables is the group of objective risk measures and whether there are missing values for those variables. Higher risk beliefs for e-cigarettes should have a positive effect on the comparative risk assessment for the risks of e-cigarettes relative to the risks of conventional cigarettes, and higher risk beliefs for conventional cigarettes should have a negative impact. These predictions are borne out, with significant effects for each of these variables in the expected direction in every case. However, given the comparative nature of the risk belief question, one might have expected that the absolute levels of risk beliefs for e-cigarettes and cigarettes would not only have opposite signs, but they also would be symmetric in terms of their magnitude. For any given person, increasing the value of e-cigarette risk beliefs by some value z should have the same effect on whether the respondent believes e-cigarettes pose comparatively greater risk as would reducing the value of the cigarette risk belief by z. However, that symmetry is not observed, as the e-cigarette lung cancer risk variable has a positive coefficient that is usually more than double the size of the negative coefficient for cigarettes, and the e-cigarette mortality risk assessment also has roughly double the influence. One possible explanation is behavioral in nature in that a comparative risk question asking respondents to assess the risks of a novel product may lead respondents to focus on the risk of this more unfamiliar product. This cognitive emphasis may lead assessments that give the e-cigarette risk beliefs a greater weight.

The respondents who did not indicate risk levels for the e-cigarette or conventional cigarette risk questions are particularly interesting in that they embody the influence of a lack of knowledge of the likely lower risk levels of e-cigarettes compared with the risks of conventional cigarettes. If the nonrespondents to the e-cigarette lung cancer risk and mortality risk questions are not aware of the literature suggesting that e-cigarettes pose lower risks, one would expect those with a nonresponse to the e-cigarette risk question to have higher comparative risk beliefs for e-cigarettes. Such a relationship is in fact borne out for both lung cancer risk beliefs and total mortality risk beliefs. Similarly, the nonresponses to the conventional cigarette lung cancer risk belief questions and total mortality risk belief questions are associated with lower comparative risk beliefs, as expected. Once again there is also an asymmetry in the magnitude of the effects for the nonresponse variables just as there was also for the risk assessment variables. The nonresponse e-cigarette risk variable coefficients are roughly double the values of the nonresponse conventional cigarette risk variable coefficients. Thus, for both the absolute risk belief responses and the "I don't know" or skipped question responses, the effects are always in the expected direction, but the role of the e-cigarette variables is consistently greater than that of the conventional cigarette variables.

Two of the personal characteristic variables have statistically significant effects even accounting for the level of risk beliefs. Current smokers assign a lower comparative risk to e-cigarettes, which is consistent with smokers being better informed of the comparative riskiness of alternative cigarette products. Men also have lower comparative risk beliefs, consistent with the previous results. Age has the expected positive effect, but it is only

statistically significant in one case in each set of results. However, respondents with children assess a larger comparatively high risk value that is statistically significant in half the cases. Respondents with young children may have higher comparative risk beliefs because of the publicity regarding the possible risk of children gaining access to e-cigarettes.

D. NICOTINE AND THE DIFFICULTY OF QUITTING

Although studies suggest that cigarettes pose starkly lower lung cancer risks and mortality risks than conventional cigarettes, the levels of nicotine are more similar as are the individual perceptions of nicotine levels. The responses in panel B of Table 4 for the comparative nicotine levels of e-cigarettes and conventional cigarettes indicate that respondents are less likely to believe e-cigarettes have nicotine levels below those of conventional cigarettes than they are to believe that the health risks are lower. Relative to the risk belief assessments in panel A, the comparative beliefs for nicotine in panel B of Table 4 are shifted toward the middle and toward the upper end of the comparative risk level responses. A majority of the respondents believe that e-cigarettes have just as much nicotine as conventional cigarettes (53 percent). There is, however, a frequent belief that e-cigarettes have lower nicotine levels, as 38 percent of respondents believe that e-cigarettes have either less nicotine (29 percent) or much less nicotine (9 percent). Only a small segment of respondents (9 percent) believe that the nicotine levels of e-cigarettes are higher, with either more nicotine (7 percent) or much more nicotine (2 percent).

Given the role of nicotine in cigarette addiction, one would expect similar distributions of responses to the quitting difficulty question. The responses to the difficulty of quitting question in panel C of Table 4 reflect further movement toward comparability of e-cigarettes to conventional cigarettes. Almost two-thirds of the respondents (64 percent) believe that e-cigarettes are just as difficult to quit as conventional cigarettes. Those who do not believe that difficulty is equal to that of conventional cigarettes tend to believe that they are less difficult to quit (23 percent) or much less difficult to quit (9 percent).

Table 6 reports the ordered probit results and a series of binary probit results for perceptions of the difficulty of quitting. For the ordered probit estimates, much more difficult to quit has a value of five, and much less difficult to quit has a value of one, and in the binary probit results, the value of one is assigned to the more difficult to quit groupings. The main relationship to be examined is whether respondents understand the central role of nicotine levels in determining the addictive properties of e-cigarettes. The omitted nicotine category is whether the respondent perceives e-cigarettes as having just as much nicotine as conventional cigarettes. The two less nicotine variables have the most consistently significant effects, as these respondents believe e-cigarettes are less difficult to quit.[19] Higher nicotine perceptions increase the perceived difficulty of quitting for the results in which e-cigarettes are viewed as more difficult to quit than conventional cigarettes, but with no significant effect when the categorizations include the large set of respondents who believe that e-cigarettes are not particularly difficult to quit. The directions of the effects accord with people understanding the linkage between nicotine and the difficulty of quitting.

19 These variables could not be included in the binary top two equations since they created singularity problems.

TABLE 6. Probit regressions for difficulty of quitting

Variables	Ordered probit 1 to 5	Binary top two	Binary top three	Binary top four
E-cigarette nicotine levels:				
Much less nicotine	−1.621[a]	–	−0.666[a]	−0.568[a]
	(0.134)		(0.034)	(0.063)
Less nicotine	−0.834[a]	–	−0.424[a]	−0.084[a]
	(0.091)		(0.036)	(0.024)
More nicotine	0.916[a]	0.253[a]	0.093	0.007
	(0.204)	(0.057)	(0.059)	(0.029)
Much more nicotine	1.974[a]	0.706[a]	0.147	−0.054
	(0.626)	(0.120)	(0.117)	(0.090)
Current smoker	−0.260[b]	−0.012	−0.160[a]	−0.053[b]
	(0.118)	(0.008)	(0.055)	0.030
Male	−0.126	−0.011	−0.039	−0.012
	(0.077)	(0.009)	(0.032)	(0.014)
Age	0.002	3.7 E-4	0.003[a]	5.6 E-4
	(0.003)	(3.4 E-4)	(0.001)	(4.9 E-4)
Education	0.023	−2.5 E-4	−0.003	0.006[b]
	(0.016)	(15.8 E-4)	(0.007)	(0.003)
Children	0.083[c]	0.011[b]	0.022	0.001
	(0.050)	(0.005)	(0.019)	(0.009)
Married	0.021	−0.016	0.003	−0.002
	(0.086)	(0.012)	(0.037)	(0.015)
N	992	603	971	967

Notes: Each equation also includes nonwhite, income, top-coded income, and three regional variables. Equation 1 also includes former smoker and did not indicate smoking status. Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

V. E-cigarette Preferences

Although e-cigarettes are a fairly new product, 12 percent of the sample has smoked e-cigarettes. As one would expect, smokers comprise the largest share of those who have tried e-cigarettes, as 51 percent of the smokers have done so. However, many former smokers have tried e-cigarettes (12 percent), as have some nonsmokers (6 percent), and a small segment of those who have never smoked any cigarettes (4 percent).

The estimates of the probability of trying e-cigarettes shown in Table 7 indicate the relation of these decisions to different risk belief variables. The first column includes the comparative risk and nicotine variables, the second column includes the lung cancer risk belief variables for cigarettes and e-cigarettes, and the third column includes the mortality risk belief variables for cigarettes and e-cigarettes. Consistent with the principal difference between e-cigarettes and conventional cigarettes, it is the lower perceived risk associated

TABLE 7. Probit regressions for trying e-cigarettes

Variables	Relative risk	Lung cancer	Mortality risk
E-cigarettes:			
Much less risky	0.196[a] (0.051)	–	–
Less risky	0.061[a] (0.023)	–	–
More risky	−0.035 (0.029)	–	–
Much more risky	−0.004 (0.097)	–	–
Much less nicotine	−0.035[c] (0.016)	–	–
Less nicotine	0.023 (0.019)	–	–
More nicotine	0.003 (0.024)	–	–
Much more nicotine	0.039 (0.174)	–	–
Cigarette risk beliefs	–	3.4 E-3 (3.9 E-3)	1.9 E-4 (3.6 E-4)
E-cigarette risk beliefs	–	−1.2 E-3[b] (0.5 E-3)	−8.4 E-4[c] (4.4 E-4)
Current smoker	0.509[a] (0.054)	0.517[a] (0.052)	0.514[a] (0.052)
Former smoker	0.129[a] (0.028)	0.131[a] (0.028)	0.131[a] (0.028)
Male	−0.004 (0.015)	0.007 (0.016)	0.008 (0.016)
Age	−2.4 E-3[a] (0.5 E-3)	−2.4 E-3[a] (0.6 E-3)	−0.002[a] (0.001)
Education	−0.002 (0.003)	−0.003 (0.003)	−0.002 (0.003)
Children	8.1 E-5 (780.8 E-5)	−0.001 (0.009)	−0.002 (0.009)
Married	−0.030[c] (0.017)	−0.033 (0.018)	−0.033[c] (0.018)
Total excise tax	0.004 (0.010)	0.005 (0.011)	0.005 (0.011)
$N = 1{,}014$			

Notes: Each equation also includes nonwhite, income, top-coded income, did not indicate comparative risk level, did not indicate nicotine level, and three regional variables. Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

with the product that is significantly related to trying e-cigarettes, with those perceiving e-cigarettes to be much less risky having a 0.20 higher probability of trying e-cigarettes and those perceiving e-cigarettes to be less risky having a 0.06 higher probability of trying e-cigarettes. Believing e-cigarettes are more risky or much more risky does not have a significant deterrent effect. In contrast, only the much less nicotine perception variable is statistically significant.[20] For the absolute risk belief variables, in each case it is the e-cigarette risk beliefs that are the significant determinants of trying e-cigarettes rather than conventional cigarette beliefs. This result echoes the earlier finding that e-cigarette beliefs disproportionately influence comparative risk beliefs and highlights the importance to risk-taking decisions of informational efforts that foster more accurate risk beliefs.

The increased probability of smoking e-cigarettes is 0.51 for current smokers and 0.13 for former smokers, where nonsmokers are the omitted group. As one would expect for this new product, there is a negative relationship of age to trying e-cigarettes. The cigarette excise tax variable is not statistically significant, as there is no apparent influence of shifting to e-cigarettes as an alternative to conventional cigarettes in the higher-tax states.

The reasons smokers of e-cigarettes give for using this product range from trying to quit conventional cigarettes (47 percent) and trying to reduce consumption of conventional cigarettes (30 percent), to a low value for better flavor than conventional cigarettes (16 percent). The intermediate categories of convenience—"since can be smoked in more places" (28 percent), "prefer not to expose people nearby to smoke" (28 percent), and "less expensive than conventional cigarettes" (25 percent)—have similar levels of e-cigarette smokers indicating that this was a reason for smoking e-cigarettes.

The probit regressions of reasons for smoking e-cigarettes that are reported in Table 8 analyze the relationship of risk beliefs and smoking status to these responses. To analyze the role of risk and nicotine beliefs, the focus is on a more aggregative version of the risk and nicotine variables given the small number of people who have smoked e-cigarettes. Thus, the responses for less risky and much less risky are pooled into a single dummy variable, as are the responses to less nicotine and much less nicotine. The omitted categories are risks perceived to be the same or greater and nicotine levels perceived to be the same or greater. These regressions include only the respondents who have tried e-cigarettes, as the questions were not posed to those who have never tried e-cigarettes. The dependent variable reflects the particular function that the respondent thought the e-cigarettes served. The current smoker variable has a positive and significant coefficient for trying e-cigarettes in order to quit conventional cigarettes or to reduce the amount of conventional cigarettes that the person smokes. The other significant effect of smoking status is its negative relation to whether the taste of e-cigarettes was a reason for smoking them. The risk attribute of e-cigarettes is positively related to a concern with not exposing others to environmental tobacco smoke but is not significantly related to whether it is more convenient to smoke e-cigarettes given the greater freedom to smoke e-cigarettes in public places. Concern with the risks to others is more consequential than freedom from regulatory constraints.

20 Even with a more parsimonious specification including only one nicotine variable, pooling the less nicotine and much less nicotine response, the nicotine variable is not statistically significant.

TABLE 8. Probit regressions for reasons for smoking e-cigarettes

	Trying to quit conventional cigarettes	Trying to reduce amount of conventional cigarettes	Better flavor than conventional cigarettes
Current smoker	0.158[c]	0.205[b]	−0.148[b]
	(0.095)	(0.086)	(0.068)
Much less risk or less risky	0.066	0.121	0.115
	(0.120)	(0.109)	(0.079)
Much less nicotine or less nicotine	−0.122	−0.020	0.042
	(0.102)	(0.093)	(0.071)
	Convenience, can smoke in more places	**Prefer not to expose people to smoke**	**Less expensive**
Current smoker	0.052	−0.063	−0.087
	(0.084)	(0.086)	(0.082)
Much less risk or less risky	−0.082	0.186[c]	0.218[b]
	(0.107)	(0.097)	(0.092)
Much less nicotine or less nicotine	0.044	−0.126	−0.102
	(0.091)	(0.088)	(0.083)
$N = 116$			

Notes: Robust standard errors are reported in parentheses. [a]$p < 0.01$, [b]$p < 0.05$, [c]$p < 0.10$.

VI. Conclusion

The perception of the risk of e-cigarettes owes a great deal to people's beliefs regarding conventional cigarettes in that they are in the same broadly defined family of cigarette products even though they don't burn tobacco. Perhaps eliminating the "cigarette" nomenclature would alter these perceptions. With respect to the lung cancer fatality and total mortality risks of e-cigarettes, the survey data are consistent with people utilizing their risk beliefs for conventional tobacco cigarettes as their prior beliefs in assessing the risks of e-cigarettes. At least two-thirds of the information used in assessing e-cigarette risks is based on their perception of the risks of conventional tobacco cigarettes. Applying this weight to conventional cigarette risk beliefs is an excellent predictor of mean risk beliefs for e-cigarettes. Other determinants of risk beliefs are also consistent with models of information acquisition and learning as smokers, younger consumers, and better-educated consumers are better able to assess the lower objective risks of e-cigarettes. Perceptions of the difficulty of quitting e-cigarettes are closely aligned with assessments of nicotine levels, consistent with the extensive medical literature linking nicotine to smoking addiction. The various risk-related properties of e-cigarettes, rather than nicotine levels, are the pivotal concerns of consumers who have tried e-cigarettes.

The availability of conventional cigarettes to serve as a risk reference point appears to play a substantial informational role for consumers seeking to assess the risks of a new,

potentially risky product. Unfortunately, a consequence of the current pattern of e-cigarette beliefs is that people greatly overestimate the risk of the product. Foregoing consumption of the product that the consumer would choose if adequately informed of the risk produces an efficiency loss. It also may lead to a public health loss to the extent that people who would have switched from conventional cigarettes to e-cigarettes are discouraged from doing so because of a misunderstanding of the risks. Differences in risk perceptions have played a pivotal role in determining individual smoking behavior,[21] and one would expect the differences in risks between conventional cigarettes and products that provide similar consumer utility at lower risk would also be quite influential.

Perhaps influenced by the history of litigation against the cigarette industry and regulatory restrictions on health claims, companies have marketed e-cigarettes on dimensions other than safety, such as "tastes like the real thing," "no smoke" so there is no "offensive 'secondhand smoke,'" and "authentic flavor." Recently, some cigarette companies marketing e-cigarettes have included warnings on their e-cigarette brands pertaining to the hazards of nicotine.[22] California Proposition 65 warnings pertaining to the risk of birth defects are also applicable.[23] Current e-cigarette warnings are not designed to foster lower risk beliefs with respect to e-cigarettes or to promote accurate comparative risk beliefs. The public can, of course, utilize information from media coverage of the properties of e-cigarettes to assess the risks. However, if there is a public debate with respect to the magnitude of the risk, the presence of risk ambiguity will promote continued overestimation of the risk. Given the current liability and regulatory environment, any information disclosure efforts to convey the level of risks from e-cigarettes will likely come from government sources. If, however, the government requires that e-cigarettes bear warnings identical to those of conventional cigarettes, such an effort will reinforce current beliefs that the risks of e-cigarettes are comparable in character and magnitude to the risks of cigarettes. The particular challenge for informational policies is to convey the properties of e-cigarettes, which pose far lower health risks than conventional cigarettes but are more comparable in terms of the nicotine levels.

21 For example, see Viscusi (1990, 1991, 1992), Liu and Hsieh (1995), Viscusi et al. (2000), Sloan, Smith, and Taylor (2003), Lundborg and Lindgren (2004), Khwaja, Sloan, and Chung (2006, 2007), Lundborg (2007), Lundborg and Andersson (2008), Viscusi and Hakes (2008), and Lin and Sloan (2015).

22 For example, the e-cigarette NJOY marketed by Lorillard includes the following warning: "NJOY products are not smoking cessation products and have not been tested as such. NJOY products are intended for use by adults of legal smoking age (18 or older in California), and not by children, women who are pregnant or breastfeeding, or persons with or at risk of heart disease, high blood pressure, diabetes or taking medicine for depression or asthma. NJOY products contain nicotine, a chemical known to the state of California to cause birth defects or other reproductive harm. Nicotine is addictive and habit forming, and it is very toxic by inhalation, in contact with the skin, or if swallowed. Ingestion of the nonvaporized concentrated ingredients can be poisonous. NJOY Flavor Chambers may be a choking hazard. Keep all components away from children and pets. If any components are ingested, immediately consult your doctor and vet." Other companies have different warnings that also focus on nicotine (see, generally, Richtel 2014).

23 In addition to indicating "NOT FOR SALE TO MINORS," Blu e-cigarettes include the following warning: "CALIFORNIA PROPOSITION 65. **Warning**: This product contains nicotine, a chemical known to the state of California to cause birth defects or other reproductive harm."

The anchoring of risk beliefs for a new product on the risk levels of existing products in the class has more general implications for the performance of consumer markets for risky products. If new, safer products become available, these products will encounter the hurdle of overcoming consumers' prior risk beliefs associated with the product class to the extent that consumers are reluctant to alter their high-risk beliefs. The dominant market failure may involve overestimation of the new product's riskiness. This influence will impede consumers' response to new, less risky alternative products introduced in the market.

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