

ELECTRONIC CIGARETTES: DIFFUSION OF A CONTROVERSIAL INNOVATION

Jessica K. Pepper

A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Health Behavior in the Gillings School of Global Public Health.

Chapel Hill
2014

Approved by:

Noel T. Brewer

Sherry L. Emery

Kurt M. Ribisl

Christine M. Rini

Brian G. Southwell

© 2014
Jessica K. Pepper
ALL RIGHTS RESERVED

ABSTRACT

Jessica K. Pepper: Electronic Cigarettes: Diffusion of a Controversial Innovation
(Under the direction of Noel T. Brewer)

Introduction: Electronic cigarettes (e-cigarettes) are battery-powered nicotine delivery systems that have become increasingly popular in the U.S. and have the potential to serve as a harm reduction tool for adult smokers. We sought to understand the diffusion of e-cigarettes into the U.S. marketplace.

Methods: A U.S. national sample of 17,522 adults (≥ 18 years old) completed an online survey in March 2013 assessing their awareness of and sources of information about e-cigarettes. As part of the same study, smokers ($n=6,607$) responded to questions about perceived health risks related to tobacco products, and smokers who had never tried e-cigarettes ($n=3,253$) participated in a between-subjects experiment investigating their responses to e-cigarette advertisements.

Results: Most respondents (86%) had heard of e-cigarettes. The most commonly reported sources of information were another person, ads on television, and seeing e-cigarettes being sold. Smokers believed that e-cigarettes were less likely to cause lung cancer, oral cancer, and heart disease than cigarettes, traditional smokeless tobacco, snus, and dissolvable tobacco. Ads that emphasized the differences between e-cigarettes and regular cigarettes or showed an image of a person using an e-cigarette created the greatest interest among smokers in trying the product.

Conclusions: The positive reaction to e-cigarettes over other non-cigarette tobacco products may be, in part, because e-cigarettes embody more of the desirable features of an innovation (relative advantage, compatibility, trialability, and observability). Future research should concentrate on understanding the impact of risk beliefs on trajectories of use, determining efficient ways to deliver appropriate information about e-cigarettes to the public, and examining the effects of changes in the e-cigarette industry (e.g., the entry of multinational tobacco corporations into the marketplace and the development of new styles of e-cigarettes).

ACKNOWLEDGEMENTS

Thank you to my dissertation committee for their help with every phase of this research. Their assistance was invaluable. I especially thank my advisor and the chair of my committee, Dr. Noel Brewer. Noel, you have been an amazing mentor and champion, and I look forward to continuing our collaboration.

To my friends and family (with special thanks to Josh, Madeline, and Beats), I appreciate everything you have done to keep me sane and remind me of the wonderful world that exists outside my office door. Mom and Dad, I owe every success to you. I hope that one day, when I have children of my own, I can do for them what you have done for me. Uncle Bill, I think of you at every milestone in my life. Since you were the reason I wanted to work in public health, I like to think you'd be especially pleased about this one.

Finally, I offer my biggest thanks to my husband. Matt, every night for the last 5 years you have asked me, “How was your day?” and listened patiently and thoughtfully as I described every (excruciatingly boring) detail. When the day was bad, you were there to comfort me. When the day was good, you were there to help me celebrate. I could not have done this without your love, support, and humor.

TABLE OF CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES	x
CHAPTER 1: ELECTRONIC NICOTINE DELIVERY SYSTEM (ELECTRONIC CIGARETTE) AWARENESS, USE, REACTIONS, AND BELIEFS: A SYSTEMATIC REVIEW	1
Introduction	1
Safety of ENDS	2
Public Interest in ENDS.....	3
Methods.....	4
Article Searches	4
Study Selection	5
Data Abstraction	6
Results	7
Awareness of ENDS	8
Use of ENDS	10
Subjective Reactions to Using ENDS.....	14
Beliefs about and Reasons for Using ENDS.....	19
Conclusions	23
CHAPTER 2: SPECIFIC AIMS AND PREDICTIONS	37
Specific Aim 1 (Paper 1).....	37
Specific Aim 2 (Paper 2).....	39
Specific Aim 3 (Paper 3).....	43

CHAPTER 3: HOW U.S. ADULTS FIND OUT ABOUT ELECTRONIC CIGARETTES: IMPLICATIONS FOR PUBLIC HEALTH MESSAGES	45
Introduction	45
Methods	46
Sample	46
Measures	47
Data Analysis	48
Results	49
Correlates of Awareness	49
Sources of Awareness	49
Discussion	50
CHAPTER 4: SMOKERS' PERCEPTIONS OF THE HEALTH RISKS OF ELECTRONIC CIGARETTES COMPARED TO REGULAR CIGARETTES AND OTHER TOBACCO PRODUCTS	59
Introduction	59
Methods	61
Sample	61
Measures	62
Data Analysis	63
Results	64
Comparison of E-Cigarettes to Cigarettes (Hypothesis 1)	64
Comparison of Alternative OTPs to Cigarettes (Hypothesis 2)	65
Comparisons Between E-Cigarettes and Alternative OTPs	65
Correlates of Perceived Risks of E-Cigarette Use	66
Discussion	66
CHAPTER 5: EFFECTS OF ADVERTISEMENTS ON SMOKERS' INTEREST IN TRYING E-CIGARETTES: THE ROLES OF PRODUCT COMPARISON AND VISUAL CUES	76

Introduction	76
Methods.....	79
Sample	79
Procedures.....	79
Measures	80
Data Analysis.....	80
Results	81
Discussion	82
CHAPTER 6: DISCUSSION.....	95
Electronic Cigarettes and Diffusion of Innovation.....	95
E-cigarettes as an Innovation	95
Relationship of Dissertation Findings to Diffusion of Innovation.....	98
Strengths and Limitations.....	100
Future Directions	102
Conclusion.....	104
APPENDIX: MAIN FINDINGS OF ARTICLES INCLUDED IN SYSTEMATIC REVIEW	106
REFERENCES	130

LIST OF TABLES

Table 1.1. Characteristics of Studies Included in Review	28
Table 3.1. Sample Characteristics ($n=17,522$).....	53
Table 3.2. Correlates of Awareness of E-Cigarettes ($n=17,522$).....	55
Table 4.1. Sample Characteristics ($n=6,607$ current smokers).....	72
Table 4.2. Comparison of Smokers' Perceived Likelihood of Health Problem by Type of Product ($n=6,607$)	73
Table 4.3. Correlates of Perceived Likelihood that E-Cigarettes Cause Health Problems ($n=1,669$).....	74
Table 5.1. Sample Characteristics ($n=3,253$).....	88
Table 5.2. Respondent Characteristics by Experimental Condition	89
Table 5.3. Interest in Trying E-Cigarettes, By Ad Characteristics	91

LIST OF FIGURES

Figure 1.1. Flow diagram of literature search and article identification.....	36
Figure 3.1. Channels of awareness of e-cigarettes among current smokers ($n=6,311$), former smokers ($n=3,709$), and never smokers ($n=5,551$) who have heard of e-cigarettes.....	57
Figure 3.2. Increase in awareness of e-cigarettes among U.S. adults: 16% in 2009, ⁵⁸ 37% (mean) in 2010, ⁵⁸⁻⁶⁰ 58% in 2011, ⁶⁰ 75% in 2012, ¹³² and 86% in 2013.	58
Figure 4.1. Perceived health risks of tobacco products. Error bars show standard errors.	75
Figure 5.1. Four of twenty-four advertisements used in the experiment.	92
Figure 5.2. Effect of comparison type on interest in trying e-cigarettes. Error bars show standard errors.	93
Figure 5.3. Effect of advertisement image on interest in trying e-cigarettes. Error bars show standard errors.	94
Figure 6.1. Pictures of e-cigarettes included in the TCME survey.....	105
Figure 6.2. Alternative types of electronic nicotine delivery products: e-hookah and e-cigarette tank model.	105

CHAPTER 1: ELECTRONIC NICOTINE DELIVERY SYSTEM (ELECTRONIC CIGARETTE) AWARENESS, USE, REACTIONS, AND BELIEFS: A SYSTEMATIC REVIEW*

Introduction

Electronic nicotine delivery systems (ENDS), also called e-cigarettes or electronic cigarettes, are battery-operated devices that contain an inhalation-activated mechanism that heats a cartridge, producing vapor that the user, sometimes called a “vaper,” inhales. Liquid in the refillable cartridges typically has nicotine and humectants, although non-nicotine cartridges and disposable models are available. Notably, ENDS do not rely on combustion, meaning that users do not expose themselves or others to many of the harmful tobacco smoke constituents and particles produced by regular cigarettes.¹ ENDS are controversial: safety information is sparse and inconsistent,^{2,3} regulation is in flux,⁴ and public interest is increasing rapidly⁵ despite the lack of research establishing ENDS’ long-term health effects or cessation properties for smokers. In addition, public health advocates are concerned that ENDS could act as a gateway to future smoking⁶ or prevent smokers from quitting by maintaining their nicotine addiction or deterring them from using existing, effective cessation tools.⁷ The ENDS literature is expanding rapidly, but to date no systematic review has summarized the findings across populations or identified gaps in the research. It is important to understand not only patterns of ENDS use across populations and time, but also what beliefs and reactions drive either use or avoidance of ENDS. This review seeks to improve

* Pepper JK, Brewer NT. Electronic nicotine delivery system (electronic cigarette) awareness, use, reactions, and beliefs: A systematic review. *Tob Control*. Published online November 20, 2013.

our understanding of who has used ENDS, how they feel about using them, and what both users and non-users think about this controversial product.

Safety of ENDS

With any nicotine or tobacco product, health and safety are primary public health concerns. However, evidence about the safety of ENDS, particularly related to the “e-liquid” in the cartridges, is mixed. The U.S. Food & Drug Administration (FDA) analyzed the contents of ENDS cartridges² and found four major tobacco-specific nitrosamines (TSNAs), a family of carcinogenic chemicals, but they reported only that these chemical were detected, not whether the amounts detected reached harmful levels.⁸ A study of the effects of 40 different samples of refill liquids on pulmonary fibroblasts which model adult lung cells³ found tremendous variability in cytotoxicity even among individual samples from the same brand and flavor.

Experts disagree about the potential harms of propylene glycol, a chemical that serves as a humectant in e-liquid.^{9,10} While theater fog is associated with impaired lung function,¹¹ no studies have examined the long-term effects of inhaled propylene glycol in humans.⁷ Ingestion of or exposure to liquid nicotine from ENDS cartridges may also be unsafe. Many of the cartridges and the packets of e-liquid are not childproof,¹² and children might be drawn to the candy- and fruit-flavored e-liquids.¹³ If ingested by a child, high doses of nicotine can be fatal.¹³

Another concern is the lack of quality control standards. Multiple studies have detected nicotine in cartridges labeled nicotine-free.^{2,14,15} Some cartridges leak, are incorrectly or ambiguously labeled, or vary in content even though they are labeled as being the same brand and flavor.^{3,12}

In sum, scientific consensus has yet to emerge about the degree of danger posed by ENDS. Making cartridges and e-liquids child-proof and instituting quality control standards would help to avoid some safety problems. Whether purposeful exposure, i.e., ongoing use of ENDS, has harmful long-term consequences remains an open question.

Regulation of ENDS

Approaches to regulation vary widely. For example, Brazil bans the sale, import, and advertising of ENDS, while Finland treats ENDS as medicinal products and bans only advertising.¹⁶ In the U.S., the FDA is expected to propose deeming regulations in fall 2013.⁴ In the meantime, some local governments in the U.S. have taken action to prohibit sales to minors or otherwise restrict ENDS use.¹⁷ Given that ENDS vary widely, ranging from disposable models that can cost several dollars but have limited flavor and nicotine options to “personal vaporizers” that can cost several hundred dollars but have hundreds of options for flavors and a wider variety of nicotine strengths, it will be important for policymakers to issue regulations that cover these different models.

Public Interest in ENDS

The public has shown tremendous interest in ENDS, and the popular media has extensively covered ENDS.^{18,19} Celebrities have used them in movies and on television.²⁰ Between January 2008 and February 2010, online searches for information on ENDS increased several hundred-fold.⁵ ENDS are extensively marketed online, promoted in YouTube videos, and advertised on Twitter.^{21,22}

One result of high levels of public interest is that ENDS have quickly become a big business.²³⁻²⁵ The current ENDS industry size is estimated to be \$500 million in annual sales and increasing rapidly (expected to reach \$1 billion by the end of 2013).^{23,24,26} “Big

Tobacco” companies entered the market when Lorillard purchased Blu eCigs, a major ENDS brand.²⁷ R.J. Reynolds has also introduced their own ENDS line, and Altria (owner of Phillip Morris USA) plans to launch MarkTen ENDS in test markets in summer 2013.²⁵

In sum, ENDS are increasingly popular, although their safety record is not yet established and regulation is still in flux. There is a need to understand what the public knows and believes about ENDS, as well as who uses ENDS and why. Health behavior theories and the empirical literature show that beliefs and attitudes drive risky behavior, including health-protective behaviors like vaccination^{28,29} and cancer screening^{30,31} and risk-taking behaviors like tanning³² and unprotected sex,³³ so they may also be important motivators of ENDS use. This review does not address product safety or biological measurements of ENDS as we believe a separate, in-depth review would better address these critical questions. Thus, the goal of this review is to synthesize research on use of and beliefs about ENDS in order to identify gaps in the literature, inspire future research questions, and understand the implications of these findings for public health efforts.

Methods

Article Searches

One investigator (JKP) searched PubMed, CINAHL, Web of Science, EMBASE, and PsycInfo for articles published between January 1, 2006 (the year that ENDS became available in Europe and 1 year before they became available in the U.S.)³⁴ and July 1, 2013. Search terms were: “electronic cigarette” OR “electronic cigarettes” OR “e-cigarette” OR “e-cigarettes” OR “electronic nicotine delivery.” We selected this set of broad search terms as

no relevant medical subject heading (MeSH term) existed at the time of this review. We also searched the reference sections of included articles.

Study Selection

After removing duplicates, both authors reviewed the titles and abstracts ($k=244$) and discarded were conference or dissertation abstracts ($k=17$) or articles that were not in English ($k=21$) (see Figure 1.1). Thirteen of the non-English articles had English-language abstracts; 2 of those appeared to be relevant to the review. The additional 8 articles without English-language abstracts appeared unlikely to contain relevant information based on translations of their titles or visual inspection of the article (e.g., they contained no numbers). We also excluded articles that were not relevant to ENDS, typically because the search query identified articles with the phrase “i.e. cigarettes” ($k=24$). In a second step, the first author reviewed the remaining abstracts and, when necessary, full articles, and conferred with the second author where eligibility was unclear. We excluded articles that did not contain original data about ENDS, such as commentaries, literature reviews, and information about regulation ($k=96$); were experiments or laboratory studies without descriptions of “natural” patterns of use (i.e., usage not instructed by the researcher) or subjective reports from participants on relevant dependent variables ($k=26$); were not peer-reviewed, such as industry reports ($k=10$); or did not include appropriate dependent variables (i.e., they reported data about Internet search engines^{5,35} or pharmacies; $k=3$).³⁶ We relied on the expanded Campbell approach to assess study quality, focusing on factors that bear on internal validity (study design) and external validity (sampling).³⁷ We did not use a quality scoring system that yields a single score (e.g., the Jadad scale)³⁸ because of the exceptional breadth of

methodologies and dependent variables across the studies and because single-score approaches combine distinct and important issues.

Data Abstraction

The first author coded the remaining articles ($k=47$) using a standardized data abstraction form. The second author or one of two additional coders reviewed each article, conferring with the first author in case of disagreements. Coders recorded ENDS awareness, “natural” patterns of use (i.e., use outside of a lab setting, including dual use of ENDS with other tobacco products), subjective reactions to use (by users only), and beliefs or reasons for use (by users or non-users). We define “dual use” as use of both ENDS and other tobacco products in the past 30 days. For the last two outcomes, coders also recorded whether the measure assessed: the perceived cost of ENDS, including the relative cost of ENDS and regular cigarettes (*cost*); the possibility that ENDS would serve as a gateway to other tobacco use (*gateway*); health, safety, and side effects, including the relative safety of ENDS and regular cigarettes (*health*); quitting or reducing smoking or tobacco use because of ENDS (*quit*); the use of ENDS to avoid restrictions on smoking (*restrict*); the degree of satisfaction with ENDS’ taste, smell, and quality (*satisfaction*); the extent to which ENDS have the same taste, smell, or feeling of use as regular cigarettes (*similar*); and changes in withdrawal symptoms, desire to smoke, and cravings (*withdrawal*). For example, the statement “ENDS helped me quit smoking” would be classified as *quit* in the category of reactions, while the statement “I started using ENDS because I wanted to be healthier” would be classified as *health* in the category of beliefs or reasons.

We selected these codes because they represented themes that were frequently reported by users or were specific public health concerns. For example, we coded for *restrict*

because public health advocates are worried that people will use ENDS in order to bypass existing smoking regulations.^{7,39} Indeed, one ENDS brand highlights this benefit in its name: Smoking Everywhere. We also coded for *similar* because, as touted by ads for the product, ENDS can look, feel, or taste like regular cigarettes as a way to appeal to smokers who might swap regular cigarettes for electronic ones. We review perceived cost of ENDS as the same objective (actual) cost might be prohibitively expensive for one user but negligible for another.

Because of the potential for industry affiliations and funding to influence conclusions in tobacco research,^{40,41} we coded that the study had a financial relationship with the ENDS industry if an ENDS manufacturer or distributor funded the study or supplied ENDS or cartridges to the researchers.

Results

Forty-nine studies from 47 articles about ENDS met the inclusion criteria (Table 1.1). The number of study participants ranged from 1 to 25,029. Of studies that reported location, most were conducted in the United States ($k=23$) or with participants from multiple countries ($k=7$). Other common locations included Italy ($k=5$) and the UK ($k=4$). Twenty-five studies used cross-sectional or repeated cross-sectional surveys, 8 were laboratory experiments, 5 were case reports, 4 were observational, 3 were prospective trials, 2 used qualitative interviews, and 2 used focus groups. Fourteen studies used probability sampling. Six studies relied on industry support; 7 studies did not report this information. Detailed descriptions of study findings appear in Appendix 1.

Studies had several important limitations. Nine studies recruited ENDS users in ways likely to overrepresent satisfied users (e.g. from online user forums, websites that sell ENDS, or ENDS conventions⁴²⁻⁵⁰). It would be difficult to generalize to other populations based on some studies' samples (e.g., customers exiting shops in Prague;⁵¹ freshman and sophomore students recruited from one college lecture class;⁵² and YouTube videos of ENDS and cigarette users²²). Thirteen studies did not report the date or location of data collection. Finally, although ENDS require some time to learn to use and models vary in quality, at least five laboratory studies tested only one model of ENDS or did not provide time for participants to learn to use the product.⁵³⁻⁵⁷

Awareness of ENDS

ENDS awareness is generally high and increasing. In three large national surveys with probability sampling, awareness of ENDS among U.S. adults increased from 16% in 2009⁵⁸ to 32-41% in 2010⁵⁸⁻⁶⁰ and 58% in 2011.⁶⁰ Men were more likely to be aware of ENDS than women in 2 of the 3 studies,^{58,59} and younger respondents were typically more likely to be aware of ENDS than older respondents.⁵⁸⁻⁶⁰ In all three studies, African-American participants were less likely to have heard of ENDS than White participants. Current smokers were always more likely to have heard of ENDS than never smokers and sometimes more likely than former smokers. For example, in a 2011 U.S. study, 77% of current smokers, 65% of former smokers, and 50% of never smokers had heard of ENDS.⁶⁰

Studies in other countries found similar patterns of awareness. The International Tobacco Control (ITC) Four-Country Survey examined awareness of ENDS among probability samples of current and former smokers in 2010-2011 in the U.S., U.K., Canada, and Australia. Across the four countries, younger, male, current smokers were more likely to

have heard of ENDS than older, female, former smokers.⁶¹ Awareness was higher in the U.S. (73%) and U.K. (54%), where ENDS can be legally marketed and sold, than in Canada (40%) or Australia (20%), where they cannot be sold and may be more difficult to obtain.⁶¹ In a more recent survey of U.K. adults, awareness varied by smoking status; 79% of daily smokers compared to 38% of never smokers had heard of ENDS in 2012.⁶²

Awareness among youth was variable. Only 10% of a probability sample of middle- and high-school students surveyed in 2008 in Korea was aware of ENDS.⁶³ In contrast, 86% of Polish students (ages 15-24)⁶⁴ and 70% of Midwestern U.S. young adults (ages 20-28)⁶⁵ had ever heard of ENDS in separate probability-based surveys. In the latter, males, current or former smokers, and participants with at least one close friend who smokes were more likely to be aware of ENDS than their counterparts.⁶⁵ Two-thirds (67%) of U.S. adolescent boys ages 11-19 had heard of ENDS when surveyed in 2011.⁶⁶ The discrepancy between the low rates of youth awareness in Korea and the high rates in Poland and the U.S. may be due to regional differences or the dates of data collection.

In addition to the ITC Four-Country survey, two other studies examined awareness only among current and former smokers. More than half (58%) of U.S. smokers were aware of ENDS in a large 2010 survey.⁵⁹ Most (86%) of a convenience sample of adults exiting stores in Prague, Czech Republic after having purchased cigarettes had heard of ENDS.⁵¹

Only 3 studies reported sources of awareness. The most common sources were the Internet, friends or personal contacts, and advertisements.^{42,50,63}

Use of ENDS

Ever Use

In large surveys, use of ENDS was low but increasing. Only 1% of U.S. adults surveyed in 2009 had tried ENDS.⁵⁸ Prevalence of use among the general U.S. adult population was higher but still minimal (2-3%) when assessed in 2010 in four national surveys with probability samples.^{58-60,67} In all of these studies, more current smokers had tried ENDS than former smokers or never smokers.^{59,60,67} Rates of use in the U.S. continued to rise in 2011 (6% overall) with the same gradient pattern by smoking status (1% of never smokers, 7% of former smokers, and 21% of current smokers).⁶⁰ Demographic correlates of use varied across studies. When these studies limited their samples to only smokers, ENDS use was unrelated to history of quit attempts in 2 studies,^{58,59} but smokers in one study who intended to quit in the next 6 months were more likely to have tried ENDS than smokers with no intention to quit.⁵⁹

Multiple studies included only current and former smokers in their samples. Across the four countries surveyed by ITC, 8% of current and former smokers had ever tried ENDS.⁶¹ Daily heavy smokers had the highest use, and long term quitters had the lowest use. ENDS users were not more likely to have quit smoking since the previous wave of the ITC survey than non-users. Twenty-percent of adult U.S. smokers had tried ENDS when surveyed as part of a 2011 probability panel.⁶⁸ Unsuccessful quitters were more likely to have tried ENDS than those who had never tried to quit. In another probability panel of U.S. smokers, 10% of cigarette-only smokers had tried ENDS, but 24% of dual cigar and cigarette users had done so.⁶⁹ Current smokers in the Legacy Longitudinal Smoker Cohort were more likely to have tried ENDS than former smokers (6% versus 3% respectively).⁵⁹ Li and colleagues

found that 7% of current smokers and recent quitters in New Zealand in 2011 had ever purchased an ENDS (a proxy for use).⁷⁰ Finally, in the most recent survey of ENDS use in 2012, 22% of current smokers in the U.K. had ever tried ENDS, compared to 4% of former smokers and <1% of never smokers.⁶² In many of these studies of current and former smokers, women^{61,68} and younger participants^{59,61,62,68,70} had higher rates of use than never smokers, men, and older participants. In some studies, ENDS use was not associated with quit attempts^{59,70} or quit intentions.^{59,61,68}

In surveys with probability samples, use of ENDS by adolescents and young adults varied considerably by region and year, from less than 1% (U.S. male adolescents in the U.S. in 2011 and Korean adolescents in 2008)^{63,66} to 21% (Polish high school and university students in 2010-2011).⁶⁴ In other surveys with probability sampling, 5% of college students in North Carolina⁷¹ and 7% of young adults in the Midwestern U.S. had tried ENDS.⁶⁵ In general, the higher rate of ENDS use among Polish youth compared to U.S. youth may relate, in part, to higher population-wide rates of tobacco use in Poland than in the U.S.^{72,73} Across studies of youth, males,^{63-65,71} smokers,^{63-65,71} and those with important others (friends, family, or partners) who smoked^{64,65} were often more likely to have tried ENDS than their counterparts. In at least two studies, the relationship between ever use of ENDS and smoking status should be interpreted with caution due to the very low prevalence of smoking in the sample.^{63,66}

Other reported rates of ever use of ENDS are difficult to interpret because of the nature of their samples. For example, 85% of a convenience sample of adults surveyed by Etter & Bullen had used ENDS, but the majority of their participants were recruited through online ENDS forums.⁴⁴ Among callers to seven tobacco quitlines who responded to a follow-

up survey (35% response rate), 31% had ever tried ENDS, and users were less likely to have quit smoking since their initial call to the quitline than non-users.⁷⁴

Current Use

Adults consistently reported low current use (i.e., in the past 30 days). Around 1% of respondents were current ENDS users in three 2010 U.S. national, probability-based surveys.^{58,59,67} As with ever use of ENDS, current smokers were more likely to be current ENDS users than either former or never smokers.^{58,59,62} In surveys limited to current and former smokers, rates varied from 3% (across four countries in 2010-2011 ITC survey)⁶¹ to 8% (U.S. in 2011).⁶⁸ In a convenience sample of callers to tobacco quitlines, 9% of current and former smokers reported that they currently used ENDS some days or every day.⁷⁴

Youth also reported low current use. Only 1% of young adults in the Midwestern U.S.⁶⁵ and 2% of North Carolina college students⁷¹ were current ENDS users in 2010-2011 and 2009, respectively. Possibly reflecting the overall higher rates of smoking in Poland compared to the U.S., a higher percentage of high school and university students (7%) were current ENDS users.⁶⁴

Dual Use

In population-based surveys, most current (or past 30 days) smokers were not current (or past 30 days) ENDS users. In two 2010 probability samples of U.S. adults, 4%⁵⁹ and 6%⁵⁸ of current smokers had used ENDS in the past 30 days. More than 11% of those who were current users of more than one tobacco product (e.g., cigarettes, cigars, snuff, hookah) had used ENDS in the past month.⁵⁸ In another probability sample, 11% of Polish youth and young adults who were current smokers had used ENDS in the past 30 days.⁶⁴ In a large

survey with U.K. adults based on an opt-in survey panel, 3% of daily smokers in 2010 and 7% of daily smokers in 2012 used ENDS.⁶²

Dual use of ENDS with regular cigarettes was fairly common in convenience samples. In surveys with convenience samples of dedicated ENDS users, 12-34% of ENDS users were current smokers.^{42,44,46,47} Of 179 ENDS users, 6% used hookah, snuff, or some other non-cigarette tobacco product.⁴⁷ However, among a sample of people who had bought ENDS 6 months earlier, 35% of current ENDS users did not smoke cigarettes, suggesting up to 65% dual use.⁴⁸ Finally, in three prospective trials with convenience samples, dual use of ENDS and regular cigarettes appeared to be common, with some of the smokers who reduced their consumption of cigarettes continuing to use ENDS at the end of the study.⁷⁵⁻⁷⁷

Amount and Duration of Use

Daily use among ENDS users was common^{43-47,55} in all but two studies.^{48,74} It is difficult to further quantify the amount of use because, unlike regular smoking which can be measured by the number of cigarettes smoked, ENDS use has no clear metric. An individual does not usually “vape” an entire cartridge of an ENDS in a single sitting. Some studies quantified use by estimating puffs per day (range 120-236),⁴²⁻⁴⁵ while others reported the number of bouts of use per day (median of 20 per day⁴⁶ or 67% use more than 15 times per day).⁴⁷ Measurements of the number of e-liquid cartridges (range 0-4)⁷⁵⁻⁷⁷ or ml of e-liquid used per day (range 3-5 ml)^{42,55} are difficult to interpret because cartridges leak, vary in strength both within and across brands, and require different levels of vacuum to inhale.^{3,12,78} Another metric for quantifying use is puff duration. Two studies, one in a laboratory⁵⁵ and one that examined 73 YouTube videos,²² found that ENDS users take longer puffs on ENDS than conventional smokers do on regular tobacco cigarettes.

Ten studies reported how long participants had been using ENDS.^{42-47,50,55,74,79} Estimates varied from less than 1 month of prior use for 62% of callers to state quit lines⁷⁴ to a mean of 13 months of use in a convenience-based survey of experienced ENDS users ($n=104$) conducted in 2011.⁴⁶ We are not aware of any data about the extent or amount of use of disposable ENDS, although 5 studies described the use of modified ENDS (sometimes called “mods”) or personal vaporizers that do not mimic the appearance of regular cigarettes.^{42,46,49,50,79}

Subjective Reactions to Using ENDS

Cost

ENDS users’ experiences with the cost savings from using ENDS in lieu of regular tobacco cigarettes are inconsistent.^{43,50} In open-ended survey questions, some participants in a convenience sample survey of ENDS users ($n=81$) said that they found ENDS to be less expensive than cigarettes (10 comments), while others said they were too expensive (14 comments).⁴³ Most dedicated ENDS users interviewed at a convention ($n=15$) found them less expensive than cigarettes.⁵⁰ Finally, among Czech smokers who had tried but stopped using ENDS, 13% did so because they found ENDS to be too expensive.⁵¹

Gateway Use

Among the 179 Polish ENDS users surveyed online in 2009, 25 reported that they were non-smokers when they previously began using ENDS. Of those, 20% ($n=5$) currently smoked cigarettes at the time of the survey.⁴⁷

Health and Safety

Many users report positive changes in their health after they begin using the product. In surveys, interviews, and case reports, users often describe improved breathing,^{42,43,50} less

coughing,^{42,43,50} fewer sore throats,⁴³ and improvements in overall health and fitness.^{43,50,80}

In one case report, switching from cigarettes to ENDS alleviated a patient's previously elevated white blood cell count (neutrophilia).⁸¹

Some users also report experiencing side effects from using ENDS. As of the first quarter of 2012, the FDA had received 47 reports about adverse events related to ENDS use.⁸² Of those, they classified 8 as serious adverse events, including pneumonia and chest pain, and 39 as minor, including headache and cough. Of the 405 health effects reported by users in an online ENDS forum, 326 were negative; the most frequently reported problems were in the mouth, throat, respiratory system, and neurological system.⁸³ One case report described a patient developing lipid pneumonia,⁸⁴ and another described a patient experiencing heart arrhythmia from using ENDS.⁸⁵

In surveys with non-probability samples, laboratory research, and other case reports, the majority of reported side effects were minor, including mouth or throat irritation/dryness,^{42-44,53} cough,^{47,80,86} vertigo,^{43,53} headache,^{43,47,53} and nausea.^{43,53} In three prospective trials in which smokers tried ENDS for 6 or 12 months, there were no serious adverse events.⁷⁵⁻⁷⁷ Many of the minor side effects experienced at baseline, including cough,⁷⁵⁻⁷⁷ mouth and throat irritation,^{75,77} and headache,^{76,77} lessened considerably or resolved completely by the end of the study period.

Quitting or Reducing Tobacco Use

Although successful quitting was generally not associated with ENDS use in large surveys,^{58,61,68,74} in convenience sample surveys, focus groups, case studies, and interviews with dedicated ENDS users, they often reported that using the product helped them quit smoking^{42-44,46-50,80,81,86} or significantly reduce tobacco use,^{42,44,48} often despite being heavy

smokers or having failed quit attempts in the past.^{43,44,46,48-50,80,81,86} Unlike quitting smoking, reducing smoking may not represent a positive public health outcome, given that it may indicate dual use of ENDS and regular cigarettes.

Only three longitudinal studies have examined smokers' use of ENDS to quit smoking. Two of the three prospective trials were uncontrolled. In the first, a 12-month trial with 14 patients being treated for schizophrenia, 7 of 14 participants reduced their smoking at least 50% and 2 others quit smoking entirely.⁷⁶ In the second, a 6-month prospective trial of 40 smokers, 13 were lost to follow-up, 13 reduced their cigarette consumption by at least 50%, and an additional 9 participants quit smoking entirely.⁷⁵ Another prospective trial randomly assigned 300 smokers to use either ENDS with nicotine or ENDS without nicotine.⁷⁷ At the end of the 12-month period, 11% of smokers using ENDS with nicotine had quit and 10% reduced their cigarette consumption by at least 50%, while 4% of the non-nicotine group had quit and 12% had reduced their consumption. More than one-third were lost to follow-up. The differences in cessation between groups were not statistically significant. The results of these trials should be interpreted with caution given that only one randomized participants to conditions (and it did not include a comparison condition with an alternative quit aid), and all three relied on convenience samples in a limited geographical setting.

Restrictions on Smoking

The extent to which smokers use ENDS to avoid smoking restrictions was not clear. About one-third (36%) of ENDS users in one survey said that they frequently used ENDS in places where smoking was banned.⁴² In contrast, in another survey of ENDS enthusiasts ($n=104$) recruited from a convention, 90% said they were able to use where smoking was

banned, although they did not clarify how often they did so.⁴⁶ In a third survey, a substantial number of daily ENDS users from a variety of countries reported using their ENDS at work (71%) or in cafes, restaurants, or bars (43%), but it is difficult to interpret these results with respect to avoiding smoking restrictions given that restrictions vary by country.⁴⁴

Satisfaction

Satisfaction with ENDS that contained nicotine was moderate in most laboratory studies^{53,56,57,79} and very high in surveys of committed ENDS users.^{42-44,49,50} Users often mentioned taste and flavor. For example, more than 90% of users surveyed by Etter and Bullen liked the taste of ENDS.⁴⁴ Smokers who used ENDS in prospective trials had mixed reactions,^{75,77} as did many smokers interviewed in Prague.⁵¹ Finally, in 5 studies, ENDS users expressed concerns about the quality of ENDS they used, including leaking cartridges or broken components.^{43,44,50,51,75} Some stopped using ENDS because of problems with the devices.^{44,51}

Similarity to Regular Cigarettes

Studies showed little agreement about how much users of ENDS thought they look, feel, or taste like cigarettes, as well as whether similarity to cigarettes was a benefit or a drawback. In small focus groups with former smokers ($n=11$), users mentioned that they not only liked how using ENDS mimicked the feel of smoking cigarettes, but also that they swapped regular cigarettes for ENDS as part of the same daily routines (e.g., used after a meal).⁴⁹ The similarity between the products also made it easier to switch from one to the other. Other ENDS users recruited at a convention ($n=15$) noted that their desire for ENDS to mimic regular cigarettes had changed over time; although they began using ENDS that looked and felt like cigarettes, most transitioned to using personal vaporizers that did not

look like cigarettes.⁵⁰ In a large convenience sample survey, over half of participants said they used ENDS “in a similar manner” as cigarettes.⁴² A small number of users stopped using ENDS because they did not have the same flavor,⁴³ but others preferred the flavor of ENDS to regular cigarettes.⁴⁶ During bouts of use of ENDS as part of lab studies ($n=20$ and $n=32$), participants’ ratings of “mild as own brand”^{56,57} and “taste like own brand”⁵⁷ increased as they continued to use the product. In direct comparisons, about two-thirds of users in separate convenience sample surveys rated ENDS as equally or more satisfying than cigarettes.^{42,47}

Withdrawal Symptoms, Desire to Smoke, and Cravings

ENDS typically provided some relief of smokers’ nicotine cravings and withdrawal symptoms. In 6 lab studies, participants who had been tobacco abstinent for 2-12 hours reported that using nicotine-containing ENDS reduced their desire to smoke or cravings during their in-laboratory use session,^{53,56,57,79,87,88} although this was not true in 1 study.⁵⁴ In some cases, this reduction was shown to be greater for nicotine-containing ENDS than for non-nicotine ENDS^{53,87,88} or for just holding unlit regular cigarettes or ENDS.^{56,88} Interestingly, this reduction in desire to smoke or lessening of cravings occurred even in some cases where objectively measured nicotine uptake was low or modest.^{53,56} Evidence for the alleviation of specific withdrawal symptoms in these lab studies was inconsistent.^{53,56,57,79,87,88}

Dedicated ENDS users frequently reported that using ENDS successfully reduced their cravings to smoke and some withdrawal symptoms.^{42-44,46,49,50} For example, experienced “vapers” interviewed at the Midwest Vapefest “routinely described relief of nicotine cravings within 5 minutes of vaping” and said they could comfortably go long periods of time between bouts of use without experiencing withdrawal symptoms.⁵⁰ However, in a large

online survey with current and former users, 33% of users said they stopped using because ENDS did not reduce their cravings.⁴⁴ Finally, in the three prospective trials in Italy that followed smokers who began using ENDS for 6-12 months, participants experienced few or no withdrawal symptoms.⁷⁵⁻⁷⁷

Beliefs about and Reasons for Using ENDS

Cost

ENDS users' beliefs about the cost savings from using ENDS in lieu of regular tobacco cigarettes are inconsistent. In multiple convenience sample surveys from the U.S. and other countries, a small percent of users said they first tried or used ENDS for cost savings,^{42,43,47,74} although a much higher percent reported this reason in another convenience sample survey.⁴⁴ More than half (53%) of U.K. smokers, including a mix of users and non-users, believed that ENDS might be too expensive.⁶²

Gateway Use

One study documented beliefs about ENDS as gateways to use of tobacco products. Young adult smokers and non-smokers in focus groups in Minnesota, U.S. believed that ENDS and other novel tobacco products, including snus and dissolvable tobacco, might appeal to non-smokers who have “always wanted to know the feeling of a cigarette.”⁸⁹ They felt that these products could lead non-smokers to become smokers.

Health and Safety

Many users believe that ENDS are healthier than regular cigarettes for themselves^{42-44,46,47,49,50} or for others,⁴⁶ and they use ENDS for this reason. For example, of 179 Polish adult ENDS users in a convenience sample, 82% believed that ENDS were less dangerous than cigarettes, and an additional 15% believed that ENDS were “absolutely safe.”⁴⁷

Typically only a handful of users are concerned about the potential negative health effects or toxicity of ENDS.^{43,44}

Respondents in surveys that include non-users generally indicate slightly less confidence in the healthfulness of ENDS. In three probability sample surveys of adult current and former smokers, 70-85% of those who were aware of ENDS believed they were less harmful than regular cigarettes.^{59,61} In a non-probability survey of adult smokers in the U.K., 71% held this belief, although 21% still felt that ENDS might not be safe enough.⁶² Only one-third of adult New Zealand smokers believed that ENDS were less harmful than regular cigarettes.⁷⁰

In multiple studies of students and young adults, 23-55% believed that ENDS were safer than regular cigarettes.^{64,65,71} In focus groups, young adults who had never tried ENDS expressed mixed beliefs about whether ENDS were equivalent to or less harmful than regular cigarettes.⁸⁹

Examining Twitter accounts related to smoking cessation, Prochaska and colleagues also found a range of beliefs about the healthfulness of ENDS, including tweets with health warnings as well as tweets touting health benefits.⁹⁰

Quitting or Reducing Tobacco Use

The majority of ENDS users believe that ENDS can help people quit or reduce smoking, and they often use ENDS themselves for this reason.^{42-44,46,47,49,61,62,74,80} Two surveys with probability sampling described beliefs about the cessation properties of ENDS. Among Midwestern young adults (ages 20-28), almost half (45%) of those who had heard of ENDS agreed that they can help people quit smoking.⁶⁵ One-third of New Zealand smokers

believed that ENDS could help smokers quit, and 58% said they would be willing to try ENDS for that reason.⁷⁰

In two studies in which researchers provided smokers with ENDS (both $n=40$), those smokers later said that they would recommend ENDS to friends or family who wished to quit smoking.^{53,75} Some commercial and personal Twitter accounts also promoted ENDS as a quit tool.⁹⁰ Finally, in focus groups of young adult non-users ($n=66$), participants expressed differing opinions about whether ENDS could be used as a cessation device, and some spontaneously recounted anecdotes about people they knew who quit smoking using ENDS.⁸⁹

Restrictions on Smoking

ENDS users have conflicting beliefs about using ENDS to avoid smoking restrictions. In some surveys, only a small percent of users describe this as a motivation.^{42,43,47,74} However, in other surveys, more than 40% of respondents said they used ENDS for this reason.^{46,61,62}

In small focus groups, non-users noted that an advantage of ENDS and other novel tobacco products (snus, dissolvable tobacco) is the ability to get around smoking bans and use them in places where one cannot smoke.⁸⁹

Satisfaction

Some vapers use for the pleasure of the experience.⁴³ Smokers who have not tried ENDS had mixed opinions about their potential satisfaction. About one-third believed that ENDS might taste unpleasant.⁶²

Similarity to Regular Cigarettes

Some smokers and users liked that ENDS resembled or felt like regular cigarettes, while others considered this a drawback.^{42,43,62,74} Certain elements of the vaping and smoking experiences were clearly different. Because ENDS are more complex than cigarettes, interviewed users ($n=15$) noted that, unlike cigarettes, they required a learning curve to use properly.⁵⁰ In focus groups, some young adult smokers mentioned that the social experience of smoking might not be replicated with ENDS.⁸⁹

Withdrawal Symptoms, Desire to Smoke, and Cravings

Beliefs about the addictive properties of ENDS vary. About one-quarter of Midwestern young adults, most of whom were non-users, believed that ENDS are less addictive than regular cigarettes.⁶⁵ In contrast, in an Internet-based survey of a convenience sample of Polish ENDS users, 60% believed that ENDS were less addictive than regular cigarettes, and an additional 7% believed that ENDS were not addictive at all.⁴⁷ However, more than half believed they were addicted to ENDS.

Very few (8%) ever users in another online survey said they were afraid of becoming addicted to ENDS, although 4% of the sample stated that they used ENDS because they were unable to stop using them.⁴⁴ More than half (60%) of U.K. smokers, only some of whom had used ENDS, believed that ENDS might satisfy the desire to smoke.⁶² Indeed, some vapers used ENDS to relieve their cravings or alleviate their withdrawal symptoms.^{43,44,46,50,74}

Other Beliefs

Three other important themes emerged in the literature. First, concerns about personal appearance (e.g., preventing yellow teeth) or odor (e.g., clothes not smelling like smoke) sometimes motivated interest in or use of ENDS.^{43,44,47,49,50,62,75,89} Second, ENDS users felt a

sense of camaraderie with one another; they gathered at vaping conventions^{46,50} and in online forums where they shared information, recommendations, and personal experiences.^{43,49,50} However, a small minority of ENDS users were concerned about the social acceptability of ENDS use and felt embarrassed about using the product.^{42,51} University students, few of whom had tried ENDS, viewed ENDS use as more socially acceptable than smoking.⁵² Third, some ENDS enthusiasts were concerned that the product will be banned.^{43,44,50} We did not find any arguments by users that ENDS should be specifically exempted from smoke-free indoor air laws.

Conclusions

As the public health community settles an internal debate over the safety and cessation properties of ENDS, interest and use by the public are increasing rapidly. Consistently across the literature, current and former smokers were more likely to be aware of and use ENDS than non-smokers, although quit intentions and attempts were often not associated with ENDS use. In surveys and interviews with dedicated ENDS users, users were generally satisfied with the product and believed it was healthier than regular cigarettes. Current and former smokers not only believed that ENDS could help them quit smoking, but a significant proportion reported that ENDS already helped them reduce the amount they smoke or quit entirely. Dedicated ENDS users who are or were smokers often commented that ENDS alleviate their cravings to smoke, and they felt healthier because of using ENDS. Some evidence suggested that smokers use ENDS in order to avoid smoking restrictions, but no longitudinal studies have evaluated whether ENDS serve as a gateway to future tobacco use. In lab-based studies, smokers often reported that ENDS reduced their desire to smoke

and alleviated some withdrawal symptoms, although they experienced minor side effects. In prospective trials testing ENDS as a potential quit aid, a moderate number of smokers were able to quit, but many appeared to engage in dual use of ENDS and regular cigarettes.

Some of the reviewed studies received either funding from ENDS companies or used ENDS that these companies donated. Prior systematic reviews have found that financial relationships may influence study findings. For example, nearly all studies funded by the tobacco industry found a relationship between smoke-free restaurant and bar laws and reduced sales or employment in the hospitality industry; none of the non-industry supported studies found this association.⁴⁰ Although we detected no apparent pattern of results associated with ENDS industry funding, it remains important to be aware of possible conflicts of interest when interpreting these findings.

The literature on ENDS described in this review suggests several important questions that future research should address. First, future research should identify effective messages for discouraging ENDS use among vulnerable populations, given the beliefs and attitudes identified in our review. Two specific vulnerable populations are non-smokers who could begin smoking as a result of developing nicotine addiction from ENDS use and smokers who use ENDS only as a bridge to their next cigarette. If we better understand why ENDS may be attractive to some vulnerable populations (e.g., teenagers think ENDS are fashionable),⁸⁹ we can craft and deliver effective messages that deter use.

Another question for future research is how well perceived health risks of using ENDS correspond to objective risks, and whether beliefs about these risks change as additional safety data become available. Future safety studies will hopefully clarify some of the conflicting findings of past studies.^{2,3,9} Current ENDS users who are former smokers

frequently state that they use ENDS because they are healthier than regular cigarettes. If future safety studies find evidence of long-term harms, will these ENDS users stop using? If not, can we improve how we communicate safety information? Designing appropriate warning labels on ENDS packages could be an important first step.

A third important research question is whether ENDS users' self-reports of successful smoking cessation match evidence from the currently ongoing randomized controlled trials (RCTs) evaluating the efficacy of ENDS as a smoking cessation tool. Caponnetto and colleagues conducted a randomized controlled trial, but it did not include an arm testing an alternative to ENDS (i.e., nicotine replacement therapies (NRTs) or other proven smoking cessation methods).⁷⁷ Bullen and colleagues recently described the protocol for their study in which adult smokers who want to quit are randomly assigned to use ENDS with 16 mg nicotine cartridges, 21 mg nicotine patches, or placebo (ENDS with 0 mg nicotine).⁹¹ The primary outcome is the proportion of participants who maintain smoking abstinence 6 months after the start of the study, but investigators will also assess reductions in smoking, safety of the ENDS and patches, and perceptions of the products. This RCT and other similar studies are critical to understanding whether, as users have reported, ENDS can serve as harm reduction tools.

Finally, it will be important to understand how users of the various kinds of ENDS differ. ENDS are available in many different varieties. For example, there are disposable ENDS, often available at gas stations for only a few dollars, and more expensive refillable models that require an initial investment for a starter kit. Some ENDS mimic the appearance of regular cigarettes, while some modified ENDS do not resemble cigarettes. Understanding whether and why different types of ENDS appeal to different populations could assist efforts

to regulate these products. For example, if young people who have not already initiated tobacco use prefer inexpensive, readily available disposable models, restricting the sale of these models would be a key public health priority.

Several additional research questions, beyond the scope of the material covered in this review, will also be important to answer. One key question is whether ENDS are safe to use. Observing adverse events in RCTs, such as the one described by Bullen and colleagues, will help to determine this. What is the best way to measure ENDS use (e.g., number of puffs versus number of e-liquid cartridges used) so that findings can be compared across studies? Do ENDS act as gateway devices, causing individuals who would not otherwise use tobacco to initiate use? More than 10% of college students who reported using ENDS had never smoked a conventional cigarette,⁷¹ and we do not yet know whether those young people will start smoking as a result of their experience with ENDS. Prospective cohort studies, particularly with adolescents and young adults, are necessary to track patterns of use of ENDS and other tobacco products. Other important questions posed by a recent Cancer Research U.K. report include how will future regulation impact quit attempts using ENDS; do ENDS “re-normalize” smoking; and are ENDS undermining the use of other NRTs in smoking cessation attempts?¹⁶

Limitations to this systematic review include that, because the quality of the studies included in this review varies tremendously, readers should interpret the findings with care. In addition, as we reviewed only articles written in English and indexed electronically or cited in papers we reviewed, the review may have missed some relevant articles. While we provide an overview of findings across the literature, we did not conduct a meta-analysis to provide a quantitative synthesis due to the small number of studies and variability in their

designs and measures. Also, the codes we developed may not have included all relevant areas and some findings may have overlapped across codes. Finally, because this literature is young and evolving quickly, the conclusions of this review may not capture all of these changes.

In sum, concerns about ENDS include their safety, the lack of regulation, the possibility of gateway use, and the potential for dual use or avoidance of existing smoking restrictions. However, harm reduction advocates note that ENDS may be less harmful—and are highly unlikely to be *more* harmful—to smokers than regular cigarettes which are a proven cause of morbidity and mortality.^{8,92} Thus the concerns about ENDS must be balanced with the possibility that ENDS could prove to be a valuable harm reduction tool for addicted adult smokers, provided they do not encourage dual use or prevent other cessation efforts. Furthermore, as we learn more about the safety of ENDS and their efficacy as a quit tool, we will hopefully be able to design better tobacco control and cessation programs in the future.

Table 1.1. Characteristics of Studies Included in Review

1st Author (year)	<i>n</i>	Country (State)	Population	Probability Sampling of Cases	Data collection date	Study Design	Financial Relationship	Key Limitations
Adkison (2013) ⁶¹	5,939	US, UK, Canada, Australia	≥18 years, T	Yes	Jul 2010- Jun 2011	Survey	No	Survey wave response rate not reported.
Barbeau (2103) ⁴⁹	11	US (MA)	18-64 years, M, ENDS users	No	Feb 2010	Focus groups	NR	Recruited from ENDS user forums and advocacy groups.
Bullen (2010) ⁵³	40	New Zealand	18-70 years, T, ENDS naïve	No	Jan-Feb 2008	Exper	Yes	<1 day of exposure. Did not provide time for participants to become familiar with using ENDS. Did not achieve desired (power) sample size. Some participants still smoked on days assigned to ENDS. Only tested 1 model of ENDS.
Caponnetto (2011) ⁸⁶	2	Italy	50-51 years, T, ENDS users	No	Jan 2010	Case report	No	Only 2 participants.
Caponnetto (2011) ⁸⁰	3	Italy	38-65 years, T, ENDS users	No	NR	Case report	No	Only 3 participants.
Caponnetto (2013) ⁷⁶	14	Italy	Mean 45 years (SD 13), T	No	NR	Prosp trial	Yes	Uncontrolled trial of people with schizophrenia.
Caponnetto (2013) ⁷⁷	300	Italy	Mean 44 years (SD 13), T	No	2010-2011	Prosp trial	Yes	Control group tested non-nicotine ENDS, not alternative cessation products. Recruitment ads described ENDS as healthier than cigarettes. 39% lost to follow up.

Chen (2013) ⁸²	47 adverse event reports	US	N/A	No	2008 – 2012	Observ	No	Adverse events may not be caused by ENDS.
Cho (2011) ⁶³	4,341	Korea	Mean 14 years (SD 1) in middle schools, mean 17 years (SD 1) in high schools, M	Yes ^a	2008	Survey	No	Regional sample. Did not ask about current use of ENDS so could not assess dual use.
Choi (2012) ⁸⁹	66	US (MN)	18-26 years, M	No	Jul-Dec 2010	Focus groups	No	Small group size in some focus groups. Did not differentiate comments from smokers vs. non-smokers or whether certain comments were relevant to ENDS versus other tobacco products.
Choi (2013) ⁶⁵	2,624	US (MN, SD, ND, MI, KS)	20-28 years, M	Mixed ^b	Oct 2010-Mar 2011	Survey	No	Regional sample. Mix of probability and non-probability sampling.
Dawkins (2012) ⁸⁸	86	United Kingdom	18-52 years, T, ENDS naïve	No	NR	Exper	Yes	Did not include a comparison condition in which participants smoked cigarettes. Participants were only 1-2 hours abstinent from smoking. Brief exposure (experimental session <1 hour). Only tested 1 model of ENDS.
Dawkins (2013) ⁸⁷	20	United Kingdom	Mean 32 years (SD 9), T	No	NR	Exper	Yes	Did not include a comparison condition in which participants smoked cigarettes. Brief exposure (experimental session <1 hour). Only tested 1 model of ENDS.

Dawkins (2013) ⁴²	1,347	33 countries (72% in Europe)	Mean 43 years (SD 12), M, ENDS users	No	Sep 2011-May 2012	Survey	No	Recruited through ENDS company websites.
Dockrell (2013) ⁶²	12,597 in 2010; 12,432 in 2012	United Kingdom	Adults ≥ 18 years, M	No	Feb 2010 & Feb 2012	Survey	No	In 2010 survey, only current smokers were asked about ENDS use. Response rate not reported.
Dockrell (2013) ⁶²	1,380	United Kingdom	Adults ≥ 18 years, T	No	Apr 2010	Survey	No	Did not differentiate users' and non-users' attitudes about ENDS. Response rate not reported.
Eissenberg (2010) ⁵⁴	16	US (VA)	Mean 30 years (SD 11), T, ENDS naïve	No	NR	Exper	NR	Did not provide time for participants to become familiar with using ENDS. Brief exposure (experimental session <2 hours).
Etter (2010) ⁴³	81	Belgium, Canada, France, Switzerland	Mean 37 years (range 19-65), M, current or former ENDS users	No	Sep-Oct 2009	Survey	No	Recruited from smoking cessation websites, ENDS discussion forums, and websites that sell ENDS.
Etter (2011) ⁴⁴	3,587	US, France, United Kingdom, Switzerland, Canada, & others NR	Median 41 years, M	No	Mar-Oct 2010	Survey	No	Most recruitment from smoking cessation websites, ENDS discussion forums, and websites that sell ENDS.

Etter (2011) ⁴⁵	31	US, France, United Kingdom, Switzerland, Canada, Italy	Median 41 years, M, ENDS users	No	Sep 2010-Jan 2011	Survey	No	Very low response rate (16%). Most recruitment from smoking cessation websites, ENDS discussion forums, and websites that sell ENDS.
Farsalinos (2013) ⁸¹	1	NR	35 years, ENDS user, T	No	Aug-Nov 2012	Case report	No	Only 1 participant. Improvements in health may not be due to ENDS use.
Farsalinos (2013) ⁵⁵	80	Greece	Mean 37-38 years (range 20-45), M, ENDS users and ENDS naïve	No	NR	Exper	NR	Brief exposure (experimental session <1 hour). Only tested 1 mode 1 of ENDS.
Foulds (2011) ⁴⁶	104	US (PA)	Mean 34 years (SD 9), ENDS users, T	No	2011	Survey	No	Recruited from meeting of ENDS enthusiasts.
Goniewicz (2012) ⁶⁴	13,787	Poland	Mean 18 years (range 15-24), M	Yes ^a	Sep 2010-Jun 2011	Survey	No	Did not survey students living in rural areas with populations of <20,000 or attending private schools.
Goniewicz (2013) ⁴⁷	179	Poland	3% were 16-18 years, 18% 19-24 years, 79% ≥25 years, M, ENDS users	No	Fall 2009 (approx.)	Survey	No	Recruited from ENDS discussion forums and websites that sell ENDS.

Hua (2013) ²²	73	NR	83% 19-45 years, 17% age NR, separate groups of T & ENDS users	No	NR	Observ	No	Use ENDS in YouTube videos may differ from use of ENDS in the general population. Not known whether participants were dual users.
Hua (2013) ⁸³	543 posts	US, Canada, United Kingdom, Ireland, Australia, New Zealand, & others NR	18-71 years (age NR for some users), ENDS users, M	No	Up through Jul 2011	Observ	No	Could not validate accuracy of user reports. Reported effects may not be due to ENDS use.
King (2013) ⁶⁰	6,689 in 2010; 4,050 in 2011	US	≥18 years, M	Yes	Jul-Sep 2010 Jul-Aug 2011	Survey	No	Did not ask about current use of ENDS so could not assess dual use. Data collection methods varied.
Kralikova (2012) ⁵¹	973	Czech Republic	Mean 32 years, T	No	Oct 2011	Structured interviews	NR	Did not collect data on smoking history or amount of ENDS use.
Li (2013) ⁷⁰	480 in 2011; 360 in 2012	New Zealand	≥18 years, T	Yes	Jul-Sep 2011 Mar-May 2012	Survey	No	Treated purchase behavior as a proxy for use. High proportion of “don’t know” responses suggests lack of familiarity with ENDS. Response rate not reported.
McCauley (2012) ⁸⁴	1	US (OR)	42 years, ENDS user, tobacco use NR	No	NR	Case report	No	Only 1 case. Health problems may not be due to ENDS use.

McMillen (2012) ⁶⁷	3,240	US	14% 18-24 years, 86% ≥ 25 years, M	Yes	Sep-Nov 2010	Survey	No	Did not distinguish between ENDS and other emerging tobacco products when reporting on smoking cessation.
McQueen (2011) ⁵⁰	15	US (MO)	Range 20-70 years (approx.), ENDS users, T	No	Aug 2010	Qual interv	No	Recruited from meeting of ENDS enthusiasts. Varied and unsystematic interview methodology.
Monroy (2012) ⁸⁵	1	US (TX)	70 years, ENDS user, T	No	NR	Case report	No	Only 1 case. Health problems may not be due to ENDS use.
Pearson (2012) ⁵⁹	2,649	US	≥ 18 years, M	Yes	Jun 2010	Survey	No	None.
Pearson (2012) ⁵⁹	3,658	US	18-49 years, T	Yes ^a	Jan-Apr 2010	Survey	No	Did not ask about current use so could not estimate dual use.
Pepper (2013) ⁶⁶	228	US	11-19 years, M	Yes	Nov 2011	Survey	No	Males only. Very few smokers.
Polosa (2011) ⁷⁵	40	Italy	Mean 43 years (SD 9), T	No	Winter-summer 2010 (approx.)	Prosp trial	Yes	Uncontrolled trial. 33% lost to follow-up.
Popova (2013) ⁶⁸	1,836	US	Mean 42 years, T	Yes	Nov 2011	Survey	No	Potentially moderate response rate (58% completed screening; 41% of those qualified and completed the survey). Did not differentiate ENDS from other smokeless tobacco products when asking about reasons for using.
Prochaska (2012) ⁹⁰	153 Twitter accounts	Multiple countries (not listed)	N/A	No	Jul 2007-Aug 2010	Observ	No	Only captured Tweets from accounts with user names that referenced smoking cessation.

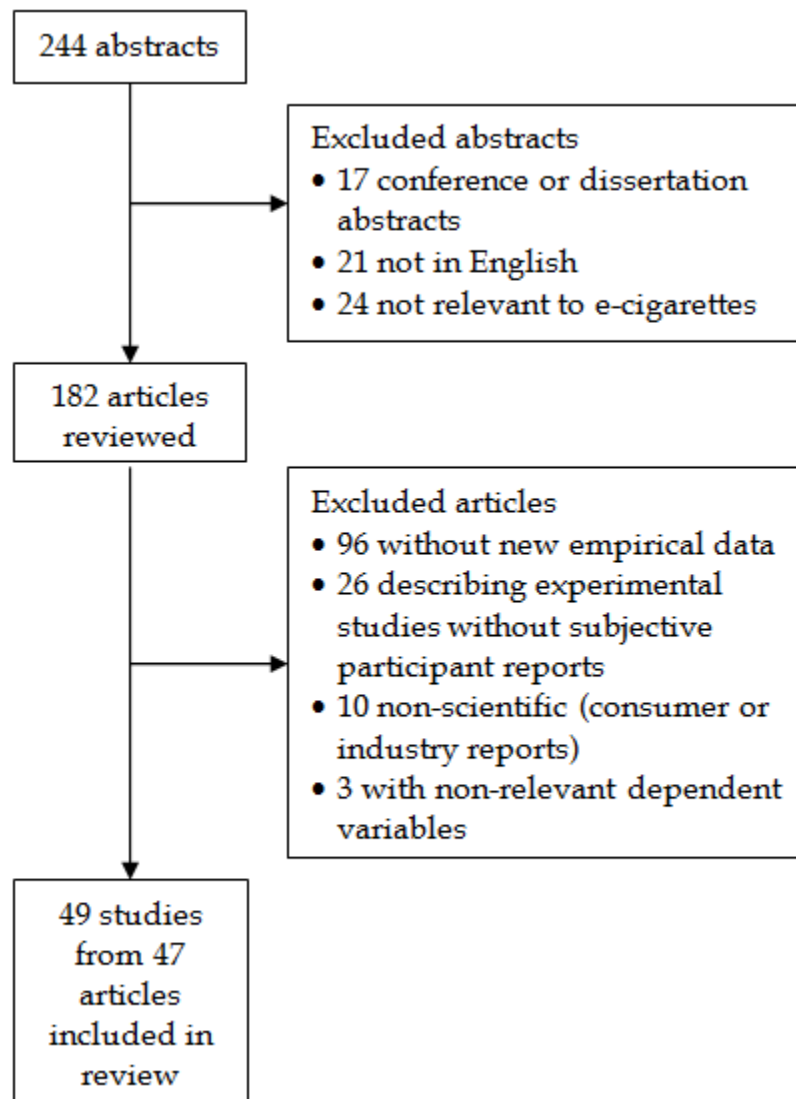
Regan (2013) ⁵⁸	10,587 in 2009; 10,328 in 2010	US	Adults ≥ 18 years, M	Yes ^a	Apr-May 2009 & Apr-May 2010	Survey	NR	Moderate response rates (50-52%). May underrepresent people without mailing addresses. Did not ask about current use of ENDS in 2009.
Richardson (2012) ⁶⁹	1,310	US	Adults ≥ 18 years, T	Yes	June 2010	Survey	No	Potentially moderate response rate (65% completed screening; 39% of those qualified and completed the survey). Did not assess current use of ENDS so could not determine dual use of ENDS.
Siegel (2011) ⁴⁸	216	NR	Adults ≥ 18 years, T, ENDS purchasers	No	Mar 2010	Survey	NR	Very low response rate (5%). Sampled from 1 ENDS brand during the company's first weeks of operation.
Sutfin (2013) ⁷¹	4,444	US (NC)	Mean 21 years (SD 3), M	Yes ^a	Fall 2009	Survey	No	Moderate response rate (41%). Did not distinguish former versus experimental smokers.
Trumbo (2013) ⁵²	244	US (CO)	19-22 years, M	No	Apr 2011	Survey	No	Participants were students in one lecture class at a university.
Vansickel (2010) ⁵⁶	32	US (VA)	18-55 years, T, ENDS naïve	No	NR	Exper	No	Brief exposure (experimental session <2 hours). Did not provide time for participants to become familiar with using ENDS.
Vansickel (2012) ⁵⁷	20	US (VA)	18-55 years, T, not current ENDS users	No	NR	Exper	NR	Brief exposure (experimental session <3 hours). Only tested 1 model of ENDS. Does not describe how participants were recruited.
Vansickel (2013) ⁷⁹	8	US (VA)	18-55 years, ENDS users, T	No	NR	Exper	No	Brief exposure (experimental session 5 hours). Does not describe how ENDS users were recruited.

Vickerman (2013) ⁷⁴	2,476	US (CT, LA, NE, NC, SC, TX)	Mean 49 years (SD 13), T	No	Jan 2012-Oct2012	Survey	No	Low response rate (35%). Not known whether participants tried ENDS before calling quitline or whether participants used ENDS as part of their quit attempts.
--------------------------------	-------	-----------------------------	--------------------------	----	------------------	--------	----	--

Note: ENDS = electronic nicotine delivery system. US = United States. N/A = not applicable. NR = not reported. SD = standard deviation. T = limited to current and former tobacco users. M = mix of tobacco users and non-users. Exper = experimental study design. Observ = observational study design. Prosp trial = prospective trial. Financial relationship = funded by or received free products from ENDS industry.

^aParticipants were randomly selected from clusters chosen purposively. ^bCombination of probability and quota sampling methods.

Figure 1.1. Flow diagram of literature search and article identification.



CHAPTER 2: SPECIFIC AIMS AND PREDICTIONS

This dissertation uses a diffusion of innovation (DOI) framework⁹³ to understand awareness and perceptions of e-cigarettes, as well as responses to messages about e-cigarettes. E-cigarettes embody two key hallmarks of an innovation. They have a *relative advantage* over the product they supersede (i.e., cigarettes) because they are or are perceived to be healthier, cheaper, or able to be used in smoke-free situations.⁹⁴ E-cigarettes also exhibit *compatibility* with users' needs and experiences because they mimic some aspects of smoking, including relatively fast nicotine delivery and the feel of inhalation.⁹⁴ The DOI framework describes five steps in the innovation adoption process: knowledge (an individual learns about e-cigarettes), persuasion (the individual forms an attitude about e-cigarettes), decision (the individual chooses whether to use e-cigarettes), implementation (the individual begins to use e-cigarettes), and confirmation (the individual seeks reinforcement of or decides to reject the previous choice to use e-cigarettes).

My specific aims for this dissertation, described in the context of the DOI framework, are as follows.

Specific Aim 1 (Paper 1)

Document and examine differences in smokers' and non-smokers' awareness of e-cigarettes and the most frequent ways that they have heard of e-cigarettes.

The proposed research will assess whether all survey respondents, both smokers and non-smokers, have heard of e-cigarettes and the channels through which they have heard of them.

Prediction 1.1: Nearly all U.S. adults will be aware of e-cigarettes.

In 2009, 16% of U.S. adults had heard of e-cigarettes.⁵⁸ By 2011, that figure rose to 58%.⁶⁰ Between 2010 and 2013, the media covered e-cigarettes extensively, and there has been an increase in online searching for information about e-cigarettes.^{5,18,19,95} Based on these trends, I believe that awareness has continued to rise and, as of March 2013, nearly all U.S. adults will have heard of e-cigarettes. Given the variety of channels of information about e-cigarettes (the Internet, popular media, interpersonal, etc.), I anticipate that most respondents who have heard of e-cigarettes will report having heard of them through multiple channels. I also anticipate that smokers will be more likely to be aware of e-cigarettes than non-smokers, as has been found consistently in other studies.^{58,59}

Prediction 1.2: Among those who have heard of e-cigarettes, smokers and e-cigarette users will be more likely to report learning about e-cigarettes from someone who uses e-cigarettes than will non-smokers and non-users.

Most e-cigarette users are or were smokers.^{43,44,46,50,58,59} Individuals who smoke are especially likely to have family members and friends who smoke.⁹⁶ The clustering of smokers within families is due in part to genetic factors.⁹⁷ Homophily (i.e., developing relationships with others who are similar to you) and social learning contribute to the clustering of smokers in peer groups.^{98,99} Thus, if one smoker begins using an e-cigarette, other smokers in that person's network are likely to see or hear about it, resulting in frequent reports from smokers and e-cigarette users that they heard information about e-cigarettes

through someone who has used them. As described in the DOI framework, interpersonal communication channels are particularly important for connecting early adopters of an innovation (smokers who use e-cigarettes) with other potential adopters.⁹³

Prediction 1.3: Adults less than 30 years old will be more likely to hear about e-cigarettes from Internet sources (an e-cigarette Web site, online ad, Twitter, or Facebook) than will adults ages 30 and over.

Adults ages 18–29 are more likely to use the Internet, own devices that access the Internet, watch videos on YouTube, and be active on Twitter and Facebook than adults ages 30 and over.¹⁰⁰⁻¹⁰² Each of those online channels is a potential source of information about e-cigarettes. Thus, I believe that adults under age 30 will be more likely to have heard about e-cigarettes from an online source than those ages 30 and over. The Internet is a particularly important channel from a DOI perspective because it combines mass media (the key channel for increasing knowledge) and interpersonal communication (the key channel for influencing adoption decisions).

As part of this paper, I will also examine other differences in sources of information, particularly differences by gender, race and ethnicity, and socioeconomic status. I do not have a priori predictions about these disparities.

Specific Aim 2 (Paper 2)

Compare smokers' perceptions of the health risks of e-cigarettes to the health risks of other traditional and novel tobacco products.

Risk perceptions are associated with a variety of health protective behaviors. For example, a meta-analysis by found that perceived risk likelihood, susceptibility, and severity

were all moderately but significantly related to adult vaccination.²⁸ Perceived risk of developing cancer is associated with having had a mammogram, sigmoidoscopy, or colonoscopy.¹⁰³

The relationship between smoking risk perception and smoking attitudes and behaviors is somewhat more complicated. Concern about the health consequences of smoking motivates smokers to try to quit.¹⁰⁴ Smokers know that smoking cigarettes is harmful to one's health, but they may not fully appreciate all of the relevant risks.¹⁰⁵ For example, respondents in a national survey underestimated lung cancer mortality rates and overestimated duration of survival after diagnosis.¹⁰⁵ When asked about their risk, smokers often express unrealistic optimism about their likelihood of developing smoking-related illness or their ability to quit smoking.^{106,107} The proposed research will assess current smokers' risk beliefs about their personal likelihood of developing three specific health problems (lung cancer, oral cancer, and heart disease) in the next 10 years due to regular use of different tobacco products.

Prediction 2.1: Smokers will report believing that, relative to regular cigarettes, e-cigarettes are less likely to cause health harms to them personally.

The objective long-term safety of e-cigarettes is unknown, although the product is clearly less harmful than cigarettes.¹⁰⁸ E-cigarette users,^{43,44,46,47,50} who are mostly current and former smokers, as well as smokers who do not use e-cigarettes⁵⁹ consistently report believing that e-cigarettes are less harmful than regular cigarettes. Although smokers may not be able to articulate specific reasons (e.g., e-cigarette use does not produce combustion-related carcinogens), I predict that smokers surveyed in the proposed research will report perceiving that regular cigarettes are more likely to cause lung cancer, oral cancer, and heart

disease than e-cigarettes. I believe that smokers will not distinguish among these health conditions because they see e-cigarettes as having a consistent relative advantage over cigarettes.

Prediction 2.2: E-cigarette users will have stronger beliefs than will non-users that e-cigarettes are less harmful than regular cigarettes.

Subjective expected utility (SEU), a key concept in theories of decision-making, is the perception of the extent to which the consequences of a behavior are desirable. For health behaviors, SEU represents the difference in perceived harms that result if there is no change in behavior versus the adoption of a protective measure.^{109,110} In the case of e-cigarettes, a smoker's belief that e-cigarettes are less likely to cause health problems than regular cigarettes is an indicator that they perceive the use of e-cigarettes as having positive SEU.

Existing research on the use of alternative nicotine products demonstrates a relationship between beliefs about reduced harm (akin to positive SEU) and use of the product. For example, relative to those who believed that snus were as harmful as or more harmful than cigarettes, smokers who believed (correctly) that snus are less harmful than cigarettes were more willing to try snus in a future quit attempt.¹¹¹ Based on predictions related to SEU and this prior research on alternative tobacco products, I posit that beliefs about lower likelihood of health problems will be associated with current use of e-cigarettes.

Because of the cross-sectional nature of the proposed research, I cannot specify the direction of the causal relationship for this prediction. As noted by Weinstein, Brewer, and others, once people have carried out a precautionary behavior, in this case using e-cigarettes, their risk perceptions may have changed and it is not possible to establish whether their risk perceptions were causes of or responses to the behavior.^{28,112}

Prediction 2.3: Smokers will view e-cigarettes as less likely to cause health problems than traditional smokeless tobacco products (moist snuff, dip, spit, or chewing tobacco).

The survey will measure the perceived likelihood of harms from regular use of traditional smokeless tobacco as well as e-cigarettes, snus, and dissolvable tobacco. Most smokers and non-smokers typically believe that smokeless tobacco is roughly as harmful to health as regular cigarettes.¹¹³⁻¹¹⁵ Health authorities like the Centers for Disease Control and Prevention (CDC) and American Cancer Society have presented the message that using smokeless tobacco is as dangerous as smoking cigarettes, and the public has absorbed this message.¹¹⁶ Indeed, one of the smokeless warning labels required by the Tobacco Control Act states, “This product is not a safe alternative to cigarettes,” even though there is evidence that smokeless tobacco is less harmful than cigarettes.^{117,118} Smokers may not view smokeless tobacco as having the same health-related relative advantage over cigarettes that e-cigarettes do. Therefore, I expect to see a similar pattern to the one described in prediction 2.1: Smokers will perceive that e-cigarettes are safer than traditional smokeless tobacco products.

I do not have an a priori prediction about perceptions of snus and dissolvables relative to e-cigarettes, partly because knowledge of and messages about these products are still relatively uncommon. In a nationally representative survey of U.S. adults in 2009, a large proportion of respondents were unsure about the dangers of using snus and dissolvables relative to regular cigarettes.¹¹⁹ Thus, I do not make a prediction about how they will rate the risks posed by these products relative to e-cigarettes.

Specific Aim 3 (Paper 3)

Assess the effects of e-cigarette testimonial messages on interest in trying e-cigarettes among smokers who have not previously tried e-cigarettes.

As part of this proposed research, current smokers who have not previously tried e-cigarettes will be randomly assigned to view one advertisement promoting a reason to use e-cigarettes. The messages in the advertisements will promote e-cigarettes using one of three comparison types based on the diffusion of innovation framework: difference (i.e., relative advantage), similarity (i.e., compatibility), or no comparison (control condition). The respondent will then indicate how much hearing the message makes them want to try e-cigarettes. I anticipate that desire to try e-cigarettes will vary by experimental condition. I have the following specific hypotheses.

Prediction 3.1: Among smokers, messages that include a comparison between e-cigarettes and regular cigarettes will be associated with greater interest in trying e-cigarettes than messages that do not include a comparison.

Humans rely on comparisons to process the information we encounter.¹²⁰ Comparative thinking increases the efficiency of our thinking (making it faster without sacrificing accuracy)¹²¹ and makes us more confident about our judgments.¹²² Many of the current messages about e-cigarettes are directed toward smokers and emphasize how e-cigarettes are similar to or different from regular cigarettes. We can see this focus in popular media coverage¹²³ and e-cigarette advertising.¹²⁴ In general, comparative advertising increases consumer attention, message awareness, brand awareness, favorable brand attitudes, purchase intention, and purchase behavior relative to non-comparative advertising.¹²⁵ Comparative advertising is particularly effective when the sponsored brand in

the advertisement is new to the market (i.e., like e-cigarettes of any brand) and the comparison brand is a market leader (i.e., like regular cigarettes of any brand).¹²⁵

Prediction 3.2: Among smokers, comparative messages that focus on differences between e-cigarettes and regular cigarettes (relative advantage) will be associated with greater interest in trying e-cigarettes relative to comparative messages that focus on similarities (compatibility).

Relative advantage and compatibility are both desirable qualities in an innovation, but I believe that messages emphasizing relative advantage will be most effective in generating interest in this particular innovation. Regular cigarettes, the product that e-cigarettes supersede, have negative connotations. Even smokers see cigarettes as unhealthy¹²⁶ and stigmatized.^{127,128} Indeed, e-cigarette users' two most frequently reported reasons for using (i.e., improved health and help with quitting smoking) focus on the differences between e-cigarettes and regular cigarettes.⁹⁴ Fewer users report that e-cigarettes' similarity to regular cigarettes motivates use.⁴³

CHAPTER 3: HOW U.S. ADULTS FIND OUT ABOUT ELECTRONIC CIGARETTES: IMPLICATIONS FOR PUBLIC HEALTH MESSAGES

Introduction

Electronic cigarettes, also called e-cigarettes or electronic nicotine delivery systems, are battery-operated devices that produce vapor by heating a cartridge containing nicotine, flavoring, and humectants. Many researchers and public health advocates are concerned about e-cigarettes' safety,^{2,3} possible use as a gateway to future smoking,^{6,129} and potential to prevent smokers from trying proven cessation tools. Evidence of e-cigarettes' ability to help smokers quit is suggestive but not definitive.^{94,130} The federal government does not currently regulate e-cigarettes but intends to do so through the Food and Drug Administration.¹³¹

E-cigarette awareness among U.S. adults has increased from 16% in 2009⁵⁸ to 75% in 2012.¹³² Ever use has also increased from 1% of U.S. adults in 2009⁵⁸ to 8% in 2012.¹³² Current and former smokers are more likely to be aware of and use e-cigarettes than never smokers.^{58-60,132}

Our study expands on past research by documenting how adults learn about e-cigarettes, describing how those channels might be used for public health communication, and discussing the potential need to regulate marketing on those channels. We tested three predictions. First, we predicted that hearing about e-cigarettes from a person who uses them would be more common among *smokers* than non-smokers, given that smokers have higher rates of e-cigarette use than non-smokers, and smokers gather together in social and family groups (i.e., homophily).⁹⁶ Second, we predicted that hearing about e-cigarettes from a

person who uses them would be more common among *e-cigarette users* than non-users because e-cigarette users gather with other users (homophily) and exchange information about the product.^{43,46,49} Third, we predicted that young adults would be more likely to hear about e-cigarettes through online sources because young adults are more likely than older adults to use the Internet and social media.^{100,101}

Methods

Sample

This study relied on data collected from U.S. adults (age ≥ 18) in a March 2013 online survey as part of the Tobacco Control in a Rapidly Changing Media Environment study that examined the relationship between recall of receiving and sharing tobacco-related information and smoking attitudes, beliefs, and behavior. Most respondents (75%) were members of KnowledgePanel, a nationally representative online survey panel constructed using random-digit dialing supplemented by address-based sampling.¹³³ To recruit the rest of the sample, the survey company screened people who clicked on online ads and quota matched them to the probability sample based on demographic and tobacco use characteristics. The survey company also screened names and addresses and removed duplicates before inviting them to complete the survey. Non-responders received up to four reminders, and all participants provided consent online before taking the survey. Sixty-one percent of invited KnowledgePanel members completed the screening, and 97% of eligible respondents completed the survey. Response rates for the convenience sample cannot be calculated because there is no known sampling frame. The study received institutional review board approval.

Measures

The survey described e-cigarettes while displaying generic images of the product: “An e-cigarette looks like a regular cigarette, but it runs on a battery and produces vapor instead of smoke. There are many types of e-cigarettes. Some common brands are Smoking Everywhere, NJOY, Blu, and Vapor King.” Next, one item assessed awareness of e-cigarettes: “Before today, had you ever heard of e-cigarettes?” (yes/no).

Respondents who had heard of e-cigarettes received a question about the sources of their awareness, “From which of the following sources have you ever heard about e-cigarettes?”: another person; online; an ad on TV; an ad in a newspaper or magazine; a news story on TV or in a newspaper or magazine; and seeing them for sale in stores, including gas stations. Respondents who had heard about e-cigarettes from another person received the question, “Who did you hear about e-cigarettes from?”: a friend or family member who uses e-cigarettes, a friend or family member who does not use e-cigarettes, someone else who uses e-cigarettes, and someone else who does not use e-cigarettes. Respondents who had heard about e-cigarettes online received the question, “Where did you hear about e-cigarettes online?”; response options were Twitter, an ad or user on Facebook, an ad or user on YouTube, an ad on some other website, a website that sells e-cigarettes, and an online news source.

The survey assessed demographics and smoking status. Current smokers received questions about intentions to quit (“Do you plan to quit smoking for good...?”: in the next 7 days, in the next 30 days, in the next 6 months, in the next year, more than one year from now, or I do not plan to quit smoking for good) and previous quit attempts (“During the past year, have you stopped smoking for one day or longer because you were trying to quit

smoking for good?": yes/no). We conducted cognitive interviews with 16 participants during survey item development and pre-tested the revised items with 160 respondents.

Data Analysis

Analyses used Stata Version 12 (svy commands to account for the complex survey design), two-tailed statistical tests, and a critical alpha of .01. We examined bivariate associations between respondent characteristics and awareness of e-cigarettes using logistic regression, and included statistically significant correlates in a multivariate model. To address our predictions, we conducted three multivariate logistic regressions, each adjusted for significant bivariate correlates and using source of awareness as the outcome. The regressions assessed whether (1) *current smokers* (smoke every day or some days) *and former smokers* (smoked more than 100 cigarettes in their lifetime but not currently smoking) were more likely than never smokers (smoked fewer than 100 cigarettes) to have heard about e-cigarettes from someone who uses them (a combination of the responses “a friend or family member who uses e-cigarettes” and “someone else who uses e-cigarettes”); (2) *e-cigarette users* were more likely than non-users to hear about e-cigarettes from someone who uses them; and (3) respondents ages 30 and younger were more likely than those over age 30 to hear about e-cigarettes online.

Frequencies are unweighted, and percentages and analyses are weighted. Post-stratification sample weights accounted for study design, including the combination of the probability and non-probability samples, and representativeness of the sample compared to the U.S. population.

Results

More than half of respondents (52%) were never smokers, 28% were former smokers, and 21% smoked every day or some days (Table 3.1). Among current smokers, 54% intended to quit smoking in the next year. Most respondents were non-Hispanic White (68%) and had at least some college education (57%). The mean age was 47 years (SD 27). Eighty-six percent of U.S. adults had heard of e-cigarettes in 2013. Among those who were aware of e-cigarettes, 83% had never tried them, 11% were former users, and 6% were current users.

Correlates of Awareness

In multivariate analysis, former smokers (90% aware) and current smokers (95%) were more likely to have heard of e-cigarettes than never smokers (81%, both $p<.001$) (Table 3.2). Greater awareness was associated with gender (89% of males vs. 84% of females, $p<.01$), higher education (88% of those with some college education and 87% of those with college or more vs. 78% of those with less than a high school education, both $p<.001$), and race (80% of non-Hispanic Black, 77% of non-Hispanic other race, and 80% of Hispanic adults vs. 89% of non-Hispanic White adults; all $p<.001$). Awareness decreased with age ($p<.001$).

Sources of Awareness

The most frequent way that adults had heard of e-cigarettes was through another person (34% of never, 39% of former, and 48% of current smokers) (Figure 3.1), by seeing them for sale in stores (22% of never, 27% of former, and 47% of current smokers), and by seeing them advertised on television (31% of never, 35% of former, and 40% of current smokers). Fewer respondents endorsed the Internet (12% of never, 12% of former, and 28% of current smokers) as a source of awareness.

As predicted, current smokers (83% aware) were more likely to have heard about e-cigarettes from an e-cigarette user than former smokers (78%, $p < .01$) or never smokers (72%, $p < .001$). Consistent with our second prediction, 85% of ever e-cigarette users who heard about e-cigarettes from another person said that that person used e-cigarettes, compared to 74% of those who had never used e-cigarettes ($p < .001$). Finally, as predicted, respondents over age 30 were less likely to have heard about e-cigarettes through the Internet than those ages 30 and younger (14% vs. 23%, $p < .001$).

Discussion

Most U.S. adults (86%) had heard of e-cigarettes by 2013, continuing the increasing trend from 2009 (Figure 3.2). Demographic groups with higher smoking rates in the general population (e.g., men, non-Hispanic Whites)⁷² were often more likely to be aware of e-cigarettes in our study, although this pattern was not consistent for education. This discrepancy may reflect exposure to outlets selling e-cigarettes, which are more widely available in high socioeconomic status neighborhoods.¹³⁴

Interpersonal communication was an important source of information among current and former smokers. Because of homophily,⁹⁶ smokers often associate with other smokers, who appear to be important sources of information about e-cigarettes. Similarly, e-cigarette users often congregate with other users,^{43,46,49} so product information likely spreads through those connections.

E-cigarettes have a strong online presence,^{21,135} which helps to explain why more than one-quarter of smokers learned about e-cigarettes online. The Internet may play an important role by reinforcing word of mouth messages, providing additional information as follow-up

to personal conversations, or priming people to participate in conversations about e-cigarettes. Our results were consistent with our prediction that online sources were more common for adults under 30, who are more likely than those over 30 to use the Internet and social media.^{100,101}

These results have important implications for public health communication. First, interpersonal discussion is a key source of information, so future efforts should consider including grassroots “word of mouth” strategies. Televised advertising, a frequent source of information, could be used to communicate public health messages. Given that seeing e-cigarettes for sale in stores was a common source of awareness and point-of-sale cigarette marketing is already known to influence smoking behavior,¹³⁶ warning labels should be clearly displayed on the products and their advertising at the point of sale, as is currently done for cigarettes and smokeless tobacco products. Based on our findings, web-based communications could be helpful to reach young adults 18-30. Finally, because these same routes of communication also serve as marketing channels, the public health community should closely track them and, as necessary, consider regulation to prevent targeted marketing to youth, non-tobacco users, and other at-risk groups. For example, if youth frequently learn about e-cigarettes from televised advertising or such advertising renormalizes the image of smoking, the FDA might promulgate regulations to restrict or ban such ads on television.

Limitations include the study’s cross-sectional design that precluded examining whether different sources of awareness predicted initiation or changes in e-cigarette use. We did not study first source of awareness, the content of the information people received, or their perceptions of its validity. Future studies will also need to establish the generalizability

of our findings to youth and to newer types of e-cigarettes, including tank models. While we recruited a supplementary convenience sample, we quota matched them to the probability sample on demographic and tobacco use characteristics.

In sum, awareness of e-cigarettes has increased rapidly in recent years, but we do not know whether the information that people are receiving is accurate or appropriate. Our results suggest that some channels (e.g., word of mouth, television, point-of-sale displays) may be more useful for spreading timely, accurate information about e-cigarettes than others.

Table 3.1. Sample Characteristics (*n*=17,522)

Characteristic	<i>n</i>	Weighted %
Respondent		
Gender		
Male	7,819	48.0
Female	9,703	52.0
Age, mean (SD)		46.9 (26.5)
Education		
Less than high school	697	6.8
High school	3,901	36.1
Some college	6,342	31.2
Bachelor's degree or higher	6,582	25.9
Cigarette smoking status		
Never smoker ^a	6,755	51.8
Former smoker ^b	4,160	27.5
Current smoker ^c	6,607	20.7
Intention to quit smoking ^d		
In the next year	3,683	53.7
More than 1 year from now	918	15.0
Do not plan to quit	2,006	31.3
E-cigarette use and awareness		
Not aware	1,951	13.8
Aware but never tried	11,661	71.5
Former user	2,305	9.6
Current user	1,605	5.1
Race/ethnicity		
White, non-Hispanic	13,931	68.1
Black, non-Hispanic	1,317	11.5
Other, non-Hispanic	556	5.5
Hispanic	1,246	13.5
>1 race, non-Hispanic	472	1.4
Marital status		
Married or living with partner	10,697	62.0
Never married	3,215	21.6
Divorced or separated	2,668	12.0
Widowed	942	4.3
Employment		
Working	9,351	57.0
Not working: laid off or looking for work	1,560	10.0
Not working: retired, disabled, or other	6,611	33.1
Household		
Region		
Northeast	3,029	18.2
Midwest	4,478	22.2

South	6,037	37.3
West	3,978	22.4
Household income		
Less than \$25,000	3,716	18.7
\$25,000 - \$49,999	4,739	23.6
\$50,000 - \$74,999	3,613	19.6
\$75,000 - \$99,999	2,440	18.5
\$100,000 or more	3,014	19.5
High speed Internet access		
Yes	16,525	92.9
No	997	7.1

Note. Frequencies are unweighted. ^aSmoked fewer than 100 cigarettes in lifetime. ^bSmoked 100 or more cigarettes in lifetime but does not currently smoke. ^cSmokes cigarettes some days or every day. ^dAmong current smokers ($n=6,607$).

Table 3.2. Correlates of Awareness of E-Cigarettes (*n*=17,522)

	Number aware of e-cigarettes / Total number in category (weighted %)		Bivariate		Multivariate	
	<i>n</i>	(%)	<i>OR</i>	(95% CI)	<i>OR</i>	(95% CI)
Overall	15,571 / 17,522	(86.2)				
Respondent characteristics						
Gender						
Male (Ref)	7,089 / 7,819	(88.6)	1.00	-	1.00	-
Female	8,482 / 9,073	(83.9)	0.67	(0.58, 0.78)**	0.76	(0.65, 0.89)*
Age						
			0.99	(0.99, 1.00)*	0.99	(0.98, 0.99)**
Education						
Less than high school (Ref)	585 / 697	(78.1)	1.00	-	1.00	-
High school	3,424 / 3,901	(85.3)	1.64	(1.22, 2.20)*	1.51	(1.10, 2.09)
Some college	5,777 / 6,342	(88.1)	2.08	(1.54, 2.80)**	1.91	(1.37, 2.65)**
Bachelor's degree or higher	5,785 / 6,582	(87.1)	1.91	(1.42, 2.55)**	1.99	(1.42, 2.80)**
Cigarette smoking status						
Never smoker ^a (Ref)	5,551 / 6,755	(80.6)	1.00	-	1.00	-
Former smoker ^b	3,709 / 4,160	(90.1)	2.19	(1.84, 2.62)**	2.50	(2.07, 3.03)**
Current smoker ^c	6,311 / 6,607	(94.9)	4.47	(3.60, 5.56)**	4.93	(3.93, 6.20)**
Race/ethnicity						
White, non-Hispanic (Ref)	12,564 / 13,931	(89.2)	1.00	-	1.00	-
Black, non-Hispanic	1,094 / 1,317	(80.1)	0.49	(0.39, 0.61)**	0.55	(0.43, 0.70)**
Other, non-Hispanic	459 / 556	(76.8)	0.40	(0.30, 0.54)**	0.37	(0.26, 0.51)**
Hispanic	1,036 / 1,246	(79.8)	0.48	(0.39, 0.59)**	0.47	(0.37, 0.60)**
>1 race, non-Hispanic	418 / 472	(86.4)	0.77	(0.49, 1.21)	0.75	(0.48, 1.16)
Marital status						
Married or living with partner (Ref)	9,493 / 10,697	(86.2)	1.00	-		
Never married	2,865 / 3,125	(85.4)	0.94	(0.77, 1.14)		

Divorced or separated	2,424 / 2,668	(89.1)	1.31	(1.05, 1.64)		
Widowed	789 / 942	(81.9)	0.72	(0.55, 0.96)		
Employment						
Working (Ref)	8,493 / 9,351	(88.0)	1.00	-	1.00	-
Not working: laid off or looking for work	1,390 / 1,560	(83.8)	0.71	(0.54, 0.92)*	0.79	(0.59, 1.04)
Not working: retired, disabled, or other	5,688 / 6,611	(83.7)	0.70	(0.60, 0.81)**	0.85	(0.71, 1.03)
Household						
Region						
Midwest (Ref)	4,035 / 4,478	(89.2)	1.00	-	1.00	-
Northeast	2,674 / 3,029	(85.4)	0.71	(0.57, 0.89)*	0.77	(0.61, 0.98)
South	5,359 / 6,037	(85.9)	0.74	(0.61, 0.90)*	0.87	(0.71, 1.08)
West	3,503 / 3,978	(84.2)	0.65	(0.52, 0.80)**	0.84	(0.67, 1.07)
Household income						
Less than \$25,000 (Ref)	3,271 / 3,716	(84.0)	1.00	-	1.00	-
\$25,000 - \$49,999	4,200 / 4,739	(84.8)	1.07	(0.86, 1.32)	0.98	(0.77, 1.24)
\$50,000 - \$74,999	3,245 / 3,613	(87.5)	1.33	(1.06, 1.68)	1.13	(0.87, 1.47)
\$75,000 - \$99,999	2,160 / 2,440	(86.6)	1.23	(0.97, 1.57)	1.03	(0.78, 1.36)
\$100,000 or more	2,695 / 3,014	(88.3)	1.44	(1.14, 1.81)*	1.25	(0.94, 1.66)
High speed Internet access						
No (Ref)	818 / 997	(78.3)	1.00	-	1.00	-
Yes	14,753 / 16,525	(86.8)	1.82	(1.42, 2.33)**	1.40	(1.06, 1.84)

Note. Multivariate model contains all correlates significant ($p < .01$) in bivariate models. OR = odds ratio. CI = confidence interval. Ref = reference category. Frequencies are unweighted; the other statistics are from weighted analyses. * $p < .01$. ** $p < .001$.

Figure 3.1. Channels of awareness of e-cigarettes among current smokers ($n=6,311$), former smokers ($n=3,709$), and never smokers ($n=5,551$) who have heard of e-cigarettes.

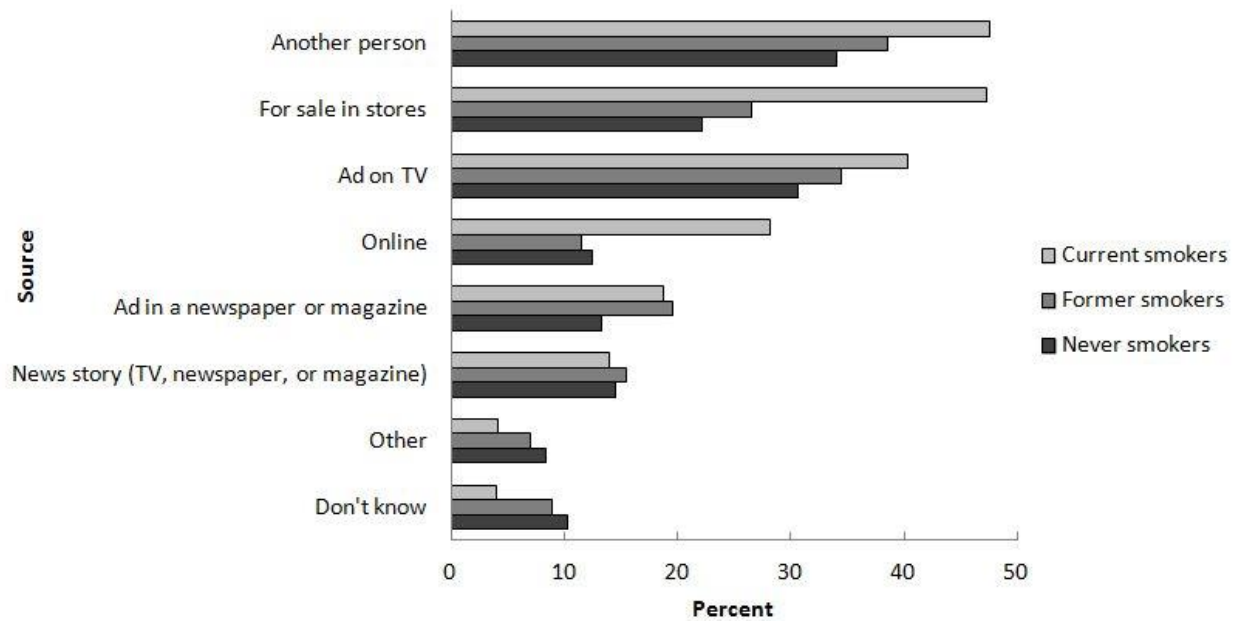
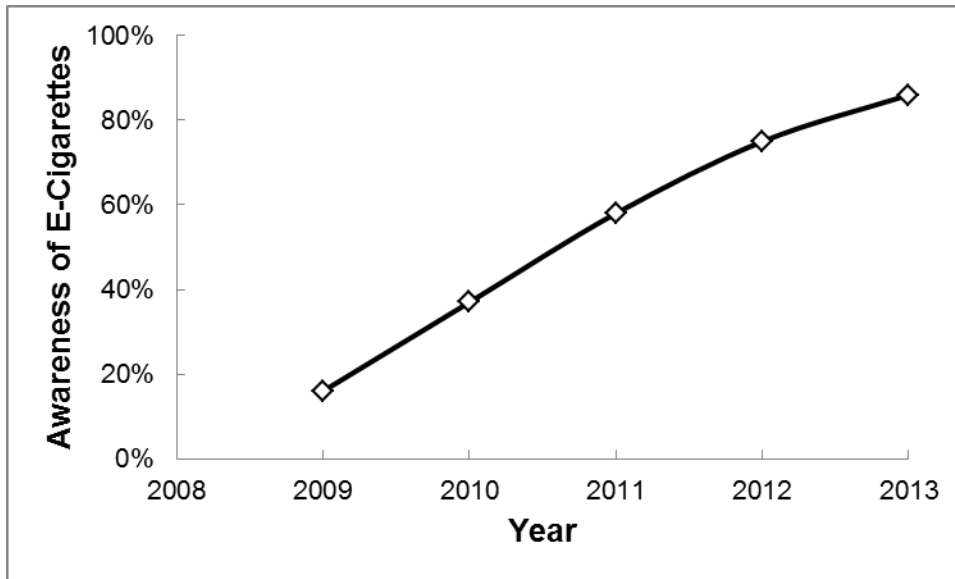


Figure 3.2. Increase in awareness of e-cigarettes among U.S. adults: 16% in 2009,⁵⁸ 37% (mean) in 2010,⁵⁸⁻⁶⁰ 58% in 2011,⁶⁰ 75% in 2012,¹³² and 86% in 2013.



CHAPTER 4: SMOKERS' PERCEPTIONS OF THE HEALTH RISKS OF ELECTRONIC CIGARETTES COMPARED TO REGULAR CIGARETTES AND OTHER TOBACCO PRODUCTS

Introduction

Although traditional cigarettes remain the most popular tobacco product in the U.S. (19% of U.S. adults were current smokers in 2010),⁷² there are many other non-medicinal nicotine and tobacco products currently available in the U.S. market, including electronic cigarettes (e-cigarettes), snus, dissolvable tobacco, and traditional smokeless tobacco. These other tobacco products (OTPs) vary in terms of their popularity and mode of nicotine delivery. E-cigarettes are battery-powered devices that produce vapor by heating a solution containing nicotine, humectants, and flavoring, although non-nicotine versions are available. The percentage of U.S. adults who have tried e-cigarettes in the past (“ever users”) rose from 1% in 2009⁵⁸ to 15% in 2013,¹³⁷ and rates are higher among smokers. Half of current smokers in a 2013 nationally representative U.S. survey had ever tried e-cigarettes, and 80% of e-cigarette ever users also smoked.¹³⁷ Snus are packets of moist tobacco that users place between their gums and cheeks. About 4% of U.S. adults surveyed in 2012 had ever tried snus.¹³² Dissolvable tobacco typically comes in the form of sticks, strips, or orbs; fewer than 1% of U.S. adults had ever tried dissolvable tobacco as of 2010.⁶⁷ Compared to e-cigarettes, snus, and dissolvable tobacco, many more people in the U.S. (18% of those over age 12 in 2012)¹³⁸ have ever tried traditional smokeless tobacco, including chewing tobacco and snuff. Although rates of cigarette smoking among U.S. adults have declined, rates of use of other tobacco products have increased.^{72,94,139}

Because products like e-cigarettes, snus, dissolvable tobacco, and traditional smokeless tobacco do not rely on combustion, they do not produce the same harmful chemicals and particles that regular cigarettes do and are therefore considered by scientists to be less dangerous.^{140,141} However, non-combustible tobacco products are not entirely without potential harm. For example, certain models of e-cigarettes have been found to contain carcinogenic tobacco-specific nitrosamines,¹⁴² and some researchers are concerned about the long-term impact of inhaling humectants like propylene glycol.¹¹ Harm reduction advocates emphasize the need to communicate information about the *relative* harm of non-combustible products compared to cigarettes, not merely the *absolute* harm of such products.^{116,143} In contrast, some tobacco control messages focus on the basic idea that “there is no safe tobacco product.”¹⁴⁴

The degree to which the public believes that OTPs are less harmful than regular cigarettes has important implications for their use. Expectancy value theories such as the Health Belief Model,¹⁴⁵ as well as past studies examining a variety of behaviors (e.g., vaccination²⁸ and cancer screening¹⁰³) suggest that risk beliefs (e.g., perceived likelihood of harm) can drive health behavior. Research shows that these beliefs can affect smoking behavior, although not consistently. For example, concern about the health consequences of smoking motivates many smokers to try to quit,¹⁴⁶ and some smokers switched to “light” cigarettes because they believed these were healthier than regular cigarettes.¹⁴⁷ However, across multiple prospective studies, the stated reason for wanting to quit smoking (i.e., health concerns versus other concerns) was rarely associated with success in quitting.¹⁰⁴ Thus, there is a need to understand whether smokers might be motivated to use OTPs because they

perceive those products to be less harmful and whether that motivation produces actual behavioral change.

We sought to understand how U.S. adult smokers perceived the risks of using cigarettes and OTPs. We focused on smokers because they are more likely than non-smokers to use OTPs. First, we hypothesized that smokers would view e-cigarettes as less likely to cause health problems than cigarettes (Hypothesis 1). Consistent with Rogers' diffusion of innovation theory,⁹³ smokers may see a novel product (e-cigarettes) as an improved replacement for a traditional product (regular cigarettes) and thus would see the latter as riskier to use. We also hypothesized that smokers would see cigarettes as more likely to cause lung cancer than smokeless tobacco, snus, and dissolvable tobacco, but less likely to cause oral cancer (Hypothesis 2). Some people base their beliefs about a tobacco product's health risks in part on how it comes into contact with the user's body,⁸⁹ and smokeless tobacco, snus, and dissolvable tobacco are placed directly against the cheeks, tongue, or gums. In addition to testing these hypotheses, we conducted exploratory analysis comparing e-cigarettes to alternative OTPs.

Methods

Sample

The Tobacco Control in a Rapidly Changing Media Environment (TCME) project gathered data from a national sample of 17,522 U.S. adults (6,607 current smokers, 4,160 former smokers, and 6,755 never smokers). The TCME survey, conducted online in March 2013, assessed recall of and searching for tobacco-related information, as well as the relationship between that information and tobacco use behaviors, beliefs, and attitudes. The

majority of participants (75%) were recruited from KnowledgePanel, a nationally representative online survey panel that recruits participants through random-digit dialing, supplemented by address-based sampling to capture cell phone–only households.¹³³ Of 34,097 KnowledgePanel members sampled, 61% ($n=20,907$) completed the screening. Among eligible respondents ($n=13,531$), 97% ($n=13,144$) completed the survey. Other participants were recruited from convenience samples of online market research panels, using quota sampling to match demographic characteristics of a nationally representative sample; response rate data from the market research panels are not available. For this study, we report data from current smokers ($n=6,607$). Institutional review boards at the National Cancer Institute and the University of Illinois at Chicago approved the study.

Measures

Smokers responded to an item about the health risks of cigarettes: “How likely do you think it is that smoking cigarettes regularly would cause you to develop each of the following in the next 10 years? (If you’re not sure, please give us your best guess).” The health conditions were lung cancer, heart disease, and mouth or throat cancer (referred to as “oral cancer” hereafter). Respondents rated their likelihood of developing these health conditions on a 5-point response scale (“not at all likely” (coded as 1) to “extremely likely” (5)). We averaged the ratings of the likelihood of developing the three health conditions to create a scale ($\alpha=0.95$).

We then randomly assigned smokers to receive another question about e-cigarettes, snus, dissolvable tobacco (sticks, strip, orbs), or traditional smokeless tobacco (moist snuff, dip, spit, chew). To conserve space on the survey, participants answered this item about only one product. Participants viewed a description of the product before responding to the item.

The item read “Imagine that you stopped smoking regular cigarettes and only used [product]. How likely do you think it is that using [product] regularly would cause you to develop each of the following in the next 10 years? (If you’re not sure, please give us your best guess.)” The health conditions and response scale were the same as in the parallel item about regular cigarettes. We created a composite perceived risk measure for e-cigarettes by averaging the ratings of the likelihood of developing the three health conditions for that product ($\alpha = 0.97$).

To assess understanding of item wording and ease of responding to survey items, we conducted cognitive interviews with 16 people and then pre-tested the revised survey with 160 respondents. For all variables, we recoded missing scores (<0.5% for each item) to the mean of that item.

Data Analysis

To address Hypothesis 1, we conducted within-subjects analyses, using paired *t*-tests to compare the perceived risk of each of the three health problems for cigarettes versus e-cigarettes. To examine the robustness of the findings comparing perceived risk for cigarettes and e-cigarettes, we repeated the *t*-tests for demographic subgroups (e.g., only males, only smokers who intended to quit smoking in the next year).

To address Hypothesis 2, we repeated the paired *t*-tests to compare cigarettes to smokeless tobacco, snus, and dissolvable tobacco for each of the three health problems. For the exploratory analysis comparing e-cigarettes to the alternative OTPs we conducted a between-subjects analysis, using linear regression to examine whether the perceived risk of developing lung cancer varied by OTP type (e-cigarettes, smokeless tobacco, snus, and dissolvable tobacco). The reference category was e-cigarettes. We repeated the regression for perceived risk of developing heart disease and oral cancer.

We also examined the demographic and behavioral variables listed in Table 4.1 as potential correlates of the composite perceived risk measure for e-cigarettes using bivariate linear regressions. We included variables with statistically significant bivariate relationships to perceived risk in a simultaneous multivariate linear regression model.

Analyses were run in Stata Version 12. Frequencies are unweighted. Percentages and all other analyses used the “svy” command and post-stratification weights to adjust for the representativeness of the sample compared to the U.S. population and the sampling design, including the combination of probability and non-probability samples. We report standardized regression coefficients as betas (β). Statistical tests were two-tailed with a critical alpha of .05.

Results

Of current smokers ($n=6,607$) in our sample, most were non-Hispanic White (69%) (Table 4.1). About half were female (51%), had at least some college education (47%), and had an annual household income over \$50,000 (45%). Half had tried e-cigarettes at least once in the past, and 21% currently used them. Only 6% had ever tried dissolvable tobacco products. Most respondents intended to quit smoking cigarettes in the next year (54%) or more than 1 year from now (15%).

Comparison of E-Cigarettes to Cigarettes (Hypothesis 1)

Participants perceived e-cigarettes as less likely to cause lung cancer (mean difference 1.17 between values for e-cigarettes and cigarettes, $p<.001$), heart disease (1.07, $p<.001$), and oral cancer (1.04, $p<.001$) compared to regular cigarettes (Figure 4.1). The belief that e-cigarettes were less harmful than regular cigarettes was robust. It persisted in in

each tested demographic subgroup, all $p < .001$: men (mean difference 1.09 between values for e-cigarettes and regular cigarettes), women (1.10), high school or less education (1.20), some college or more education (0.96), non-Hispanic Whites (1.06), non-Hispanic Blacks (1.56), non-Hispanics of other or multiple races (0.78), Hispanics (0.91), those with household incomes below \$50,000 (1.14), and those with household incomes of \$50,000 or more (1.03). It also persisted among smokers who plan to quit in the next year (1.25), smokers who plan to quit more than one year from now (1.05), smokers who do not plan to quit (0.86), ever users of e-cigarettes (1.06), and never users of e-cigarettes (1.09).

Comparison of Alternative OTPs to Cigarettes (Hypothesis 2)

Participants believed that smokeless tobacco was less likely to cause lung cancer than cigarettes (mean difference 0.51 between values for smokeless tobacco and cigarettes, $p < .001$), equally likely to cause heart disease (0.06, $p = .13$), and more likely to cause oral cancer (0.61, $p < .001$) (Figure 4.1). Similarly, compared to cigarettes, participants perceived snus as less likely to cause lung cancer (0.58, $p < .001$), equally likely to cause heart disease (0.07, $p = .14$), and more likely to cause oral cancer (0.58, $p < .001$). Participants also believed that dissolvable tobacco was less likely to cause lung cancer (0.54, $p < .001$) and more likely to cause oral cancer (0.27, $p < .001$) than cigarettes, but they believed that dissolvable tobacco was less likely to cause heart disease compared to regular cigarettes (0.17, $p < .001$).

Comparisons Between E-Cigarettes and Alternative OTPs

Smokers believed that they were more likely to develop lung cancer from using smokeless tobacco, snus, or dissolvable tobacco than from e-cigarettes (mean differences 0.57, 0.58, and 0.74, respectively; all comparisons $p < .001$) (Figure 4.1, Table 4.2). They similarly perceived greater likelihood of developing heart disease from other non-

combustible products than from e-cigarettes (mean differences 0.97 for smokeless tobacco, 0.98 for snus, and 1.08 for dissolvable tobacco; all comparisons $p<.001$). Participants also believed that smokeless tobacco, snus, and dissolvable tobacco were more likely to cause oral cancer than e-cigarettes (mean differences 1.59, 1.58, and 1.44, respectively; all comparisons $p<.001$).

Correlates of Perceived Risks of E-Cigarette Use

Multivariate analysis of perceived risks of e-cigarette use found that women perceived themselves as more likely to develop health problems from using e-cigarettes ($\beta=0.11$, $p<.01$) than men (Table 4.3). Compared to non-Hispanic whites, non-Hispanic participants of other or multiple races believed themselves to be more at risk from using e-cigarettes ($\beta=0.08$, $p<.05$), as did Hispanic participants ($\beta=0.14$, $p<.01$). Neither intention to quit smoking nor use of e-cigarettes was associated with perceptions of the health risks of e-cigarettes.

Discussion

We aimed to understand smokers' perceptions of the likelihood that tobacco products would cause them to develop lung cancer, oral cancer, and heart disease. Because respondents were smokers and the survey item about alternative products appeared directly after a similar item about regular cigarettes, we believe that smokers treated regular cigarettes as a benchmark for establishing risk. Their expressed beliefs about the other products reflected a comparison to regular cigarettes, although this comparison was not necessarily scientifically accurate. One of the key safety advantages of OTPs over cigarettes is the lack of combustion.^{140,141} If participants understood this distinction, they would have described all

four OTPs as consistently less harmful than regular cigarettes, but their views varied by product type and health problem.

As hypothesized, smokers believed that e-cigarettes were less likely to cause health problems than regular cigarettes (Hypothesis 1). This response could reflect the process participants used to arrive at their judgments of health risks. Instead of careful reasoning, smokers may use mental shortcuts or heuristics related to perceived “goodness” or “badness,” a process known as the affect heuristic.¹⁴⁸ Participants may have had a positive affective response to e-cigarettes, which have been branded as fashionable, new, and safe¹⁴⁹ compared to regular cigarettes, which are likely viewed as outmoded, old, and unhealthy. Exposure to pro-e-cigarette messages could drive these impressions. Two of the most common ways that current smokers report learning about e-cigarettes were e-cigarette users and advertisements on television, both of which likely tout the advantages of the product.^{132,150} Positive messages about e-cigarettes also appear regularly on YouTube¹⁵¹ and in online ads.¹³⁵ In addition, Rogers’ diffusion of innovation theory suggests that smokers might hold this positive view because e-cigarettes are novel products and thus perceived to have relative advantages (including, potentially, healthfulness) over the product they are replacing, i.e., regular cigarettes.⁹³ Although snus and dissolvable tobacco are also novel products, they may be too different in form to be considered a replacement for cigarettes.

Although smokers consistently described e-cigarettes as less harmful than regular cigarettes, there was some variation in individuals’ beliefs about e-cigarettes’ healthfulness. Women believed that e-cigarettes were more likely to cause health problems than did men. Women often, although not always,¹⁵² perceive themselves to be at higher risk of developing health problems than men,¹⁵³ and that includes smoking-related cancer.¹⁵⁴ Because boys are

socialized to be strong, take risks, and avoid seeking help, men—particularly those with stronger masculine identity—are more likely than women to see themselves as invulnerable.¹⁵³ Additionally, women may feel at increased risk because they are often more involved with family life than men, so they could be exposed to more cases of cancer among family members and thus believe cancer to be more common.¹⁵⁵ Non-Hispanic Whites perceived themselves at lower risk of experiencing health problems from e-cigarettes than did some other racial and ethnic groups. These differences could reflect participants' understanding that racial and ethnic minorities are more likely to die from some tobacco-related illnesses than non-Hispanic Whites.¹⁵⁶

Past use of e-cigarettes and intention to quit smoking were not related to beliefs about the riskiness of e-cigarettes. These findings may reflect a general lack of variability in perceptions of the likelihood that e-cigarettes cause health problems and a general positive affective response to e-cigarettes.¹⁴⁸ Even though there was no cross-sectional relationship between risk beliefs and use of e-cigarettes, we cannot conclude that these variables are unrelated. Only longitudinal or experimental studies can confirm the behavior motivation hypothesis, i.e., that e-cigarette risk perceptions cause a change in e-cigarette use.¹⁵⁷

As anticipated in Hypothesis 2, participants believed that snus and dissolvable and smokeless tobacco were more likely to cause oral cancer than cigarettes, although this is not objectively true.¹⁴¹ This difference likely relates to the mode of nicotine delivery and the physical act of use. In a 2010 focus group study, young adults expressed particular concern about snus and dissolvable tobacco because those products come in direct contact with the mouth, and thus they perceived them to be likely to cause oral cancer and gastrointestinal disease.⁸⁹ Traditional smokeless tobacco is also placed directly in the mouth, so it might be

perceived similarly. Indeed, people often overestimate the harm of smokeless tobacco,¹¹⁵ an error that is common even among tobacco control professionals.¹⁵⁸

In line with the belief that mode of nicotine delivery affects health risk, smokers viewed regular cigarettes as more likely to cause lung cancer than oral cancer. Respondents may have perceived that cigarettes' primary mode of contact, unlike snus, dissolvable tobacco, or smokeless tobacco, is inhaled smoke. That smokers viewed smokeless tobacco, snus, and regular cigarettes as equally likely to cause heart disease is consistent with this hypothesis; mode of tobacco administration has no clear connection to the heart. The difference between dissolvable tobacco and cigarettes with respect to heart disease appears to be an artifact of that group having slightly higher ratings of the likelihood that cigarettes cause heart disease.

The finding from the exploratory analysis that smokers in our study perceived e-cigarettes to be less harmful than snus, dissolvable tobacco, and smokeless tobacco is consistent with the literature. A recent survey of university students reported similar findings, although the report did not explicitly test these comparisons.¹⁵⁹ The perceived differences between e-cigarettes and the alternative OTPs may reflect exposure to positive messages in e-cigarette marketing. Future studies could explore that hypothesis by comparing the amount and content of advertising for each product.

All studies of perceived health risks, including this one, include an important limitation with respect to measurement. Perceptions of risk can vary by how one asks the question,^{126,160} and there are many ways to ask about risk (e.g., relative versus absolute, numeric vs. semantic response scales). For example, one recent study found that perceptions of harm caused by snus versus cigarettes were not equivalent when participants were asked

directly (i.e., one question asking for an explicit comparison) or indirectly (i.e., one question per product, then comparing ratings).¹⁶¹ Thus the results of the present study may have been influenced by the measure of risk. Further, smokers may be particularly bad at judging risk, regardless of question type, because they engage in defensive processing and thus discount their own risk.¹⁰⁷ Indeed, few smokers believed that they were “very likely” or “extremely likely” to experience any of the health conditions for any of the products.

Additional limitations include that this study only asked about cancer and heart disease, not other conditions like emphysema, and only used single-item measures of risk for each illness. The combination of probability and non-probability samples is also a limitation, although the large probability sample helped us properly weight the non-probability sample. Finally, the cross-sectional design prevents us from establishing whether risk beliefs cause changes in behavior.¹⁵⁷ In spite of these limitations, the data present a clear picture that smokers perceive the health risks of e-cigarettes to be lower than both traditional and alternative tobacco products.

The widespread belief that e-cigarettes are less harmful than other products may be driving their rise in popularity. Should that be the case, our findings suggest that use of alternative OTPs, including novel ones like snus and dissolvable tobacco, are unlikely to increase in the same manner as e-cigarettes. Although using non-combustible tobacco is less risky than cigarette smoking, few data exist on the short- and long-term health effects of e-cigarettes in particular. Additional research is needed to quantify both the absolute risk of using e-cigarettes, as well as the risk of using e-cigarettes relative to that of smoking cigarettes. Future research should also investigate the impact of exposure to e-cigarette advertising and other media on beliefs about e-cigarettes’ harm, how beliefs about e-

cigarettes' harm change over time, and whether those beliefs affect smokers' trajectories of e-cigarette and regular cigarette use. Such research could help the public health community identify and deliver appropriate messages about e-cigarettes' safety.

Table 4.1. Sample Characteristics ($n=6,607$ current smokers)

Characteristic	<i>n</i>	Weighted %
Respondent		
Gender		
Male	2,654	48.8
Female	3,953	51.2
Age, mean (SD)		44.2 (15.2)
Education		
Less than high school	365	9.9
High school	1,777	42.9
Some college	2,976	34.0
Bachelor's degree or higher	1,489	13.2
Race/ethnicity		
Non-Hispanic White	5,179	68.7
Non-Hispanic Black	535	12.6
Non-Hispanic, Other/multiple races	412	6.3
Hispanic	481	12.4
Employment		
Working	3,380	53.6
Not working: laid off or looking for work	855	14.2
Not working: retired, disabled, or other	2,372	32.2
Intention to quit smoking		
In the next year	3,683	53.7
More than 1 year from now	918	15.0
Do not plan to quit	2,006	31.3
E-cigarette awareness and use		
Not aware	296	5.1
Aware but never tried	2,969	44.7
Former user	1,876	29.4
Current user	1,466	20.9
Dissolvable tobacco awareness and use		
Not aware	4,667	71.2
Aware but never used	1,493	22.5
Have used	447	6.3
Household		
Region		
Midwest	1,657	24.3
Northeast	1,123	17.4
South	2,305	39.9
West	1,522	18.4
Household income		
Less than \$25,000	2,038	29.2
\$25,000 - \$49,999	1,983	26.4
\$50,000 - \$74,999	1,313	19.1
\$75,000 - \$99,999	687	14.9
\$100,000 or more	586	10.5

Note. Percentages are weighted, and n 's are unweighted.

Table 4.2. Comparison of Smokers' Perceived Likelihood of Health Problem by Type of Product ($n=6,607$)

	Mean (SD)	β
Lung cancer		
E-cigarettes	1.89 (1.03)	
Smokeless tobacco	2.46 (1.27)	0.19***
Snus	2.47 (1.30)	0.20***
Dissolvable tobacco	2.63 (1.33)	0.25***
Heart disease		
E-cigarettes	1.90 (1.04)	
Smokeless tobacco	2.87 (1.26)	0.32***
Snus	2.88 (1.27)	0.33***
Dissolvable tobacco	2.98 (1.27)	0.35***
Oral cancer		
E-cigarettes	1.89 (1.03)	
Smokeless tobacco	3.48 (1.22)	0.50***
Snus	3.47 (1.22)	0.50***
Dissolvable tobacco	3.33 (1.26)	0.45***

Note. Higher mean scores indicate higher perceived likelihood of a health problem (1= *not at all likely* – 5 = *extremely likely*).

*** $p < .001$.

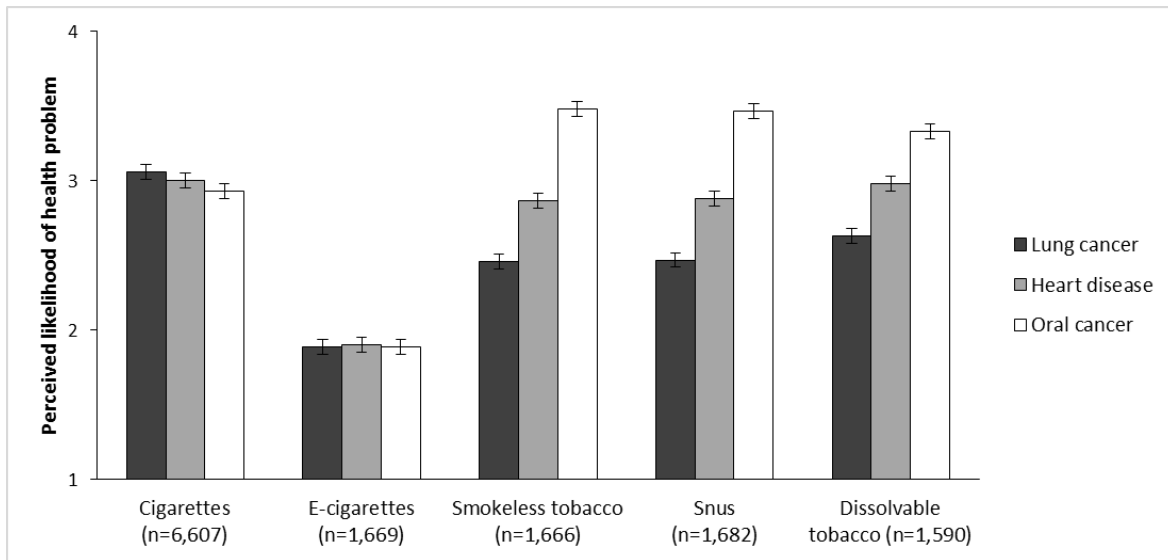
Table 4.3. Correlates of Perceived Likelihood that E-Cigarettes Cause Health Problems
(*n*=1,669)

Characteristic	Mean (SD)	Bivariate β	Multivariate β
Respondent			
Gender			
Male (Ref)	1.80 (0.86)		
Female	2.00 (1.22)	0.10*	0.11**
Age		-0.07	
Education			
Less than high school (Ref)	1.96 (0.85)		
High school	1.85 (0.76)	-0.05	
Some college	1.93 (1.21)	-0.01	
Bachelor's degree or higher	1.93 (1.49)	-0.01	
Race/ethnicity			
Non-Hispanic White (Ref)	1.83 (1.08)		
Non-Hispanic Black	1.83 (0.85)	-0.00	0.00
Non-Hispanic, Other/multiple	2.15 (1.12)	0.07*	0.08*
Hispanic	2.27 (0.85)	0.13**	0.14**
Employment			
Working (Ref)	1.94 (0.97)		
Not working: laid off or looking for work	1.93 (1.16)	-0.00	
Not working: retired, disabled, or other	1.82 (1.08)	-0.06	
Intention to quit smoking			
In the next year (Ref)	1.81 (0.97)		
More than 1 year from now	1.97 (1.12)	-0.06	
Do not plan to quit	1.79 (0.91)	-0.08	
E-cigarette awareness and use			
Not aware or never used (Ref)	1.86 (0.99)		
Former user	1.89 (0.99)	0.01	
Current user	1.99 (1.22)	0.05	
Household			
Region			
Midwest (Ref)	1.90 (1.03)		
Northeast	1.81 (0.94)	-0.04	
South	1.88 (0.97)	-0.01	
West	2.03 (1.26)	0.05	
Household income			
Less than \$25,000 (Ref)	1.89 (1.16)		
\$25,000 - \$49,999	1.97 (1.13)	0.04	
\$50,000 - \$74,999	1.89 (0.96)	0.00	
\$75,000 - \$99,999	1.72 (0.80)	-0.06	
\$100,000 or more	2.00 (1.00)	0.04	

Note. Multivariate model contained correlates significant ($p < .01$) in bivariate models.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Figure 4.1. Perceived health risks of tobacco products. Error bars show standard errors.



CHAPTER 5: EFFECTS OF ADVERTISEMENTS ON SMOKERS' INTEREST IN TRYING E-CIGARETTES: THE ROLES OF PRODUCT COMPARISON AND VISUAL CUES

Introduction

Electronic cigarettes, also called e-cigarettes or electronic nicotine delivery systems, are battery-powered devices that heat cartridges, which typically contain nicotine and humectants, to create a vapor that the user inhales. E-cigarettes are controversial. The scientific community is concerned about safety,^{2,3,142} the product's use as a "gateway" to other tobacco products,⁶ and the possibility of renormalizing smoking.¹⁶² At the same time, e-cigarettes are a non-combustible product that could meet some of the needs of nicotine-addicted smokers and thus hold the potential to be a valuable harm reduction tool for smokers who switch.¹⁴³ Many e-cigarette users also claim that e-cigarettes helped them quit smoking.^{44,49} Longitudinal studies and large surveys are inconsistent in supporting this claim.^{68,163,164} The one randomized controlled trial that compared e-cigarettes to another nicotine replacement therapy did not find a difference between cessation rates for e-cigarettes versus the nicotine patch.¹³⁰

Despite the controversy, e-cigarettes are increasingly popular. Use is particularly high among smokers,^{58,59,132} with 32% of smokers in 2012 and 50% of smokers in 2013 reporting having ever tried e-cigarettes.^{132,137} The glut of e-cigarette advertising could be contributing to e-cigarettes' rise in popularity. Greater exposure to cigarette advertising predicts greater likelihood of smoking initiation.^{165,166} By extension, exposure to e-cigarette advertising may prompt people to start using e-cigarettes. Smokers appear to respond positively to such ads.

In a recent study, two-thirds of smokers who watched a television ad for Blu e-cigarettes indicated interest in trying e-cigarettes after watching the ad, although this study did not use an experimental protocol or measure interest prior to exposure.¹⁶⁷ While we cannot draw a causal inference, rates of use of e-cigarettes have risen^{58,94,132} in tandem with increases in e-cigarette advertising.^{124,168,169}

Television, radio, and print ads and other forms of e-cigarette marketing aimed at smokers often compare e-cigarettes with regular cigarettes.^{124,149,168} Ads describe e-cigarettes as newer, healthier, cheaper, and easier to use in smoke-free situations, all reasons that e-cigarette users claim motivate their use.^{94,132} Advertisers also promote e-cigarettes as a cessation tool, although they often use indirect methods like affiliate marketing^{135,151} to avoid violating a 2010 U.S. district court decision that blocked such claims.¹⁷⁰ Some ads also highlight how e-cigarette use mimics the positive aspects of smoking regular cigarettes, i.e., the social experience or satisfaction.^{135,151}

Smokers' responses to different ads may depend on how they view the comparison between the novel or innovative product (i.e., e-cigarettes) and the traditional one (i.e., regular cigarettes). Unique features of new nicotine products might be attractive in ways that will encourage use.¹⁷¹ Commentary and theory regarding the diffusion of innovation is useful in this regard, as it suggests that adoption of a new technology is faster when the innovation embodies certain key characteristics.⁹³ First, innovations that spread quickly have a *relative advantage* over the object they are replacing (e.g., e-cigarettes cost less than cigarettes). Second, popular innovations are *compatible* with the values, experiences, and needs of the adopter (e.g., using e-cigarettes feels the same as smoking).

Our study sought to better understand the potential for advertising to facilitate diffusion of e-cigarettes to current cigarette smokers. We conducted an experiment testing advertising messages that focus on differences between e-cigarettes and regular cigarettes (i.e., relative advantage) and similarities of the two products (i.e., compatibility). The specific messages we chose to include in these ads are typical messages found in e-cigarette advertising, as shown in recent content reviews.^{124,168,169} Based on our observation that many e-cigarette ads depicted a person using an e-cigarette, we also aimed to understand why such ads might be particularly persuasive. We chose three images (a woman using an e-cigarette, a man not using an e-cigarette, and an e-cigarette kit) to determine which feature of the ad (that it showed a person, the product, or a person interacting with the product) produced the greatest interest.

We predicted that ads emphasizing the differences (i.e., relative advantages) between e-cigarettes and regular cigarettes would elicit more interest in trying e-cigarettes than control ads, because many smokers view cigarettes as unhealthy,¹⁷² are aware of the substantial stigma attached to smoking,^{127,128} and want to quit.¹⁷³ We expected less benefit of ads emphasizing their similarities (i.e., compatibility), because smoking is a stigmatized activity even among smokers.¹²⁸ We also predicted that smokers would be more interested in trying e-cigarettes when shown an ad depicting a person using an e-cigarette compared to ads with other images. Images of smoking cause cravings among smokers,^{174,175} so seeing someone use a similar-looking product could elicit desire to use the product.

Methods

Sample

In March 2013, 17,522 U.S. adult (age 18 or older) smokers and non-smokers completed an online survey as part of the Tobacco Control in a Rapidly Changing Media Environment study. Seventy-five percent of respondents came from KnowledgePanel, a nationally representative online survey panel constructed using random-digit dialing supplemented by address-based sampling to account for cell phone-only households. A convenience sample of adults who responded to online ads comprised the remaining 25%; the survey company screened their names and addresses, removed duplicates, and quota matched to the probability sample based on demographics and tobacco use characteristics. Of the 34,097 KnowledgePanel members sampled, 61% completed the screening, and 97% of those who were eligible completed the online survey. Response rate data for the convenience samples are not available because there is no known sampling frame. For this study, we report data from current smokers (those who reported smoking every day or some days) who had never tried e-cigarettes ($n=3,253$). All participants provided consent online before beginning the survey. Institutional review boards at the National Cancer Institute and the University of Illinois at Chicago approved the study.

Procedures

We randomly assigned participants to one of 9 conditions in a 3 (image in ad) X 3 (type of comparison) between-subjects factorial experiment. An advertising agency designed the ads (Figure 5.1) with a mock e-cigarette brand, “Evermist e-cigs.” The *ad image* showed a person using an e-cigarette (a woman using an e-cigarette with a red glowing tip), a rechargeable e-cigarette kit, or no e-cigarette (a man looking at a laptop computer screen).

Each ad had one of three headlines, which indicated a *comparison type* (difference, similarity, or neither (i.e., control)). The difference ads had the headline, “Better than a cigarette” accompanied by one of four *ad messages* (costs less, use anywhere, healthier, and helps to quit smoking) that emphasized the differences between the products. The similarity ads had the headline, “Just like a cigarette” accompanied by one of three ad messages (feels the same as smoking, relieves your cravings, and still smoke with friends) that emphasized the similarities between e-cigarettes and regular cigarettes. The control ads (no comparison) had the headline, “E-cigarettes” accompanied by a message (great to use) that did not emphasize differences similarities or differences.

Measures

While viewing the ad, participants responded to the item, “How much does seeing this ad make you want to try e-cigarettes?” using a 5-point scale (“not at all” (coded as 1), “a little bit” (2), “a moderate amount” (3), “quite a bit” (4), and “a great deal” (5)).

Data Analysis

To check whether random assignment created demographically equivalent groups by comparison type (similarity, difference, and control), we used chi square tests for categorical demographic variables (gender, education, race/ethnicity, employment status, and income) and linear regression for the continuous demographic variable (age). We repeated these tests for ad message and for the other experimental manipulation, ad image.

We examined the effects of the experimental manipulations on interest in trying e-cigarettes using a 3 X 3 ANOVA. The factors were comparison type and ad image. Because the interaction was not statistically significant ($p=.20$), we repeated the ANOVA model without the interaction term. We used a Bonferroni correction to adjust for multiple

comparisons. We also used ANOVA to confirm that there was no interaction between the experimental manipulations and the sampling method (i.e., whether the experimental findings differed for respondents recruited through convenience versus probability sampling) ($p > .05$ for both interactions). For descriptive purposes, we conducted a linear regression to determine if interest in trying e-cigarettes varied by the specific ad message (relieves cravings, costs less, etc.), using the control message (great to use) as the reference category. We also conducted an ANOVA testing a possible interaction between specific ad message and image on interest in trying e-cigarettes. The interaction was not significant ($p = .36$), so we do not report it here.

Data are not weighted because of the experimental design. Analyses with Stata Version 12 used two-tailed statistical tests and a critical α of 0.025 for the ANOVA and .05 for the linear regression.

Results

The majority of participants were female (59%) and non-Hispanic White (77%) and had at least some college education (67%) and an annual household income less than \$50,000 (62%) (Table 5.1). About half (48%) were currently working, and the mean age was 50 years (standard deviation 15 years). Fifty-one percent intended to quit smoking in the next year and 14% more than one year from now, while 35% did not intend to quit smoking. Demographic characteristics of participants were equivalent across experimental conditions (all $p > .05$, Table 5.2).

Interest in trying e-cigarettes varied by comparison type ($F(2, 3248) = 3.94, p < .025$). One type of comparison ad generated effects on viewer interest: Ads that emphasized the

differences between cigarettes and e-cigarettes (mean interest 2.08) created more interest than control ads (mean 1.89, $p < .05$) (Table 5.3; Figure 5.2). The other type of comparison ad did not generate such differences: Smokers reported similar interest in trying e-cigarettes after viewing control ads and ads that emphasized similarity (mean 2.04, $p = .06$).

As for the specific comparison claims, advertisements elicited greater interest in trying e-cigarettes when they had messages stating that e-cigarettes differed from regular cigarettes because they were healthier than cigarettes (mean 2.12, $p < .01$), were less expensive than cigarettes (2.09, $p < .05$), or were helpful to quit smoking (2.06, $p < .05$) as compared to the control message (1.89) (Table 5.3). Interest in trying e-cigarettes was also higher when the ad stated that e-cigarettes were similar to cigarettes because they could be used with friends (2.09, $p < .05$) compared to an advertisement with a control message. The other three experimental messages elicited equivalent interest as the control message.

Interest in trying e-cigarettes also varied by ad image ($F(2, 3248) = 6.95, p < .01$). Ads showing a person using an e-cigarette (mean 2.15) created more interest than ads not showing an e-cigarette (mean 1.98, $p < .01$), but there was no difference between ads showing an e-cigarette kit (mean 2.00) and ads not showing an e-cigarette ($p > .99$) (Figure 5.3).

Discussion

Smokers expressed moderate interest in trying e-cigarettes after viewing the advertisements, but their level of interest varied as a function of comparison type, message, and image. The type of promotional strategy used made a significant difference as to whether an e-cigarette ad generated interest among smokers. The depiction of people actually using

the new product and comparisons that emphasized differences between e-cigarettes and regular cigarettes appeared to have important effects.

Consistent with our prediction, interest was higher among respondents who viewed difference-focused ads compared to the control ad. As a relatively new entry to the U.S market, e-cigarettes are innovative tobacco products. Although both relative advantage and compatibility enhance the likelihood that an innovation will be adopted,⁹³ the old product in this instance, namely regular cigarettes, is stigmatized and unattractive.^{127,128} Indeed, most smokers want to quit.¹⁷³ Thus the innovative tobacco product was more attractive when framed as different from the original, while similarity messages had little or no impact.

The specific ad messages associated with the greatest amount of interest described e-cigarettes' healthfulness, cost, use as a quit tool, and the social experience of use. That responses to messages about health and cessation were more positive than responses to other messages is consistent with the literature; e-cigarette users frequently report these as reasons for use.⁹⁴ In prior survey research, e-cigarettes' cost relative to cigarettes appears to motivate trying the product, although some users find the product to be more expensive than anticipated and may even discontinue use for this reason.^{50,51,94} Although the social experience of using with friends is not as frequently mentioned by current e-cigarette users, it may be that this factor created some of their initial interest in trying the product, as was found here, but did not impact their continued use.

That the message "relieves your cravings" was unrelated to interest is not surprising as research on smokers' subjective and objective experiences show large variability in e-cigarettes' ability to deliver a satisfactory amount of nicotine.^{44,54,79,88} Smokers may be aware of this issue if they have discussed e-cigarettes with other smokers who have tried them.

Indeed, smokers say that e-cigarette users are their most frequent source of information about the product.¹⁵⁰ The message that e-cigarettes can be used anywhere was also not particularly attractive to smokers. This result could reflect a social desirability bias. Smokers might not want to admit that they wish to skirt popular restrictions on smoking.^{176,177} It could also reflect that smokers did not believe the e-cigarettes could indeed be used in this way because of new laws or restrictions or complaints from other people.^{178,179} Unlike the claim “use with friends,” which smokers may have actually experienced in their personal lives, the claim “use *anywhere*” (emphasis ours) is something that they likely know is not objectively true.

The ads that depicted a woman using an e-cigarette were more popular than the ads showing an e-cigarette kit or a man with a laptop. Although we cannot rule out that the increased interest was because of the attractive woman, we suspect that it reflects a type of cross-cue reactivity. As described in the cue reactivity literature, smokers experience cravings when they see images of smoking.^{174,175} In this case, viewing the image of e-cigarette use may also have served as a subliminal cue for craving, which thus increased interest in trying a cigarette-like product. Smokers did not respond this way to the image of the e-cigarette kit not in use, possibly because this image showed a battery charger and tray of cartridges, which make the e-cigarette look less like a regular cigarette. Social learning theory¹⁸⁰ also suggests that seeing someone use an e-cigarette models the behavior, which could motive interest and, later, use.

Our findings have implications for both regulation and public health messaging. If ongoing research finds that e-cigarette use causes health problems or deters significant numbers of smokers from quitting, the public health community will need to discourage e-cigarette use among adult smokers. Future public health campaigns likely would need to use

materials that do not show the product being used, because this appears to be related to increased interest. One editorial recently suggested banning television ads that show smoking behavior, regardless of what product is being smoked.¹⁸¹

The potential effects of advertising on e-cigarette use is concerning. Although e-cigarettes produce fewer harmful emissions than regular cigarettes,¹⁰⁸ they are not harm-free. Moreover, if non-smokers or youth begin using e-cigarettes or if smokers use e-cigarettes in lieu of quitting, there may be a net harm at the population level even if there is a benefit for an individual smoker. Brazil and other countries have banned e-cigarette advertising and the European Union will follow suit beginning in mid-2016.^{182,183} If specific claims are unproven (e.g, e-cigarettes help smokers quit or e-cigarettes have zero toxins), they should not be allowed in advertising even if e-cigarette advertising as a whole is not banned.

Regulations restricting e-cigarette advertising features that appeal to youth are also critical, particularly given the history of marketing regular cigarettes. Camel's Old Joe campaign successfully promoted that brand to youth in the U.S.,¹⁸⁴ and in 1991, the same proportion (over 90%) of 6-year-old children recognized the Old Joe logo as recognized the Disney logo.¹⁸⁵ The 1997 Master Settlement Agreement prevented tobacco companies from using cartoon characters or otherwise targeting youth under age 18 in their advertising. We do not yet know what e-cigarette advertising features or logos will be compelling to young people or the extent to which those features will motivate e-cigarette experimentation. Should future studies like this one find that certain ad design features (e.g., cartoons) appeal to youth, regulations should limit those features. Research in this area is particularly important given the potentially strong appeal of candy- and fruit-flavored e-cigarettes to children.

Limitations to this study include the use of a psychosocial but not behavioral outcome measure. In addition, the majority of experiment participants were recruited through online convenience sampling, which limits the generalizability of the findings to the entire U.S. adult population, although we confirmed that our findings did not differ by sampling method. The experiment elicited relatively small effects; however, given that there were 42 million adult smokers in the U.S. in 2012,¹⁸⁶ small effects could still result in meaningful real-world changes.¹⁸⁷

We chose to design new ads instead of modifying existing ads because we sought to exert greater experimental control than existing ads would permit. By working with an ad agency to design new ads, we were able to maintain the maximum amount of control when varying characteristics (e.g., the ability to change the image without impacting other aspects of the layout). However, these new ads may not have matched the “feel” or effectiveness of real-world ads. Future studies might incorporate real ads to increase the external validity of findings and also use ads with several images, including males using e-cigarettes. In our study, we could not conclude whether smokers were more interested in trying e-cigarettes when shown an image of woman using an e-cigarette because they thought the specific woman depicted was attractive or because she was engaging in a smoking-like behavior. We also did not explore non-smokers’ responses to the ads and did not include a “no ad” condition to establish interest in trying e-cigarettes in the absence of an advertisement.

Finally, one critique of much work in research on communication is that intention to perform a behavior does not necessarily lead to that behavior. Although the intention-behavior gap is well documented in many areas, intentions remain a strong predictor of behavior.¹⁸⁸ Of course, we believe that this gap should not deter regulatory authorities from

instituting appropriate restrictions on e-cigarette advertising. Despite these limitations, the data are compelling and useful for future investigations of new e-cigarette marketing. The randomized design and large national sample are key strengths of the study.

E-cigarettes are a big—and rapidly growing—business. In 2013, sales of e-cigarettes were nearly \$2 billion, and sales are likely to rise to \$10 billion by 2017.¹⁸⁹ Multinational tobacco companies are entering the e-cigarette market by buying existing companies or developing their own products. The involvement of these companies will likely increase the amount, reach, and sophistication of e-cigarette advertising,^{124,149,168} and recent research suggests that exposure to e-cigarette advertising is associated with interest in trying the product.^{167,190} With the new evidence presented in this paper, it is clear that specific types of messages used to promote e-cigarettes are more effective in soliciting interest among current smokers who have yet to try e-cigarettes. Armed with such evidence, public health professionals can monitor e-cigarette marketing across a variety of channels and consider what claims and imagery regulations should address.

Table 5.1. Sample Characteristics ($n=3,253$)

	<i>n</i>	%
Respondent		
Gender		
Male	1,347	41.4
Female	1,906	58.6
Age, mean (SD)		49.6 (14.7)
Education		
Less than high school	174	5.4
High school	897	27.6
Some college	1,363	41.9
Bachelor's degree or higher	819	25.2
Intention to quit smoking		
In the next year	1,668	51.3
More than 1 year from now	440	13.5
Do not plan to quit	1,145	35.2
Race/ethnicity		
Non-Hispanic White	2,506	77.0
Non-Hispanic Black	315	9.7
Non-Hispanic, other or multiple races	199	6.1
Hispanic	233	7.2
Employment		
Working	1,563	48.1
Not working: laid off or looking for work	393	12.1
Not working: retired, disabled, or other	1,297	39.9
Household		
Household income		
Less than \$25,000	1,035	31.8
\$25,000 - \$49,999	982	30.2
\$50,000 - \$74,999	618	19.0
\$75,000 - \$99,999	341	10.5
\$100,000 or more	277	8.5

Table 5.2. Respondent Characteristics by Experimental Condition

Condition (<i>n</i> in condition)		Diff & No EC (559)	Diff & EC Kit (549)	Diff & EC User (557)	Simil & No EC (395)	Simil & EC Kit (392)	Simil & EC User (392)	Control & No EC (137)	Control & EC Kit (145)	Control & EC User (127)
Respondent		<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Gender	Male	244 (43.7%)	231 (42.1%)	212 (38.1%)	160 (40.5%)	167 (42.6%)	161 (41.1%)	58 (42.3%)	57 (39.3%)	57 (44.9%)
	Female	315 (56.4%)	318 (57.9%)	345 (61.9%)	235 (59.5%)	225 (27.4%)	231 (58.9%)	79 (57.7%)	88 (60.7%)	70 (55.1%)
	Age, mean (SD)	49.3 (14.8)	49.9 (15.5)	49.5 (15.5)	48.9 (15.2)	50.1 (14.6)	49.8 (14.9)	50.1 (13.9)	49.3 (14.9)	50.2 (15.4)
	Education									
	Less than high school	32 (5.7%)	26 (4.7%)	34 (6.1%)	22 (5.6%)	19 (4.9%)	20 (5.1%)	9 (6.6%)	8 (5.5%)	4 (3.2%)
	High school	147 (26.3%)	150 (27.3%)	161 (28.9%)	114 (28.9%)	105 (26.8%)	104 (26.5%)	30 (21.9%)	48 (33.1%)	38 (29.9%)
	Some college	233 (41.7%)	243 (44.3%)	224 (40.2%)	165 (41.8%)	181 (46.2%)	161 (41.1%)	57 (41.6%)	56 (38.6%)	43 (33.9%)
	Bachelor's degree or higher	147 (26.3%)	130 (23.7%)	138 (24.8%)	94 (23.8%)	87 (22.2%)	107 (27.3%)	41 (29.9%)	33 (22.8%)	42 (33.1%)
	Intention to quit smoking									
	In the next year	278 (49.7%)	295 (53.7%)	273 (49.0%)	212 (53.7%)	199 (50.8%)	197 (50.3%)	69 (50.4%)	79 (54.5%)	66 (52.0%)
Intention to quit smoking	More than 1 year from now	77 (13.8%)	75 (13.7%)	68 (12.2%)	54 (13.7%)	52 (13.3%)	51 (13.0%)	22 (16.1%)	23 (15.9%)	18 (14.2%)
	Do not plan to quit	204 (36.5%)	179 (32.6%)	216 (38.8%)	129 (32.7%)	141 (36.0%)	144 (36.7%)	46 (33.6%)	43 (29.7%)	43 (33.9%)
	Race/ethnicity									
Race/ethnicity	Non-Hispanic White	447	408	421	302	304	301	107	110	106

	(80.0)	(74.3%)	(75.6%)	(76.5%)	(77.6%)	(76.8%)	(78.1%)	(75.9%)	(83.5%)
Non-Hispanic Black	38	63	59	39	40	40	13	13	10
	(6.8%)	(11.5%)	(10.6%)	(9.9%)	(10.2%)	(10.2%)	(9.5%)	(9.0%)	(7.9%)
Non-Hispanic, other or multiple races	29	38	31	29	25	25	9 (6.6%)	9 (6.2%)	4 (3.2%)
	(5.2%)	(6.9%)	(5.6%)	(7.3%)	(6.4%)	(6.4%)			
Hispanic	45	40	46	25	23	26	8 (5.8%)	13	7 (5.5%)
	(8.1%)	(7.3%)	(8.3%)	(6.3%)	(5.9%)	(6.6%)		(9.0%)	
Employment									
Working	277	263	284	185	177	171	70	77	59
	(49.6%)	(47.9%)	(51.0%)	(46.8%)	(45.2%)	(43.6%)	(51.1%)	(53.1%)	(46.5%)
Not working: laid off or looking for work	61	68	60	50	52	52	14	19	17
	(10.9%)	(12.4%)	(10.8%)	(12.7%)	(13.3%)	(13.3%)	(10.2%)	(33.1%)	(13.4%)
Not working: retired, disabled, or other	221	218	213	160	163	169	53	49	51
	(39.5%)	(39.7%)	(38.2%)	(40.5%)	(41.6%)	(43.1%)	(38.7%)	(33.8%)	(40.2%)
Household									
Household income									
Less than \$25,000	168	180	183	115	137	127	36	45	44
	(30.1%)	(32.8%)	(32.9%)	(29.1%)	(35.0%)	(32.4%)	(26.3%)	(31.3%)	(34.7%)
\$25,000 - \$49,999	163	168	158	136	118	127	38	41	33
	(29.2%)	(30.6%)	(28.4%)	(34.4%)	(30.1%)	(32.4%)	(27.7%)	(28.3%)	(26.0%)
\$50,000 - \$74,999	113	115	113	69	60	66	28	34	20
	(20.2%)	(21.0%)	(20.3%)	(17.5%)	(15.4%)	(16.8%)	(20.4%)	(23.5%)	(15.8%)
\$75,000 - \$99,999	69	47	50	36	47	41	20	15	16
	(12.3%)	(8.6%)	(9.0%)	(9.1%)	(12.0%)	(10.%)	(14.6%)	(10.3%)	(12.6%)
\$100,000 or more	46	39	53	39	30	31	15	10	14
	(8.2%)	(7.1%)	(9.5%)	(9.9%)	(7.7%)	(7.9%)	(11.0%)	(6.9%)	(11.0%)

Note. Diff = difference, Sim = similarity, No EC = no electronic cigarette, EC kit = e-cigarette kit, EC user = woman using e-cigarette.

Table 5.3. Interest in Trying E-Cigarettes, By Ad Characteristics

Comparison type	Ad headline	Mean (SD)	Ad message	Mean (SD)
Control	E-Cigarettes	1.89 (1.10)		
Similarity	Just like a cigarette	2.04 (1.17)	Great to use	1.89 (1.10)
			Feels like smoking	1.99 (1.14)
			Relieves cravings	2.05 (1.14)
			Use with friends	2.09 (1.23)*
Difference	Better than a cigarette	2.08 (1.19)**	Use anywhere	2.04 (1.22)
			Helps you quit	2.06 (1.12)*
			Costs less	2.09 (1.20)**
			Healthier	2.12 (1.23)**

Note. Higher means indicate greater interest in trying e-cigarettes (1= *not at all* – 5 = *a great deal*).

Comparison to control headline/message * $p < .05$, ** $p < .01$.

Figure 5.1. Four of twenty-four advertisements used in the experiment.

Comparison type: difference. Image: no e-cigarette.



Comparison type: similarity. Image: e-cigarette kit.



Comparison type: Control. Image: person using e-cigarette.



Comparison type: Difference. Image: person using e-cigarette.



Figure 5.2. Effect of comparison type on interest in trying e-cigarettes. Error bars show standard errors.

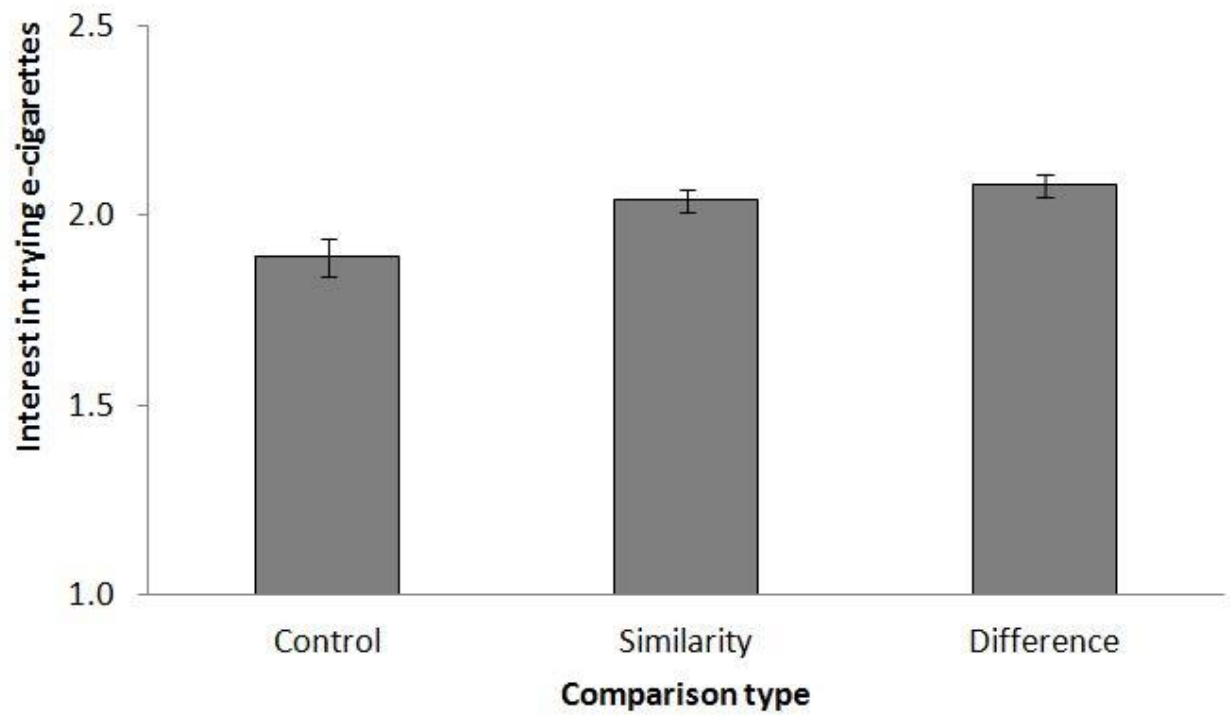
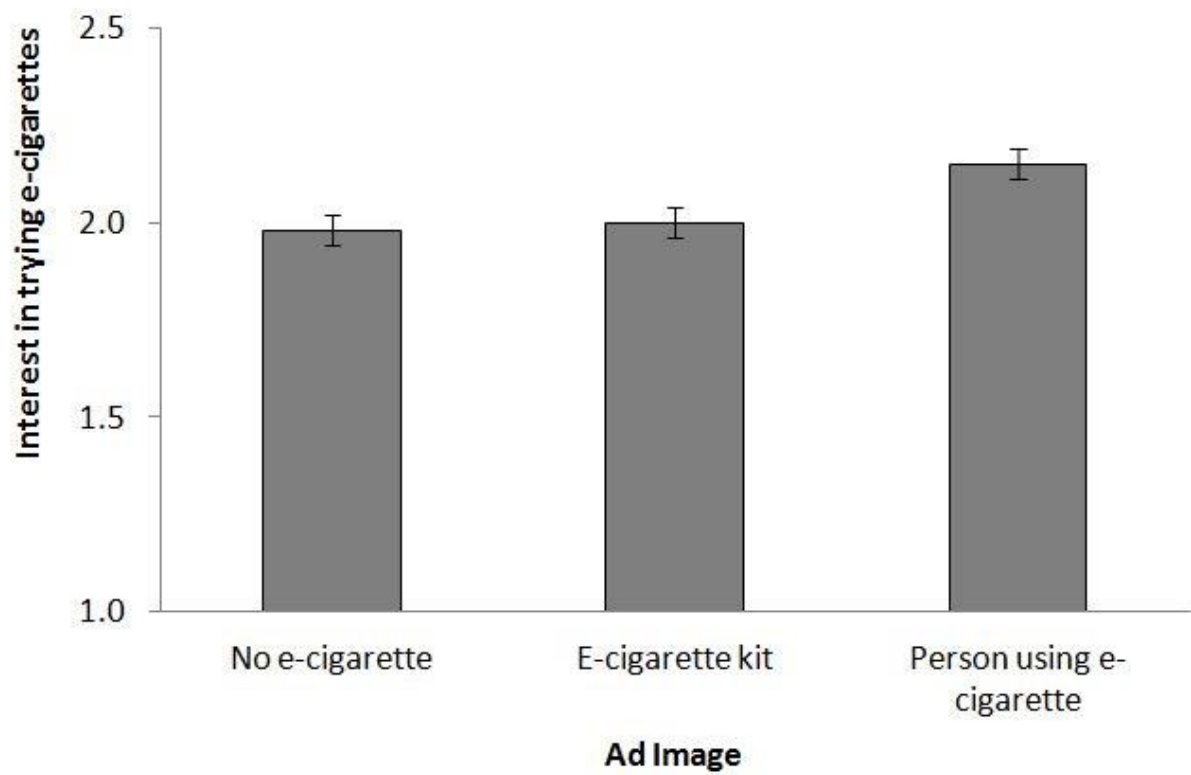


Figure 5.3. Effect of advertisement image on interest in trying e-cigarettes. Error bars show standard errors.



CHAPTER 6: DISCUSSION

Electronic Cigarettes and Diffusion of Innovation

The three manuscripts comprising this dissertation are united by a common theoretical model, diffusion of innovation (DOI).⁹³ Rogers' DOI model describes how an innovative technology spreads in a population through five stages: knowledge (an individual learns of the innovation and how it functions), persuasion (the individual forms an attitude), decision (the individual chooses to adopt or reject the innovation), implementation (the individual begins to use it), and confirmation (the individual seeks reinforcement of or decides to reject the previous choice).

E-cigarettes as an Innovation

A technology does not necessarily need to be new to be considered an innovation. Although e-cigarettes have been available in the United States since 2006, the content of media coverage and advertising^{123,124,149} and the trends in awareness and use^{94,132} suggest that the public perceives them as new. Indeed, e-cigarettes embody the hallmarks of an innovative technology, particularly from the point of view of their primary consumers, current and former smokers.^{94,132}

E-cigarettes have a *relative advantage* over regular cigarettes, the product they supersede. Compared to regular cigarettes, e-cigarettes are (or are perceived to be) cheaper, cleaner, healthier, and more modern.⁹⁴ E-cigarettes have social cachet, while regular cigarettes and those who use them are stigmatized.^{127,128,149,191}

E-cigarettes demonstrate *compatibility* with the needs of their users. Although most smokers want to quit, they are addicted to nicotine and few quit successfully.¹⁷³ Nicotine-replacement therapies (NRTs), including products like the patch or gum and pharmacologic therapies like varenicline, are unpopular,¹⁹² perhaps because they deliver nicotine slowly and are not compatible with smokers' needs. Unlike e-cigarettes, these other NRTs do not mimic the feel of holding a cigarette, drawing on it, and inhaling the smoke or the social experience of smoking with friends.⁴⁹ E-cigarettes can be sufficiently compatible that some former smokers even say that their identity as a smoker has been replaced by a new identity as an e-cigarette user or "vaper."⁴⁹

E-cigarettes exhibit *trialability*. Naïve users can purchase a disposable e-cigarette at a gas station for less than ten dollars. In the United Kingdom, some point-of-sale displays allow consumers to sample e-cigarettes.¹⁹³ Half of smokers have now tried e-cigarettes.¹³⁷ Because smokers gather together with other smokers in social and family groups,^{97,98} smokers likely know e-cigarette users who can let them try a puff. Interested individuals do not have to make a long-term investment to see if they enjoy and want to adopt this innovation.

Use of e-cigarettes is public, so they have a high degree of *observability*. E-cigarettes are widely advertised on television, promoted by celebrities, and discussed in the media.^{20,123,149,168} They are available at convenience stores and other frequently visited outlets. The blue glowing tips of Blu e-cigarettes, the most popular U.S. brand,¹⁹⁴ are clearly visible. Each time that e-cigarettes are observed represents a new opportunity for discussion and trial.

E-cigarettes exhibit varying degrees of the final aspect of an innovation, *complexity*. Disposable models are simple to operate. However, non-disposable e-cigarettes have many components (i.e., battery, heating element, and cartridge) that can malfunction⁴³ or do not work in combination.⁵⁰ In addition, some users report experiencing initial frustration as they learn to inhale the e-cigarette vapor in a way that allows them to obtain the desired dose of nicotine.⁵⁰

The more of these five aspects of an innovation a product has and the more desirable those qualities are, the faster users will adopt it.⁹³ That e-cigarettes embody the main features of an innovation could help account for the dramatic increase in prevalence of their use. In essence, the main audience for the product (i.e., current and former smokers) may see e-cigarettes as an innovative replacement or addition to cigarettes; e-cigarettes, compared to regular cigarettes, are essentially “the same—but better.” The marketing tagline for NJOY, the second most popular e-cigarette brand in the United States,¹⁹⁴ captures this idea: “You know the most amazing thing about this cigarette? It isn’t one.”

Given that many e-cigarette users also continue to smoke, even if it is a reduced amount,⁹⁴ e-cigarettes currently on the market are probably not good enough to render cigarettes obsolete. The high rates of dual use suggest that some aspect of the innovation does not meet smokers’ needs, perhaps the strength and consistency of nicotine delivery. Some users say that e-cigarettes do not satisfy their cravings.⁴⁴ Some do not like their flavor or find them too expensive.⁴³ A disposable e-cigarette can cost more than a pack of cigarettes. Although refills of e-juice are inexpensive, refillable e-cigarettes require an initial investment of at least \$20 and up to \$90 for a starter kit.^{195,196}

A small proportion of e-cigarette users (5% in 2013)¹³⁷ are not current or former smokers. For these users, e-cigarettes are not a replacement or complement to a product they are using. However, this group of users may be people who were highly susceptible to smoking, but simply started using e-cigarettes before they could begin smoking. Thus e-cigarettes could be an attractive alternative (one with relative advantage, trialability, etc.) to a product they intended to try.

Relationship of Dissertation Findings to Diffusion of Innovation

Chapter 3 focused on the first phase of the diffusion process, knowledge. We found that 86% of U.S. adults in 2013 were aware of e-cigarettes, up from 16% in 2009.⁵⁸ “Early knowers,” according to Rogers’ model, tend to have higher education, higher social status, more social participation, and greater exposure to mass media and interpersonal channels of information than do “late knowers.”⁹³ Although overall rates of awareness are too high to consider those who were aware of e-cigarettes to be early knowers, our results were still consistent with this general pattern. Specifically, we found that adults with at least a college education were more likely to have heard of e-cigarettes than those with less than a high school education. Non-Hispanic Whites, a demographic group that tends to have relatively high socioeconomic status,¹⁹⁷ or what Rogers might term “social status,” had greater awareness than other races and ethnicities. Awareness also was negatively associated with age, and younger adults were more likely to hear about e-cigarettes online than older adults. Younger adults may be earlier knowers because they participate more in social media,¹⁰⁰⁻¹⁰² a channel that encompasses both mass media and interpersonal communication. Finally, current and former smokers, who had the highest rates of awareness, were more likely to hear about e-cigarettes from users than were never smokers. This finding suggests that smokers’

homophily with other smokers⁹⁸ presents an opportunity for learning about e-cigarettes through social participation and interpersonal channels, precisely as Rogers' DOI model described.

Chapter 4 focused on the persuasion stage by describing smokers' perceptions of the risks of health harms from using e-cigarettes and other novel and traditional tobacco products. The persuasion stage is marked by the development of favorable and unfavorable attitudes. We found that smokers consistently rated e-cigarettes as less likely to cause lung cancer, oral cancer, and heart disease compared to regular cigarettes and other tobacco products (OTPs), namely smokeless tobacco, snus, and dissolvable tobacco. One contributing factor to the rise in popularity of e-cigarettes, which has not been matched by the alternative OTPs, could be that smokers view e-cigarettes as not only healthier than regular cigarettes (i.e., relative advantage), but also more similar in style and use compared to regular cigarettes (i.e., compatibility) than the alternative OTPs. Relative advantage and compatibility are particularly important for shaping attitudes during the persuasion change.⁹³

Chapter 5 tested hypotheses about the persuasion stage. Advertising not only spreads information during the knowledge stage (as evidenced by the first chapter), but also contributes to attitude formation during the persuasion stage. We found that, for smokers who had never tried e-cigarettes, ads emphasizing the relative advantages of e-cigarettes over cigarettes (e.g., healthier, cost less, helpful to quit smoking) created more interest than ads without comparisons, but ads emphasizing compatibility (e.g., feels the same as smoking) did not. Both relative advantage and compatibility are positive aspects of an innovation that promote its uptake. However, in this instance, the product that the innovation aims to unseat does not have entirely positive connotations. Smoking is a stigmatized activity.^{127,128,191} Even

smokers recognize that regular cigarettes are bad for their health,¹⁷² and most want to quit.¹⁷³ Thus it is not surprising that the innovation was most attractive when framed as different from the original.

Although both focused on the persuasion stage, Chapters 4 and 5 have implications for the decision and implementation stages. The degree to which smokers view e-cigarettes as healthier than other tobacco and nicotine options and find messages about their positive attributes appealing could influence their decisions about uptake and the likelihood that they use the product.

Strengths and Limitations

Taken as a whole, these three papers tackle a breadth of research questions and populations of interest, from purely descriptive to experimental and from all U.S. adults to a specific group (i.e., smokers susceptible to e-cigarette use). All three studies benefited from a large national sample. Although the parent study used a combination of probability and convenience sampling strategies, the large probability sample and use of quota sampling techniques helped us match the convenience sample to the probability sample as closely as possible. To enable more accurate population estimates, I also weighted the data for the analysis in the first two chapters. I did not weight the data during the analysis of the third chapter because this was a randomized experiment and not meant to generalize to a population. These projects also benefited from their recency; the landscape of e-cigarette use and research is changing rapidly, and there is little 2013 data that has yet appeared in the literature.

An additional strength of the third study is its novelty. To my knowledge, there are no published articles using an experimental approach to explore reactions to e-cigarette advertising. The stimuli I used were basic print ads; that I found any differences based on these minimal stimuli suggests that more sophisticated ads could produce more robust effects. A possible critique of the study is that I included an ad that is not realistic because it explicitly promoted e-cigarettes as a cessation tool even though a court decision prohibits advertisers from making this claim unless they want the product to be regulated as a drug or device. However, I felt it appropriate to include this claim because advertisers frequently skirt this ruling by using affiliate marketing and other indirect promotional strategies.^{135,151}

In addition to the specific limitations that the individual manuscripts discussed, several limitations cut across the papers. First, e-cigarettes are part of a class of products called electronic nicotine delivery systems or personalized vaporizers. This survey included only “traditional” e-cigarettes modeled after regular cigarettes rather than encompassing this broader class. Prior to answering any questions about e-cigarettes, the survey introduced e-cigarettes as follows: “An e-cigarette looks like a regular cigarette, but it runs on a battery and produces vapor instead of smoke. There are many types of e-cigarettes. Some common brands are Smoking Everywhere, NJOY, Blu, and Vapor King. Below are some pictures of e-cigarettes.” The pictures that accompanied the text (Figure 6.1) showed e-cigarettes with the same shape and coloring as regular cigarettes. To be inclusive of other styles, the introductory statement might have said that e-cigarettes have multiple names (e.g., “vape pen”) and can, but do not always, look like regular cigarettes. The picture might have included examples of alternative types of e-cigarettes that do not look like regular cigarettes (Figure 6.2).

These research papers relied on cross-sectional data with no behavioral outcomes. Thus I cannot conclude that information sources, risk perceptions, or ad exposure cause changes in patterns of e-cigarette use. To prove such effects, we would need longitudinal studies with assessments at baseline and follow-up. This deficit is common across the e-cigarette literature; few studies track the same group of participants over time using behavioral outcomes.

Finally, although these projects used a diffusion of innovation framework, they did not explicitly test this model. For example, I did not use existing measures¹⁹⁸ or develop measures to assess whether participants viewed e-cigarettes as innovative. Thus I cannot conclude that diffusion of innovation is the driver of our results, although I suspect it is.

Future Directions

I am interested in pursuing two lines of research on e-cigarettes that follow from my dissertation and similarly focus on the DOI framework. The first will track e-cigarettes through the remaining stages in the innovation adoption process: decision (the individual undertakes behaviors that lead to a choice about using e-cigarettes), implementation (the individual begins using e-cigarettes), and confirmation (the individual chooses to continue or stop using e-cigarettes). To understand decisions, I will examine users' reasons for trying e-cigarettes based on additional data I collected through the TCME survey. I asked e-cigarette users to endorse all of the reasons and then the main reason they tried e-cigarettes. The possible response options included, among others: "e-cigarettes come in flavors I like," "they might be less harmful to people around me than regular cigarettes," "e-cigarettes don't smell bad," "they help me deal with cravings to smoke," and "I was curious about e-cigarettes." I

also asked TCME survey participants who had tried but no longer used e-cigarettes to endorse all of the reasons and the main reason they stopped using e-cigarettes, i.e., the choice that occurs during the confirmation stage. The possible response options included: “I didn’t like how they tasted,” “E-cigarettes are poor quality, defective, or break easily,” “I didn’t like the side effects of using them,” and “I was just experimenting with e-cigarettes.” By analyzing these data and exploring demographic correlates, I can understand how different individuals move through the final stages of the DOI process from decision to confirmation.

In an additional line of research, I want to use the DOI framework to understand the innovation adoption process of other, similar products. E-cigarettes are part of an ever-expanding class of electronic nicotine delivery products. Some of these products (e.g., NJoy e-cigarettes) try to mimic the exact appearance of regular cigarettes. Other, newer products distinguish themselves with different colors (e.g., Blu e-cigarettes), shapes (e.g., tank models), or names (e.g., “e-hookah” or “vape pen”).¹⁹⁹ I am interested in tracking these newer products, particularly ones that use a different name but operate like “traditional” e-cigarettes, with the DOI framework as well. Does knowledge spread through the same channels at the same rate? Do beliefs about the health risks vary by whether the product includes the word “cigarette” in its name or how much the product looks like a cigarette? Do smokers still respond positively to messages about the relative advantage of e-cigarettes over cigarettes when the e-cigarette no longer resembles a cigarette or goes by that name? Answering these and other research questions will help clarify the applicability of the DOI model to a larger range of novel nicotine products, not just traditional e-cigarettes.

Conclusion

The current public health value of e-cigarettes is largely unknown: safety information is inconsistent, data on cessation are not conclusive, and no longitudinal research yet establishes whether e-cigarettes serve as a gateway to other tobacco use. This dissertation explores exposure to information, beliefs, and responses to messages about “traditional” e-cigarettes, but ultimately, innovations like e-cigarettes are not static. Rather, as they diffuse, adopters change them to fit their needs, a process that Rogers describes as *re-invention*.⁹³ E-cigarette users and manufacturers have already changed the product, and the entry of multinational tobacco companies into the e-cigarette market may hasten further change.²⁵ As described by the DOI model, greater re-invention leads to faster and more sustainable adoption. If this prediction holds true, e-cigarette use will likely continue to increase in tandem with the product’s evolution to fit the changing needs of the user. Simply put, e-cigarettes are not going away any time soon. Research on e-cigarettes will need to keep pace with the continuing evolution and diffusion of this innovation.

Figure 6.1. Pictures of e-cigarettes included in the TCME survey.



Figure 6.2. Alternative types of electronic nicotine delivery products: e-hookah and e-cigarette tank model.



1 st Author (year)	Brief Study Description	Rates of Awareness	Rates and Amount of Use	Reactions to Own Use (Users Only)	Beliefs about and Reasons for Use (Users and Non-Users)
Adkison (2013) ⁶¹	Survey of current and former smokers (<i>n</i> =5,939).	47% had heard of ENDS. Higher among: US and UK (vs. Canada or Australia), young, higher educ, higher income, male, white. Heavy smokers had greatest awareness. Long term quitters had lowest.	<u>Ever use</u> : 8% had ever tried ENDS. Higher among: US and UK, females, younger, higher income, perceived ENDS less harmful than cigs. Highest use among non-daily smokers and lowest among long-term quitters. Use not associated with quit intentions. <u>Current use</u> : 3% were current users. Highest use among daily heavy smokers and non- daily smokers.		<u>Health</u> : 70% of respondents aware of ENDS believed they were less harmful than cigs. Varied by country. Of users, 80% used ENDS in order to reduce harm. <u>Quit</u> : 85% used ENDS to help them quit smoking and 75% to help them reduce smoking. <u>Restrict</u> : 70% used ENDS to get nicotine in smoke-free places.

Barbeau (2013) ⁴⁹	Focus groups with ENDS users ($n=11$).	-	<u>Dual use</u> : 1 of 11 (9%) was a current smoker.	<p><u>Quit</u>: ENDS helped users quit smoking, but not necessarily quit using nicotine. Had more success quitting with ENDS than other NRTs.</p> <p><u>Satisf</u>: Enjoyed the flavors and variety of devices.</p> <p><u>Similar</u>: ENDS use mimicked the feel of smoking cigs. Had same daily routine with ENDS as with cigs. Similarity of ENDS to cigs made it easier to switch from cigs to ENDS.</p> <p><u>Withdraw</u>: ENDS alleviated withdrawal symptoms.</p>	<p><u>Health</u>: Believed ENDS were a safer form of nicotine delivery.</p> <p><u>Quit</u>: Believed ENDS were better quit aids than other NRTs.</p>
Bullen (2010) ⁵³	Randomized, repeated measures trial of 0 mg nicotine ENDS, 16 mg nicotine ENDS, cigs, and Nicorette inhalators ($n=40$).	-	-	<p><u>Health</u>: Experienced few adverse events with ENDS use. Most common were mouth/throat irritation (38%), nausea (29%), vertigo (21%), headache (18%).</p> <p><u>Satisf</u>: 16 mg nicotine ENDS was moderately satisfying and more pleasant than inhalator.</p> <p><u>Similar</u>: Nicotine ENDS considered best alternative to cigs.</p> <p><u>Withdraw</u>: ENDS with nicotine were better at reducing desire to smoke than ENDS without nicotine.</p>	<p><u>Quit</u>: Believed that 16 mg nicotine ENDS would be better than for own or friends' quit attempts than 0 mg nicotine ENDS or inhalator.</p>

Caponnetto (2011) ⁸⁶	Case reports of smokers (n=2).	-	Participant 1 no longer used ENDS after quitting cigs. Participant 2 continued using ENDS after quitting.	<u>Health</u> : Dry cough for Participant 2. <u>Quit</u> : Both participants quit smoking after a few weeks or months of ENDS use. Both had previously failed to quit using other NRTs.	-
Caponnetto (2011) ⁸⁰	Case reports of smokers (n=3).	-	2 of 3 participants continued using ENDS after quitting smoking.	<u>Health</u> : Dry cough for Participant 2. Participant 3 reported improved energy and no exacerbations of chronic lung disease. <u>Quit</u> : All 3 quit smoking after previously failing to quit using other NRTs.	<u>Quit</u> : All 3 began using ENDS to help quit smoking and believed they would not have been able to quit without ENDS.
Caponnetto (2013) ⁷⁶	12-month prospective trial of ENDS use among smokers (n=14).	-	<u>Dual use</u> : At week 52, some participants who reduced smoking were still using ENDS (% not reported). <u>Amount</u> : Mean of 1 ENDS cartridge (SD 1) used per day over the course of the study.	<u>Health</u> : No serious adverse events. Infrequent reports of dry cough, headache, nausea at early study visits. No change in symptoms of schizophrenia. <u>Quit</u> : At week 52, 14% quit smoking and another 50% reduced number of daily cigs by at least half. <u>Withdraw</u> : Participants did not experience withdrawal symptoms.	-

Caponnetto (2013) ⁷⁷	12-month randomized trial comparing use of nicotine ENDS to non-nicotine ENDS (n=300).	-	<p><u>Dual use</u>: At week 52, some participants who reduced smoking were still using ENDS (% not reported).</p> <p><u>Amount</u>: Median of 2 cartridges per day at early visits (weeks 2-10), and 0 per day at week 24 and week 52 visits.</p>	<p><u>Health</u>: No serious adverse events. 20% reported shortness of breath at baseline, but dropped to 4% by week 2. Similar patterns for cough, dry mouth, throat irritation and headache.</p> <p><u>Quit</u>: At week 52, in the nicotine ENDS group, 13% quit and another 10% reduced cigs by at least half. 4% of the non-nicotine ENDS group quit and 12% reduced cigs by at least half. No statistical difference between groups.</p> <p><u>Satisf</u>: Low satisfaction, but higher ratings of “would recommend to friend.”</p> <p><u>Withdraw</u>: Few withdrawal symptoms reported. At week 2, 7% reported hunger, 4% insomnia, 4% irritability, 3% anxiety, and 2% depression.</p>	-
Chen (2013) ⁸²	Description of 47 ENDS adverse event reports.	-	-	<p><u>Health</u>: 17% of reports were serious adverse events (e.g., pneumonia, burns, seizure). Other health effects were minor (e.g., headache, cough, nausea).</p>	-
Cho (2011) ⁶³	Survey (n=4,341).	10% had heard of ENDS. Most common sources were the Internet (46%) and friends (28%).	<p><u>Ever use</u>: <1% overall had tried ENDS. Higher among males, ever smoked cigs.</p>	-	-

Choi (2012) ⁸⁹	Focus group of tobacco- users and non-users (<i>n</i> =66).	-	-	-	<p><u>Gateway</u>: Believed that ENDS could bring people closer to smoking cigs.</p> <p><u>Health</u>: Disagreement and uncertainty about health effects of ENDS.</p> <p><u>Quit</u>: Disagreement about whether ENDS help smokers quit. Anecdotes about others' successfully quitting.</p> <p><u>Restrict</u>: Believed that ENDS could be used anywhere and helped tobacco companies bypass smoking bans.</p> <p><u>Similar</u>: Believed smokers will only use ENDS if mimic feel of cigs.</p> <p>Different social experience with using ENDS than with smoking cigs.</p> <p><u>Withdraw</u>: Believed that people might become addicted to ENDS.</p>
------------------------------	--	---	---	---	--

Choi (2013) ⁶⁵	Survey (n=2,624).	70% had heard of ENDS. Higher among: males, higher educ, current and former smokers, at least 1 close friend who smokes.	<p><u>Ever use</u>: 7% had ever used ENDS. Of those aware of ENDS, higher use among: younger, male, current or former smoker, at least 1 close friend who smokes, believe ENDS less harmful, believe ENDS can help people quit smoking.</p> <p><u>Current use</u>: 1% had used in past 30 days.</p>	-	<p><u>Health</u>: 53% believed ENDS less harmful than cigs.</p> <p><u>Quit</u>: 45% believed ENDS can help smokers quit.</p> <p><u>Withdraw</u>: 26% believed ENDS less addictive than cigs.</p>
Dawkins (2012) ⁸⁸	Randomized trial of 18 mg nicotine ENDS, 0 mg nicotine ENDS, or just holding ENDS (n=86).	-	-	<u>Withdraw</u> : Desire to smoke declined for both 18 mg and 0 mg ENDS versus just holding an ENDS. Some reductions in withdrawal symptoms (e.g., anxiety, poor concentration). Experiences varied by gender.	-
Dawkins (2013) ⁸⁷	Randomized trial of 0 mg nicotine ENDS and 18 mg nicotine ENDS (n=20).	-	-	<u>Withdraw</u> : Desire to smoke and withdrawal symptoms were lower with 18 mg nicotine ENDS than 0 mg nicotine ENDS.	-

Dawkins (2013) ⁴²	Survey of ENDS users (n=1,347).	First heard about ENDS through the Internet (41%), personal contacts (35%), other media (10%), or saw them being used (8%).	<p><u>Dual use</u>: 16% were current smokers.</p> <p><u>Amount</u>: Mean 316 days of use and maximum of 236 puffs per day and 3 mL of e-liquid</p>	<p><u>Health</u>: 72% reported better breathing. 70% said improved cough. Most common side effects were throat (37%) and mouth (23%) irritation.</p> <p><u>Quit</u>: 74% had not smoked for at least several weeks since began using ENDS. 89% said ENDS helped them quit smoking and 94% said ENDS helped them cut down on smoking.</p> <p><u>Restrict</u>: 36% said they frequently used ENDS in places where smoking was banned.</p> <p><u>Satisf</u>: High overall satisfaction levels. 3% did not like taste.</p> <p><u>Similar</u>: 56% said used ENDS “in similar manner” to cigs. 68% said ENDS as satisfying as cigs.</p> <p><u>Withdraw</u>: 91% said using ENDS substantially decreased craving for cigs, and 70% said they do not have the urge to smoke cigs as much. 56% get “definite nicotine hit” from ENDS.</p>	<p><u>Cost</u>: 3% said that they started using ENDS because they were cheaper than smoking.</p> <p><u>Health</u>: 6% said they started using ENDS for health reasons.</p> <p><u>Quit</u>: 76% said they started using as an alternative to smoking.</p> <p><u>Restrict</u>: 3% said they started using ENDS to avoid smoking restrictions.</p> <p><u>Similar</u>: 17% liked that ENDS look and feel like cigs.</p>
------------------------------	---------------------------------	---	--	---	---

Dockrell (2013) ⁶²	Survey (n=12,597 in 2010; n=12,432 in 2012).	Awareness among smokers increased from 62% in 2010 to 79% in 2012. 38% of never-smokers and 47% of former smokers had heard of ENDS in 2012.	<p><u>Ever use:</u> In 2010, 8% of smokers had ever used ENDS (reported for smokers only). In 2012, 22% of current smokers, 4% of former smokers, and <1% of never smokers (overall % not reported). Higher use among younger respondents.</p> <p><u>Current use in 2012:</u> 3% of daily smokers, 1% of former smokers <1% of never smokers (overall % not reported).</p> <p><u>Dual use:</u> 3% of daily smokers in 2010 and 7% in 2012 were current ENDS users.</p>	-	-
-------------------------------	--	--	--	---	---

Dockrell (2013) ⁶²	Survey of smokers (n=1,380).	-	<u>Ever use</u> : 35% had ever used ENDS.	-	<p><u>Cost</u>: 53% believed might be too expensive.</p> <p><u>Health</u>: 39% believed might good for own health and 40% for health of others. 21% believed might not be safe enough. 71% believed ENDS safer than cigs.</p> <p><u>Quit</u>: 55% believed ENDS might help to cut back on and 51% to help quit smoking. 35% of users first tried them to help quit smoking and 31% to cut down on smoking without quitting.</p> <p><u>Restrict</u>: 43% of users first tried ENDS so they could use them where smoking not allowed. 50% believed ENDS might help with cravings where smoking is banned.</p> <p><u>Satisf</u>: 17% believed that they might taste pleasant and 33% believed might taste unpleasant.</p> <p><u>Similar</u>: 35% did not like that ENDS might be mistaken for cigs. 17% liked that ENDS might not resemble a cigarette.</p> <p><u>Withdraw</u>: 60% believed ENDS might satisfy desire to smoke, and 39% believed they might not.</p>
-------------------------------	------------------------------	---	---	---	--

Eissenberg (2010) ⁵⁴	Trial of 2 brands of 16 mg nicotine ENDS, cigs, just holding cigs ($n=16$).	-	-	Withdraw: One ENDS brand decreased craving at 1 time point. No other effects of either ENDS brand at any other time point.	-
Etter (2010) ⁴³	Survey of current and former ENDS users ($n=81$).	-	<u>Amount</u> : 89% were daily users. Median 100 days of use and 175 puffs per day.	<u>Cost</u> : Mixed experiences of ENDS cost relative to cigs. <u>Health</u> : Most frequently listed positive effects: better breathing, less cough, and overall health improvement. Most frequently listed negative effects: dry mouth or throat, vertigo, headache, and nausea. <u>Quit</u> : Frequently listed that ENDS helped to quit smoking (79% said helped “a lot”). Some previously failed to quit using other NRTs. <u>Satisf</u> : Multiple comments that liked taste and smell and found pleasurable to use. Some disliked taste or had technical or quality problems. <u>Similar</u> : Some stopped using ENDS because did not taste like cigs. <u>Withdraw</u> : Multiple comments that using ENDS reduced cravings.	<u>Cost</u> : Reasons for use included lower cost of ENDS relative to cigs. <u>Health</u> : Reasons for use included that ENDS are healthier than cigs. Some users concerned about potential toxicity. <u>Quit</u> : Many said they used ENDS in order to quit smoking. <u>Restrict</u> : Reasons for use included that they can use ENDS in smoke-free places. <u>Satisf</u> : Reasons for use included the pleasure of the experience. <u>Similar</u> : Similarity of ENDS to cigs (inhalation, gestures/actions) perceived as a benefit. <u>Withdraw</u> : Reasons for use included to get nicotine and to relieve cravings.

Etter (2011) ⁴⁴	Survey (n=3587).	-	<p><u>Ever use</u>: 85% had ever used ENDS. Daily users (vs. never users) more likely to be men, former smokers, and have past use of some NRTs.</p> <p><u>Dual use</u>: 22% of daily ENDS users were current smokers. 65% said they had ever used ENDS and tobacco on the same day.</p> <p><u>Amount</u>: 84% were current ENDS users (81% daily and 3% occasional). Among daily ENDS users, median 91 days of use and 120 puffs per day.</p>	<p><u>Health</u>: 22% said burned throat; 26% said caused dry mouth or throat.</p> <p><u>Quit</u>: 92% of current smokers said ENDS helped reduce smoking. 96% of former smokers said ENDS helped them quit. Of those who stopped using ENDS, 25% said they relapsed to smoking.</p> <p><u>Restrict</u>: 71% used at work and 43% in restaurants/bars.</p> <p><u>Satisf</u>: High satisfaction overall. 91% liked taste, feel of inhalation. 94% would recommend to a friend. Multiple concerns about product quality (e.g., 37% said batteries run out too quickly and 18% said e-liquid leaked). 35% of those who had stopped using ENDS did so because of poor quality.</p> <p><u>Withdraw</u>: Of those who used ENDS during quit attempt, 90% said reduced cravings, 83% reduced irritability, 81% reduced anxiety, and 78% reduced restlessness. 10% still feel urge to smoke when using ENDS. 89% found it easy to abstain from smoking when using ENDS. 33% of those who had stopped using ENDS did so because ENDS did not reduce cravings.</p>	<p><u>Cost</u>: 57% used because they believed ENDS were cheaper than cigs.</p> <p><u>Health</u>: 84% used because they believed ENDS were less toxic than cigs. 6% feared ENDS might be toxic.</p> <p><u>Quit</u>: 77% used to help quit smoking or avoid relapse.</p> <p><u>Restrict</u>: 39% used to handle smoke-free situations.</p> <p><u>Withdraw</u>: 8% were afraid of becoming addicted to ENDS. 79% of former smokers feared they would relapse if do not use ENDS. 79% use ENDS to deal with cravings and 67% to deal with nicotine withdrawal. 4% believed they were addicted to ENDS.</p>
-------------------------------	---------------------	---	--	--	---

Etter (2011) ⁴⁵	Survey with saliva collection from ENDS users ($n=31$).	-	<u>Dual use</u> : 1 participant (3%) described as occasional smoker. <u>Amount</u> : 97% were daily users. Median 94 days of use and 200 puffs per day.	-	-
Farsalinos (2013) ⁸¹	Case study of 1 former smoker.	-	<u>Amount</u> : Used ENDS daily.	<u>Health</u> : Alleviated previously elevated white blood cell count (neutrophilia). <u>Quit</u> : Quit smoking cigs within 10 days. 2 previous failed attempts.	
Farsalinos (2013) ⁵⁵	Comparison of smoking topography between experienced ENDS users using ENDS ($n=45$) and ENDS naïve smokers ($n=35$) using both ENDS and cigs.	-	<u>Amount</u> : ENDS users were all daily users and former smokers. Had used ENDS mean of 7 months and vaped 5 mL per day. Observed puff duration longer for ENDS users than other conditions (smokers using cigs or smokers using ENDS).	-	-

Foulds (2011) ⁴⁶	Survey of experienced ENDS users (n=104).	-	<p><u>Dual use</u>: 12% currently smoked cigs or other tobacco.</p> <p><u>Amount</u>: 89% used ENDS ≥ 20 of past 28 days. Mean 13 months of use (SD 9) and median 20 instances of use of ENDS per day.</p>	<p><u>Quit</u>: 99% said ENDS helped them successfully quit smoking. 65% previously tried to quit using NRTs.</p> <p><u>Restrict</u>: 90% were able to use where smoking was banned.</p> <p><u>Similar</u>: 35% said they use ENDS the same amount or more frequently than cigs. 80% preferred taste of ENDS to cigs.</p> <p><u>Withdraw</u>: 93% were extremely confident they could abstain from tobacco while using ENDS.</p>	<p><u>Health</u>: 98% believed ENDS less harmful to their own health than cigs. 80% believed ENDS less harmful to others than cigs.</p> <p><u>Quit</u>: 73% started using ENDS to help quit tobacco.</p> <p><u>Restrict</u>: 64% used because they could do so where smoking is banned.</p> <p><u>Withdraw</u>: 58% believed they get the same or more nicotine with ENDS.</p>
Goniewicz (2012) ⁶⁴	Survey (n=13,787).	86% had heard of ENDS.	<p><u>Ever use</u>: 21%. Higher among ever smokers, current smokers, males, urban areas, and those who had a smoking parent or partner.</p> <p><u>Current use</u>: 7% used in the past 30 days. Higher among younger, male, urban, current smokers, and those who had a smoking parent or partner.</p> <p><u>Dual use</u>: 15% of current smokers had used ENDS in past 30 days.</p>	-	<p><u>Health</u>: 55% believed that ENDS were safer than cigs.</p>

Goniewicz (2013) ⁴⁷	Survey of ENDS users (n=179).	-	<p><u>Dual use</u>: 34% of ENDS users were current smokers.</p> <p><u>Amount</u>: 98% were daily users. 54% had used ≥ 1 month. 33% used ≤ 15 times, 27% 16-25 times, and 40% used > 25 times per day.</p>	<p><u>Gateway</u>: 20% of those who said they were non-smokers when began using ENDS became smokers.</p> <p><u>Health</u>: Most frequent side effects of ENDS use were cough (27%), phlegm production (25%), and headaches (21%).</p> <p><u>Quit</u>: 64% who smoked when they began using ENDS had quit smoking.</p> <p><u>Similar</u>: 32% found the experience of using ENDS less satisfying, 32% equally satisfying, and 36% more satisfying than smoking.</p>	<p><u>Cost</u>: 14% tried ENDS for “other” reasons, which included cost.</p> <p><u>Health</u>: 41% first tried ENDS as a safer alternative to cigs. 15% believed ENDS were absolutely safe, and 82% believed that ENDS were not absolutely safe but safer than cigs.</p> <p><u>Quit</u>: 41% first tried ENDS to quit smoking.</p> <p><u>Restrict</u>: 14% tried ENDS for “other” reasons, which included being able to use in smoke-free places.</p> <p><u>Withdraw</u>: 33% believed ENDS were as addictive as cigs; 60% believed less addictive, 7% not addictive at all. 54% believed they were addicted to ENDS.</p>
Hua (2013) ²²	Visual analysis of YouTube videos of individuals using ENDS and smoking cigarettes (n=73).	-	<p><u>Amount</u>: Puff duration for ENDS use was longer than puff duration for cigarette smoking.</p>	-	-

Hua (2013) ⁸³	Analysis of reports of health effects from ENDS use (<i>n</i> =543 posts)	-	-	<u>Health</u> : 405 symptoms (78 positive, 326 negative, 1 neutral) reported. Most common negative symptoms were in the mouth and throat and in the respiratory, neurological, sensory, and digestive systems.	-
King (2013) ⁶⁰	Surveys in 2010 (<i>n</i> =6,689) and 2011 (<i>n</i> =4,050).	39-41% had heard of ENDS in 2010. 58% had heard of ENDS in 2011. Higher among current smokers. Lower among ≥ 65 years, African Americans, low educ.	<u>Ever use</u> : In 2010, 2-3% had ever tried ENDS. Higher among current smokers. In 2011, 6% had ever tried ENDS. Higher among current smokers.	-	-
Kralikova (2012) ⁵¹	Brief structured interviews of smokers (<i>n</i> =973).	86% had heard of ENDS.	<u>Ever use</u> : 26% had ever tried ENDS. <u>Dual use</u> : 7% used ENDS regularly.	<u>Cost</u> : 13% of those who stopped using ENDS found them too expensive. <u>Satisf</u> : 43% disappointed with ENDS use experience, 33% found as expected, and 24% better than expected. Of those who stopped using ENDS, 33% reported lack of satisfaction and 32% did not like taste. <u>Similar</u> : “Other” reasons (4%) for stopping using ENDS included that ENDS did not have the same “natural timing” of cigs.	

Li (2013) ⁷⁰	Surveys of smokers and recent quitters in 2011 (<i>n</i> =480) and 2012 (<i>n</i> =360).	-	<u>Ever use</u> : 7% of respondents in 2011 survey had ever purchased an ENDS (proxy for use). Higher among younger adults, higher income. Not associated with quit attempts.	-	<u>Cost</u> : 41% would switch to ENDS if cheaper than cigs. <u>Health</u> : 33% believed ENDS were safer than cigs. <u>Quit</u> : 34% believed ENDS could help people quit. 58% said they would try ENDS to help them quit smoking.
McCauley (2012) ⁸⁴	Case study of patient with lipid pneumonia (<i>n</i> =1).	-	<u>Amount</u> : Used ENDS for 7 months before diagnosis.	<u>Health</u> : Developed lipid pneumonia from glycerin-based oils in ENDS vapor. Improved after stopping use of ENDS.	-
McMillen (2012) ⁶⁷	Surveys (<i>n</i> =3,240).	-	<u>Ever use</u> : 2% had ever tried ENDS. Higher among current smokers. <u>Current use</u> : <1% of total sample (20% of those who had ever tried ENDS) had used ENDS in past 30 days.	-	-

McQueen (2011) ⁵⁰	Interviews with dedicated ENDS users (n=15).	Most common sources of initial awareness: friends, ads, Internet.	<u>Amount</u> : Most used ENDS \leq 1 year.	<u>Cost</u> : Most found ENDS less expensive than cigs. <u>Health</u> : Less coughing and breathlessness and greater ability to be physically active when using ENDS. <u>Quit</u> : Had success quitting with ENDS even after failed with other quit aids. <u>Satisf</u> : Overall very satisfied. ENDS sometimes required troubleshooting or did not work as expected. <u>Similar</u> : Many switched from ENDS that look like cigs to modified ENDS. <u>Withdraw</u> : Some ENDS users experienced fewer withdrawal symptoms between bouts of use than they did with cigs, and they experienced relief of cravings within 5 minutes after use of ENDS.	<u>Health</u> : Users hoped that ENDS reduce health risks. <u>Similar</u> : Because ENDS are more complex than cigs, they believed there was a learning curve to ENDS use. Some believed ENDS could substitute for cigs because same physical actions of using. <u>Withdraw</u> : Believed ENDS could help get a “nicotine fix.” Believed that novice ENDS users could experience relapse temptation when cannot get ENDS to function properly.
Monroy (2012) ⁸⁵	Case study of 1 ENDS user.	-	<u>Amount</u> : Reported using ENDS for past 5-6 months.	<u>Health</u> : ENDS use associated with heart arrhythmia. Resolved after stopped using ENDS.	-

Pearson (2012) ⁵⁹	Survey (n=2,649).	40% had heard of ENDS. Higher awareness among: current and former smokers, men, younger respondents. Lower among African-Americans.	<p><u>Ever use</u>: 3% had ever used ENDS. Higher among smokers and younger age. For smokers, higher use if plan to quit in next 6 months (vs. no plans to quit). Not associated with quit attempts.</p> <p><u>Current use</u>: 1% of sample (36% of ever users) had used in past 30 days. Higher among smokers and younger age.</p> <p><u>Dual use</u>: 4% of current smokers had used ENDS in past 30 days.</p>	-	<u>Health</u> : 71% of smokers aware of ENDS believed they were less harmful than cigs.
Pearson (2012) ⁵⁹	Survey of smokers (n=3,658).	58% had heard of ENDS. Higher among men. Lower among African-Americans.	<p><u>Ever use</u>: 6% of current smokers and 3% of former smokers had ever used ENDS. Higher use among White, higher educ, younger age. Not associated with quit intentions or attempts.</p>	-	<u>Health</u> : 85% of smokers who were aware of ENDS believed they were less harmful than cigs.
Pepper (2013) ⁶⁶	Survey (n=228).	67% had heard of ENDS. Higher among older adolescents, non-Hispanic.	<p><u>Ever use</u>: <1% (n=2) had ever tried ENDS. Both were smokers.</p>	-	-

Polosa (2011) ⁷⁵	6-month prospective trial of smokers ($n=40$) using ENDS.	-	<p><u>Dual use</u>: At week 24, some participants who reduced smoking were still using ENDS (% not reported).</p> <p><u>Amount</u>: Mean 2 ENDS cartridges used per day (SD 1, range 0-4).</p>	<p><u>Health</u>: No serious adverse events. Reports of dry cough (32%), mouth (21%) or throat (32%) irritation at early study visits. Most side effects resolved by week 24.</p> <p><u>Quit</u>: 23% quit smoking and another 33% reduced number of daily cigs $\geq 50\%$. Rated ENDS highly as helpful to enable them to refrain from smoking.</p> <p><u>Satisf</u>: Moderately high ratings of satisfaction. Enjoyed feeling of inhalation and exhalation. Multiple participants experienced problems with malfunctioning ENDS.</p> <p><u>Withdraw</u>: Participants reported not experiencing withdrawal symptoms.</p>	<u>Quit</u> : Rated ENDS highly for recommending to friends or relatives who want to quit smoking.
Popova (2013) ⁶⁸	Survey of current or recently quit smokers ($n=1,836$).	-	<p><u>Ever use</u>: 20% had ever used ENDS. Higher among women, younger age, Asians, and unsuccessful quitters (vs. never tried to quit). Not associated with quit intentions.</p> <p><u>Current use</u>: 8% used ENDS in past month. Higher among those with moderate education, lower income.</p>	-	<u>Quit</u> : Greater interest in ENDS among smokers who plan to quit at any point vs. those who do not plan to quit.

Prochaska (2012) ⁹⁰	Descriptive analysis of Twitter accounts (<i>n</i> =153).	-	-	-	<u>Health</u> : Tweets about ENDS included both health warnings and claims of health benefits over cigs. <u>Quit</u> : Some tweets described ENDS as a way to quit smoking.
Regan (2013) ⁵⁸	Surveys (<i>n</i> =10,587 in 2009; <i>n</i> =10,328 in 2010)	16% in 2009 and 32% in 2010 had heard of ENDS. Higher awareness in 2010 among: males, younger, non-Hispanic White, current smokers, current tobacco users. Respondents with low educ (less than high school) less likely to be aware and those with some college more likely to be aware compared to college graduates.	<u>Ever use</u> : 1% in 2009. 3% in 2010 had tried ENDS. In 2010, higher among: women, very low and moderate incomes, low educ, former smokers, current smokers. Not associated with quit attempts or intentions. <u>Current use</u> : In 2010, 1% of sample (43% of ever users) had used in past month. Higher among: low educ, current smokers, current tobacco users. <u>Dual use</u> : In 2010, 6% of current smokers and 7% of current tobacco users had used ENDS in past month.	-	<u>Quit</u> : Among smokers, ENDS users and non-users did not differ in quit intentions.

Richardson (2012) ⁶⁹	Survey of cig and cigar smokers (n=1,310)	-	<u>Ever use</u> : 10% of cig-only smokers and 24% of dual cig and cigar smokers had ever tried ENDS.	-	<u>Health</u> : 83% of cigar only smokers, 63% of dual cig and cigar smokers, and 35% of cig-only smokers believed that ENDS were less harmful than cigs.
Siegel (2011) ⁴⁸	Survey of ENDS ever users 7 months after initial purchase (n=216).	-	<u>Current use</u> : At 6 months after purchase, 45% were not using ENDS, 33% non-daily user, and 22% daily users. <u>Dual use</u> : among current ENDS users at 6-month follow- up, 65% smoked cigs. <u>Amount</u> : Among users, 40% were daily users. 68% used ENDS ≤ 10 times per day.	<u>Quit</u> : 67% had reduced number of cigs per day. 49% quit smoking for some period of time, and 31% were smoking abstinent at 6-month follow-up.	-

Sutfin (2013) ⁷¹	Survey (n=4,444).	-	<p><u>Ever use</u>: 5% had ever used ENDS. Higher use among: males, Hispanic and other race students, members of fraternities/sororities, and current and former smokers (vs. never smokers). Less likely among those who “don’t know” about harms of ENDS vs. believed equally harmful. Not associated with quit intentions among smokers. Of ENDS ever users, 12% were never, 30% were former, 42% were current smokers.</p> <p><u>Current use</u>: 2% had used in past month.</p>	-	<p><u>Health</u>: 23% believed ENDS were less harmful, 17% as harmful, and 2% more harmful than cigs. 50% said they did not know.</p> <p><u>Quit</u>: Among smokers, ENDS users and non-users did not differ in quit intentions.</p>
Trumbo (2013) ⁵²	Survey (n=244).	71% had heard of ENDS. Higher among current or former smokers than never smokers.	<p><u>Ever use</u>: 13% had ever tried ENDS.</p>	-	<p><u>Restrict</u>: Believed that using ENDS in public places (e.g., restaurants) was more acceptable than smoking cigs in those places.</p>

Vansickel (2010) ⁵⁶	Trial of 16 mg nicotine ENDS, 18 mg nicotine ENDS, cigs, and “sham” (unlit cigs) ($n=32$).	-	-	<p><u>Satisf</u>: Ratings of satisfying and pleasant increased at all time points for both ENDS. Ratings of “taste good” increased for some time points for both ENDS.</p> <p><u>Similar</u>: Ratings of “mild as own brand [of cigs]” increased at most time points for 1 brand of ENDS.</p> <p><u>Withdraw</u>: Both ENDS significantly reduced intention to smoke, anticipation of withdrawal, craving, and urge to smoke relative to baseline or sham at some time points during observation.</p>	
Vansickel (2012) ⁵⁷	Within-subject “choice sessions” of money versus puffs of ENDS or cigs ($n=20$).	-	-	<p><u>Satisf</u>: Increases in “pleasant,” “satisfying,” and “taste good” after use of ENDS.</p> <p><u>Similar</u>: Increases in “harsh as own brand [of cigs],” “mild as own brand,” and “taste like own brand” after use of ENDS.</p> <p><u>Withdraw</u>: Decreases in intention to smoke, anticipation of relief from withdrawal, and urge to smoke after use of ENDS.</p>	
Vansickel (2013) ⁷⁹	Observation of 5-hour “puff sessions” of ENDS users ($n=8$).	-	<u>Amount</u> : Mean 12 months of use.	<p><u>Satisf</u>: ENDS use increased ratings of pleasantness, satisfaction, and “taste good.”</p> <p><u>Withdraw</u>: ENDS use decreased anxiety, restlessness, and intention to smoke.</p>	-

Vickerman (2013) ⁷⁴	Survey with tobacco users who previously called state quitlines (n=2,476).	-	<p><u>Ever use</u>: 31% had ever tried ENDS. Higher among White, higher educ, live/work with other tobacco users. ENDS users less likely to have quit than never users.</p> <p><u>Current use</u>: 9% used ENDS at time of survey.</p> <p><u>Amount</u>: Of users, 27% used every day and 73% used some days. 62% had used for <1 month.</p>		<p><u>Cost</u>: 2% of ever users tried ENDS because cheaper than cigs.</p> <p><u>Health</u>: 5% tried ENDS because they believed that they were less harmful than cigs.</p> <p><u>Quit</u>: 51% tried ENDS to quit other tobacco, 15% to replace other tobacco, and 7% to reduce other tobacco.</p> <p><u>Restrict</u>: 5% tried ENDS to use in places where other tobacco was not allowed.</p> <p><u>Similar</u>: 6% used because ENDS were a behavioral substitute.</p> <p><u>Withdraw</u>: 5% used to deal with cravings, stress, or nerves.</p>
--------------------------------	--	---	---	--	---

Note: Some % approximate due to rounding and variations in sample size. Cig = regular tobacco cigarette. ENDS = electronic nicotine delivery system. Mg = milligram. Ml = milliliter. Educ = education. NRT = nicotine replacement therapy (e.g., patch, gum, varenicline). - = not applicable. Dual use only reported if data are available on current ENDS use. Cost = the cost of ENDS. Gateway = use of ENDS causing smoking initiation. Health = health, safety, and side effects of ENDS. Quit = quitting and reducing tobacco use. Restrict = using ENDS to avoid restrictions on smoking. Satisf = satisfaction with ENDS' taste, smell, and product quality. Similar = similarity of ENDS to regular cigarettes in taste, smell, or feeling of use. Withdraw = withdrawal symptoms, desire to smoke, and cravings.

REFERENCES

1. Benowitz NL. Smokeless tobacco as a nicotine delivery device: Harm or harm reduction? *Clin Pharmacol Ther.* 2011;90(4):491–493.
2. U.S. Food and Drug Administration. *Evaluation of e-cigarettes.* 2009. DPATR-FY-09-23.
3. Bahl V, Lin S, Xu N, Davis B, Wang YH, Talbot P. Comparison of electronic cigarette refill fluid cytotoxicity using embryonic and adult models. *Reprod Toxicol.* 2012;34(4):529–537.
4. U.S. Food and Drug Administration. Public Health Focus - Electronic Cigarettes (e-Cigarettes). <http://www.fda.gov/NewsEvents/PublicHealthFocus/ucm172906.htm>. Accessed April 1, 2014.
5. Ayers JW, Ribisl KM, Brownstein JS. Tracking the rise in popularity of electronic nicotine delivery systems (electronic cigarettes) using search query surveillance. *Am J Prev Med.* 2011;40(4):448–453.
6. Grana RA. Electronic cigarettes: A new nicotine gateway? *J Adolesc Health.* 2013;52(2):135–136.
7. Cobb NK, Abrams DB. E-cigarette or drug-delivery device? Regulating novel nicotine products. *N Engl J Med.* 2011;365(3):193–195.
8. Rodu B. The scientific foundation for tobacco harm reduction, 2006-2011. *Harm Reduct J.* 2011;8:19.
9. Laugesen M. *Safety Report on the Ruyan® e-cigarette Cartridge and Inhaled Aerosol.* Health New Zealand Ltd;2008.
10. Riker CA, Lee K, Darville A, Hahn EJ. E-cigarettes: Promise or peril? *Nurs Clin North Am.* 2012;47(1):159–171.
11. Varughese S, Teschke K, Brauer M, Chow Y, van Netten C, Kennedy SM. Effects of theatrical smokes and fogs on respiratory health in the entertainment industry. *Am J Ind Med.* 2005;47(5):411–418.
12. Trtchounian A, Talbot P. Electronic nicotine delivery systems: Is there a need for regulation? *Tob Control.* 2011;20(1):47–52.
13. Cobb NK, Byron MJ, Abrams DB, Shields PG. Novel nicotine delivery systems and public health: The rise of the "e-cigarette". *Am J Public Health.* 2010;100(12):2340–2342.
14. Hadwiger ME, Trehy ML, Ye W, Moore T, Allgire J, Westenberger B. Identification of amino-tadalafil and rimonabant in electronic cigarette products using high pressure

- liquid chromatography with diode array and tandem mass spectrometric detection. *J Chromatogr.* 2010;1217(48):7547–7555.
15. Trehy ML, Ye W, Hadwiger ME, et al. Analysis of electronic cigarette cartridges, refill solutions, and smoke for nicotine and nicotine related impurities. *J Liq Chromatogr R T.* 2011;34(14):1442–1458.
 16. de Andrade M, Hastings G. *Tobacco Harm Reduction and Nicotine Containing Products: Research Priorities and Policy Directions.* Cancer Research UK; May 2013.
 17. Gilroy J. Electronic Cigarette Regulations in King County, Washington. Paper presented at: National Conference on Tobacco or Health; August 15-17, 2102; Kansas City, Missouri.
 18. Tierney J. E-Cigarettes help smokers quit, but they have some unlikely critics. *The New York Times.* Nov 7, 2011.
 19. Mishori R. E-cigarettes: Can they help you quit? *Parade Magazine.* July 12, 2009.
 20. Grana RA, Glantz SA, Ling PM. Electronic nicotine delivery systems in the hands of Hollywood. *Tob Control.* 2011;20(6):425–426.
 21. Yamin CK, Bitton A, Bates DW. E-cigarettes: A rapidly growing Internet phenomenon. *Ann Intern Med.* 2010;153(9):607–609.
 22. Hua M, Yip H, Talbot P. Mining data on usage of electronic nicotine delivery systems (ENDS) from YouTube videos. *Tob Control.* 2013;22(2):103-106.
 23. Modi N, Schmid B, Miller R. *UBS Investment Research: Clearing the Smoke on E-cigarettes.* UBS; May 14, 2012.
 24. Herzog B, Metrano B, Gerberi J. *Equity Research Tobacco Talk Survey–E-Cigarettes A Promising Opportunity.* Wells Fargo Securities; 2012.
 25. Kamerow D. Big Tobacco lights up e-cigarettes. *BMJ.* 2013;346:f3418.
 26. Esterl M, Kell J. Altria to Enter E-Cigarette Market. *The Wall Street Journal.* April 25, 2013.
 27. Lorillard Inc. *Reports Third Quarter 2012 Results.* Greensboro, NC. 2012.
 28. Brewer NT, Chapman GB, Gibbons FX, Gerrard M, McCaul KD, Weinstein ND. Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychol.* 2007;26(2):136–145.
 29. Brewer NT, Fazekas KI. Predictors of HPV vaccine acceptability: A theory-informed, systematic review. *Prev Med.* 2007;45(2–3):107–114.

30. McCaul KD, Branstetter AD, Schroeder DM, Glasgow RE. What is the relationship between breast cancer risk and mammography screening? A meta-analytic review. *Health Psychol.* 1996;15(6):423–429.
31. Vernon SW. Participation in colorectal cancer screening: A review. *J Natl Cancer Inst.* 1997;89(19):1406–1422.
32. Holman DM, Watson M. Correlates of intentional tanning among adolescents in the United States: A systematic review of the literature. *J Adolesc Health.* 2013;52(5 Suppl):S52–S59.
33. Sheeran P, Abraham C, Orbell S. Psychosocial correlates of heterosexual condom use: A meta-analysis. *Psychol Bull.* 1999;125(1):90–132.
34. Timeline – A quick look into electronic cigarette history. 2012; <http://blog.blucigs.com/timeline-a-quick-look-into-electronic-cigarette-history/>. Accessed March 21, 2013.
35. Huang J, Zheng R, Emery S. Assessing the impact of the national smoking ban in indoor public places in China: Evidence from quit smoking related online searches. *PloS One.* 2013;8(6):e65577.
36. Seidenberg AB, Hong W, Liu J, Noel JK, Rees VW. Availability and range of tobacco products for sale in Massachusetts pharmacies. *Tob Control.* 2013;22(6):372–375.
37. Shadish WR, Cook TD, Campbell DT. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference.* Boston, MA: Houghton Mifflin; 2002.
38. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: Is blinding necessary? *Control Clin Trials.* 1996;17(1):1–12.
39. Henningfield JE, Zaatari GS. Electronic nicotine delivery systems: Emerging science foundation for policy. *Tob Control.* 2010;19(2):89–90.
40. Scollo M, Lal A, Hyland A, Glantz S. Review of the quality of studies on the economic effects of smoke-free policies on the hospitality industry. *Tob Control.* 2003;12(1):13–20.
41. Cataldo JK, Prochaska JJ, Glantz SA. Cigarette smoking is a risk factor for Alzheimer's Disease: An analysis controlling for tobacco industry affiliation. *J Alzheimers Dis.* 2010;19(2):465–480.
42. Dawkins L, Turner J, Roberts A, Soar K. 'Vaping' profiles and preferences: An online survey of electronic cigarette users. *Addiction.* 2013;108(6):1115–1125.
43. Etter JF. Electronic cigarettes: A survey of users. *BMC Public Health.* 2010;10:231.

44. Etter JF, Bullen C. Electronic cigarette: Users profile, utilization, satisfaction and perceived efficacy. *Addiction*. 2011;106(11):2017–2028.
45. Etter JF, Bullen C. Saliva cotinine levels in users of electronic cigarettes. *Eur Respir J*. 2011;38(5):1219–1220.
46. Foulds J, Veldheer S, Berg A. Electronic cigarettes (e-cigs): Views of aficionados and clinical/public health perspectives. *Int J Clin Pract*. 2011;65(10):1037–1042.
47. Goniewicz ML, Lingas EO, Hajek P. Patterns of electronic cigarette use and user beliefs about their safety and benefits: An Internet survey. *Drug Alcohol Rev*. 2013;32(2):133–140.
48. Siegel MB, Tanwar KL, Wood KS. Electronic cigarettes as a smoking-cessation tool: Results from an online survey. *Am J Prev Med*. 2011;40(4):472–475.
49. Barbeau AM, Burda J, Siegel M. Perceived efficacy of e-cigarettes versus nicotine replacement therapy among successful e-cigarette users: A qualitative approach. *Addict Sci Clin Pract*. 2013;8(1):5.
50. McQueen A, Tower S, Sumner W. Interviews with “vapers”: Implications for future research with electronic cigarettes. *Nicotine Tob Res*. 2011;13(9):860–867.
51. Kralikova E, Kubatova S, Truneckova K, Kmetova A, Hajek P. The electronic cigarette: What proportion of smokers have tried it and how many use it regularly? *Addiction*. 2012;107(8):1528–1529.
52. Trumbo CW, Harper R. Use and perception of electronic cigarettes among college students. *J Am Coll Health*. 2013;61(3):149–155.
53. Bullen C, McRobbie H, Thornley S, Glover M, Lin R, Laugesen M. Effect of an electronic nicotine delivery device (e cigarette) on desire to smoke and withdrawal, user preferences and nicotine delivery: Randomised cross-over trial. *Tob Control*. 2010;19(2):98–103.
54. Eissenberg T. Electronic nicotine delivery devices: Ineffective nicotine delivery and craving suppression after acute administration. *Tob Control*. 2010;19(1):87–88.
55. Farsalinos KE, Romagna G, Tsiapras D, Kyrzopoulos S, Voudris V. Evaluation of electronic cigarette use (vaping) topography and estimation of liquid consumption: Implications for research protocol standards definition and for public health authorities' regulation. *Int J Environ Res Public Health*. 2013;10(6):2500–2514.
56. Vansickel AR, Cobb CO, Weaver MF, Eissenberg TE. A clinical laboratory model for evaluating the acute effects of electronic “cigarettes”: Nicotine delivery profile and cardiovascular and subjective effects. *Cancer Epidemiol Biomarkers Prev*. 2010;19(8):1945–1953.

57. Vansickel AR, Weaver MF, Eissenberg T. Clinical laboratory assessment of the abuse liability of an electronic cigarette. *Addiction*. 2012;107(8):1493–1500.
58. Regan AK, Promoff G, Dube SR, Arrazola R. Electronic nicotine delivery systems: Adult use and awareness of the 'e-cigarette' in the USA. *Tob Control*. 2013;22(1):19–23.
59. Pearson JL, Richardson A, Niaura RS, Vallone DM, Abrams DB. E-cigarette awareness, use, and harm perceptions in US adults. *Am J Public Health*. 2012;102(9):1758-1766.
60. King BA, Alam S, Promoff G, Arrazola R, Dube SR. Awareness and ever use of electronic cigarettes among U.S. adults, 2010-2011. *Nicotine Tob Res*. 2013;15(9):1623–1627.
61. Adkison SE, O'Connor RJ, Bansal-Travers M, et al. Electronic nicotine delivery systems: International Tobacco Control Four-Country Survey. *Am J Prev Med*. 2013;44(3):207–215.
62. Dockrell M, Morison R, Bauld L, McNeill A. E-cigarettes: Prevalence and attitudes in Great Britain. *Nicotine Tob Res*. 2013;15(10):1737–1744.
63. Cho JH, Shin E, Moon SS. Electronic-cigarette smoking experience among adolescents. *J Adolesc Health*. 2011;49(5):542–546.
64. Goniewicz ML, Zielinska-Danch W. Electronic cigarette use among teenagers and young adults in Poland. *Pediatrics*. 2012;130(4):e879–e885.
65. Choi K, Forster J. Characteristics associated with awareness, perceptions, and use of electronic nicotine delivery systems among young US Midwestern adults. *Am J Public Health*. 2013;103(3):556–561.
66. Pepper JK, Reiter PL, McRee AL, Cameron LD, Gilkey MB, Brewer NT. Adolescent males' awareness of and willingness to try electronic cigarettes. *J Adolesc Health*. 2013;52(2):144–150.
67. McMillen R, Maduka J, Winickoff J. Use of emerging tobacco products in the United States. *J Environ Public Health*. 2012:989474.
68. Popova L, Ling PM. Alternative tobacco product use and smoking cessation: a national study. *Am J Public Health*. 2013;103(5):923–930.
69. Richardson A, Xiao H, Vallone DM. Primary and dual users of cigars and cigarettes: Profiles, tobacco use patterns and relevance to policy. *Nicotine Tob Res*. 2012;14(8):927–932.

70. Li J, Bullen C, Newcombe R, Walker N, Walton D. The use and acceptability of electronic cigarettes among New Zealand smokers. *N Z Med J*. 2013;126(1375):48–57.
71. Sutfin EL, McCoy TP, Morrell HE, Hoeppe BB, Wolfson M. Electronic cigarette use by college students. *Drug Alcohol Depend*. 2013;131(3):214–221.
72. Centers for Disease Control and Prevention. Vital signs: Current cigarette smoking among adults aged ≥ 18 Years—United States, 2005–2010. *MMWR*. 2011;60(35):1207–1212.
73. Bogdanovica I, Godfrey F, McNeill A, Britton J. Smoking prevalence in the European Union: A comparison of national and transnational prevalence survey methods and results. *Tob Control*. 2011;20(1):e4.
74. Vickerman KA, Carpenter KM, Altman T, Nash CM, Zbikowski SM. Use of electronic cigarettes among state tobacco cessation quitline callers. *Nicotine Tob Res*. 2013;15(10):1787–1791.
75. Polosa R, Caponnetto P, Morjaria JB, Papale G, Campagna D, Russo C. Effect of an electronic nicotine delivery device (e-cigarette) on smoking reduction and cessation: A prospective 6-month pilot study. *BMC Public Health*. 2011;11:786.
76. Caponnetto P, Auditore R, Russo C, Cappello GC, Polosa R. Impact of an electronic cigarette on smoking reduction and cessation in schizophrenic smokers: A prospective 12-month pilot study. *Int J Environ Res Public Health*. 2013;10(2):446–461.
77. Caponnetto P, Campagna D, Cibella F, et al. Efficiency and safety of an eElectronic cigAreTte (ECLAT) as tobacco cigarettes substitute: A prospective 12-month randomized control design study. *PloS One*. 2013;8(6):e66317.
78. Trtchounian A, Williams M, Talbot P. Conventional and electronic cigarettes (e-cigarettes) have different smoking characteristics. *Nicotine Tob Res*. 2010;12(9):905–912.
79. Vansickel AR, Eissenberg T. Electronic cigarettes: Effective nicotine delivery after acute administration. *Nicotine Tob Res*. 2013;15(1):267–270.
80. Caponnetto P, Polosa R, Russo C, Leotta C, Campagna D. Successful smoking cessation with electronic cigarettes in smokers with a documented history of recurring relapses: A case series. *J Med Case Reports*. 2011;5(1):585.
81. Farsalinos KE, Romagna G. Chronic idiopathic neutrophilia in a smoker, relieved after smoking cessation with the use of electronic cigarette: A case report. *Clin Med Insights Case Rep*. 2013;6:15–21.

82. Chen I. FDA summary of adverse events on electronic cigarettes. *Nicotine Tob Res.* 2013;15(2):615–616.
83. Hua M, Alfi M, Talbot P. Health-related effects reported by electronic cigarette users in online forums. *J Med Internet Res.* 2013;15(4):e59.
84. McCauley L, Markin C, Hosmer D. An unexpected consequence of electronic cigarette use. *Chest.* 2012;141(4):1110–1113.
85. Monroy AE, Hommel E, Smith ST, Raji M. Paroxysmal atrial fibrillation following electronic cigarette use in an elderly woman. *Clin Geriatr.* 2012;20(3):28–32.
86. Caponnetto P, Polosa R, Auditore R, Russo C, Campagna D. Smoking cessation with e-cigarettes in smokers with a documented history of depression and recurring relapses. *Int J Clin Med.* 2011;2(3):281–284.
87. Dawkins L, Turner J, Crowe E. Nicotine derived from the electronic cigarette improves time-based prospective memory in abstinent smokers. *Psychopharmacology.* 2013;227(3):377–384.
88. Dawkins L, Turner J, Hasna S, Soar K. The electronic-cigarette: Effects on desire to smoke, withdrawal symptoms and cognition. *Addict Behav.* 2012;37(8):970–973.
89. Choi K, Fabian L, Mottey N, Corbett A, Forster J. Young adults' favorable perceptions of snus, dissolvable tobacco products, and electronic cigarettes: Findings from a focus group study. *Am J Public Health.* 2012;102(11):2088–2093.
90. Prochaska JJ, Pechmann C, Kim R, Leonhardt JM. Twitter=quitter? An analysis of Twitter quit smoking social networks. *Tob Control.* 2012;21(4):447–449.
91. Bullen C, Williman J, Howe C, et al. Study protocol for a randomised controlled trial of electronic cigarettes versus nicotine patch for smoking cessation. *BMC Public Health.* 2013;13:210.
92. Cahn Z, Siegel M. Electronic cigarettes as a harm reduction strategy for tobacco control: A step forward or a repeat of past mistakes? *J Public Health Policy.* 2011;32(1):16–31.
93. Rogers EM. *Diffusion of Innovations.* 5th ed. New York: Free Press; 2003.
94. Pepper JK, Brewer NT. Electronic nicotine delivery system (electronic cigarette) awareness, use, reactions, and beliefs: A systematic review. *Tob Control.* Published online November 20, 2013.
95. Google Trends. <http://www.google.com/trends/explore>.
96. Christakis NA, Fowler JH. The collective dynamics of smoking in a large social network. *N Engl J Med.* 2008;358(21):2249–2258.

97. True WR, Heath AC, Scherrer JF, et al. Genetic and environmental contributions to smoking. *Addiction*. 1997;92(10):1277-1287.
98. Flatt JD, Agimi Y, Albert SM. Homophily and health behavior in social networks of older adults. *Fam Community Health*. 2012;35(4):312–321.
99. Kobus K. Peers and adolescent smoking. *Addiction*. 2003;98:37–55.
100. Zickuhr K, Smith A. *Digital Differences*. Pew Internet & American Life Project; April 13, 2012.
101. Smith A. *Twitter Update 2011*. Pew Internet & American Life Project; June 1, 2011.
102. Madden M. *Online Video*. Pew Internet & American Life Project; July 25, 2007.
103. Moser RP, McCaul K, Peters E, Nelson W, Marcus SE. Associations of perceived risk and worry with cancer health-protective actions: Data from the Health Information National Trends Survey (HINTS). *J Health Psychol*. 2007;12(1):53–65.
104. McCaul KD, Hockemeyer JR, Johnson RJ, Zetocha K, Quinlan K, Glasgow RE. Motivation to quit using cigarettes: A review. *Addict Behav*. 2006;31(1):42–56.
105. Weinstein ND, Slovic P, Waters E, Gibson G. Public understanding of the illnesses caused by cigarette smoking. *Nicotine Tob Res*. 2004;6(2):349–355.
106. Arnett JJ. Optimistic bias in adolescent and adult smokers and nonsmokers. *Addict Behav*. 2000;25(4):625–632.
107. Weinstein ND, Marcus SE, Moser RP. Smokers' unrealistic optimism about their risk. *Tob Control*. 2005;14(1):55–59.
108. Goniewicz ML, Knysak J, Gawron M, et al. Levels of selected carcinogens and toxicants in vapour from electronic cigarettes. *Tob Control*. 2014;23(2):133–139.
109. Bauman KE, Fisher LA, Bryan ES, Chenoweth RL. Antecedents, subjective expected utility, and behavior: A panel study of adolescent cigarette smoking. *Addict Behav*. 1984;9(2):121–136.
110. Weinstein ND. Testing four competing theories of health-protective behavior. *Health Psychol*. 1993;12(4):324–333.
111. Lund KE. Association between willingness to use snus to quit smoking and perception of relative risk between snus and cigarettes. *Nicotine Tob Res*. 2012;14(10):1221–1228.
112. Weinstein ND, Kwitel A, McCaul KD, Magnan RE, Gerrard M, Gibbons FX. Risk perceptions: Assessment and relationship to influenza vaccination. *Health Psychol*. 2007;26(2):146–151.

113. Haddock CK, Lando H, Klesges RC, Peterson AL, Scarinci IC. Modified tobacco use and lifestyle change in risk-reducing beliefs about smoking. *Am J Prev Med.* 2004;27(1):35–41.
114. Peiper N, Stone R, Van Zyl R, Rodu B. University faculty perceptions of the health risks related to cigarettes and smokeless tobacco. *Drug Alcohol Rev.* 2010;29(2):121–130.
115. Tomar SL, Hatsukami DK. Perceived risk of harm from cigarettes or smokeless tobacco among U.S. high school seniors. *Nicotine Tob Res.* 2007;9(11):1191–1196.
116. Phillips CV, Wang C, Guenzel B. You might as well smoke: The misleading and harmful public message about smokeless tobacco. *BMC Public Health.* 2005;5:31.
117. Rodu B, Cole P. Smokeless tobacco use and cancer of the upper respiratory tract. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2002;93(5):511–515.
118. Huhtasaari F, Asplund K, Lundberg V, Stegmayr B, Wester PO. Tobacco and myocardial infarction: Is snuff less dangerous than cigarettes? *BMJ.* 1992;305(6864):1252–1256.
119. Regan AK, Dube SR, Arrazola R. Smokeless and flavored tobacco products in the U.S.: 2009 Styles survey results. *Am J Prev Med.* 2012;42(1):29–36.
120. Mussweiler T. Comparison processes in social judgment: Mechanisms and consequences. *Psychol Rev.* 2003;110(3):472–489.
121. Mussweiler T, Epstude K. Relatively fast! Efficiency advantages of comparative thinking. *J Exp Psychol.* 2009;138(1):1–21.
122. Mussweiler T, Posten A-C. Relatively certain! Comparative thinking reduces uncertainty. *Cognition.* 2012;122(2):236–240.
123. Rooke C, Amos A. News media representations of electronic cigarettes: An analysis of newspaper coverage in the UK and Scotland. *Tob Control.* Published online July 24, 2013.
124. de Andrade M, Hastings G, Angus K, Dixon D, Purves R. *The marketing of electronic cigarettes in the UK.* Cancer Research UK; November 2013.
125. Grewal D, Kavanoor S, Fern EF, Costley C, Barnes J. Comparative versus noncomparative advertising: A meta-analysis. *J Marketing.* 1997;61(4):1-15.
126. Weinstein ND. Accuracy of smokers' risk perception. *Nicotine Tob Res.* 1999;1 Suppl 1:S123–S130.

127. Kim SH, Shanahan J. Stigmatizing smokers: Public sentiment toward cigarette smoking and its relationship to smoking behaviors. *J Health Commun.* 2003;8(4):343–367.
128. Ritchie D, Amos A, Martin C. “But it just has that sort of feel about it, a leper”—Stigma, smoke-free legislation and public health. *Nicotine Tob Res.* 2010;12(6):622–629.
129. Centers for Disease Control and Prevention. Notes from the field: Electronic cigarette use among middle and high school students—United States, 2011–2012. *MMWR.* 2013;62(35):729–730.
130. Bullen C, Howe C, Laugesen M, et al. Electronic cigarettes for smoking cessation: A randomised controlled trial. *Lancet.* 2013;382(9905):1629–1637.
131. U.S. Food and Drug Administration. Regulation of E-Cigarettes and Other Tobacco Products. 2011; <http://www.fda.gov/NewsEvents/PublicHealthFocus/ucm252360.htm>. Accessed April 1, 2014.
132. Zhu SH, Gamst A, Lee M, Cummins S, Yin L, Zoref L. The use and perception of electronic cigarettes and snus among the U.S. population. *PloS One.* 2013;8(10):e79332.
133. GfK Knowledge Networks. KnowledgePanel Overview. 2014; <http://www.knowledgenetworks.com/knpanel/KNPanel-Design-Summary.html>. Accessed January 13, 2014.
134. Rose SW, Barker D, D’Angelo H, et al. The availability of electronic cigarettes in US retail outlets, 2012: Results of two national studies. *Tob Control.* In press. 2014.
135. Cobb NK, Brookover J, Cobb CO. Forensic analysis of online marketing for electronic nicotine delivery systems. *Tob Control.* Published online September 13, 2013.
136. Paynter J, Edwards R. The impact of tobacco promotion at the point of sale: A systematic review. *Nicotine Tob Res.* 2009;11(1):25–35.
137. Emery S. It’s Not Just Message Exposure Anymore: A New Paradigm for Health Media Research. Presented at Johns Hopkins Bloomberg School of Public Health; November 15, 2013; Baltimore, MD.
138. Substance Abuse and Mental Health Services Administration. *Results from the 2012 National Survey on Drug Use and Health: Detailed Tables.* 2012.
139. Lee YO, Hebert CJ, Nonnemaker JM, Kim AE. Multiple tobacco product use among adults in the United States: Cigarettes, cigars, electronic cigarettes, hookah, smokeless tobacco, and snus. *Prev Med.* 2014;62C:14–19.

140. Levy DT, Mumford EA, Cummings KM, et al. The relative risks of a low-nitrosamine smokeless tobacco product compared with smoking cigarettes: Estimates of a panel of experts. *Cancer Epidemiol Biomarkers Prev.* 2004;13(12):2035–2042.
141. Royal College of Physicians. *Harm reduction in nicotine addiction: Helping people who can't quit. A report by the Tobacco Advisory Group of the Royal College of Physicians.* London, UK. 2007.
142. Kim HJ, Shin HS. Determination of tobacco-specific nitrosamines in replacement liquids of electronic cigarettes by liquid chromatography-tandem mass spectrometry. *J Chromatogr.* 2013;1291:48–55.
143. Abrams DB. Promise and peril of e-cigarettes: Can disruptive technology make cigarettes obsolete? *JAMA.* 2014;311(2):135–136.
144. Kozlowski LT, Edwards BQ. "Not safe" is not enough: Smokers have a right to know more than there is no safe tobacco product. *Tob Control.* 2005;14 Suppl 2:ii3–ii7.
145. Rosenstock IM. The Health Belief Model and preventive health behavior. *Health Educ Behav.* 1974;2(4):354–386.
146. Costello MJ, Logel C, Fong GT, Zanna MP, McDonald PW. Perceived risk and quitting behaviors: Results from the ITC 4-Country Survey. *Amer J Health Behav.* 2012;36(5):681–692.
147. Cummings KM, Hyland A, Bansal MA, Giovino GA. What do Marlboro Lights smokers know about low-tar cigarettes? *Nicotine Tob Res.* 2004;6 Suppl 3:S323–S332.
148. Slovic P, Finucane ML, Peters E, MacGregor DG. The affect heuristic. *Eur J Oper Res.* 2007;177(3):1333–1352.
149. de Andrade M, Hastings G, Angus K. Promotion of electronic cigarettes: Tobacco marketing reinvented? *BMJ.* 2013;347:f7473.
150. Pepper JK, Emery SL, Ribisl KM, Brewer NT. How do U.S. adults find out about electronic cigarettes? Implications for public health messages. *Nicotine Tob Res.* In press. 2014.
151. Paek HJ, Kim S, Hove T, Huh JY. Reduced harm or another gateway to smoking? Source, message, and information characteristics of e-cigarette videos on YouTube. *J Health Commun.* Published online October 11, 2013.
152. McQueen A, Vernon SW, Meissner HI, Rakowski W. Risk perceptions and worry about cancer: Does gender make a difference? *J Health Commun.* 2008;13(1):56–79.
153. Courtenay WH. *Dying to Be Men: Psychosocial, Environmental, and Biobehavioral Directions in Promoting the Health of Men and Boys.* New York: Routledge; 2011.

154. Oncken C, McKee S, Krishnan-Sarin S, O'Malley S, Mazure CM. Knowledge and perceived risk of smoking-related conditions: A survey of cigarette smokers. *Prev Med.* 2005;40(6):779–784.
155. Montgomery GH, Erblich J, DiLorenzo T, Bovbjerg DH. Family and friends with disease: Their impact on perceived risk. *Prev Med.* 2003;37(3):242–249.
156. American Cancer Society. *Cancer Facts & Figures 2013*. Atlanta, GA. 2013.
157. Brewer NT, Weinstein ND, Cuite CL, Herrington JE. Risk perceptions and their relation to risk behavior. *Ann Behav Med.* 2004;27(2):125–130.
158. Biener L, Nyman AL, Stepanov I, Hatsukami D. Public education about the relative harm of tobacco products: An intervention for tobacco control professionals. *Tob Control*. Published online March 12, 2013.
159. Latimer LA, Batanova M, Loukas A. Prevalence and harm perceptions of various tobacco products among college students. *Nicotine Tob Res.* Published online December 4, 2013.
160. Ranby KW, Aiken LS, Gerend MA, Erchull MJ. Perceived susceptibility measures are not interchangeable: Absolute, direct comparative, and indirect comparative risk. *Health Psychol.* 2010;29(1):20–28.
161. Popova L, Ling PM. Perceptions of relative risk of snus and cigarettes among US smokers. *Am J Public Health.* 2013;103(11):e21–e23.
162. Bell K, Keane H. Nicotine control: E-cigarettes, smoking and addiction. *Int J Drug Policy.* 2012;23(3):242–247.
163. Kasza KA, Bansal-Travers M, O'Connor RJ, et al. Cigarette smokers' use of unconventional tobacco products and associations with quitting activity: Findings from the ITC-4, U.S. Cohort. *Nicotine Tob Res.* Published online December 27, 2013.
164. Etter JF, Bullen C. A longitudinal study of electronic cigarette users. *Addict Behav.* 2014;39(2):491–494.
165. Capella ML, Webster C, Kinard BR. A review of the effect of cigarette advertising. *Int J Res Mark.* 2011;28(3):269–279.
166. National Cancer Institute. The Role of the Media in Promoting and Reducing Tobacco Use. Tobacco Control Monograph No. 19. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; 2008.
167. Kim AE, Lee YO, Shafer P, Nonnemaker J, Makarenko O. Adult smokers' receptivity to a television advert for electronic nicotine delivery systems. *Tob Control*. Published online October 3, 2013.

168. Richardson A, Ganz O, Stalgaitis C, Abrams D, Vallone D. Noncombustible tobacco product advertising: How companies are selling the new face of tobacco. *Nicotine Tob Res*. Published online December 30, 2013.
169. Richardson A, Ganz O, Vallone D. Tobacco on the web: Surveillance and characterisation of online tobacco and e-cigarette advertising. *Tob Control*. Published online February 14, 2014.
170. *Smoking Everywhere, Inc., Plaintiff, and Sottera, Inc., d/b/a NJOY, Intervenor-Plaintiff v. U.S. Food and Drug Administration, et al., Defendants* (United States District Court for the District of Columbia 2010).
171. Southwell BG, Kim AE, Tessman GK, et al. The marketing of dissolvable tobacco: Social science and public policy research needs. *Am J Health Promot*. 2012;26(6):331–332.
172. Weinstein ND. Accuracy of smokers' risk perceptions. *Ann Behav Med*. 1998;20(2):135–140.
173. Centers for Disease Control and Prevention. Quitting Smoking Among Adults—United States, 2001–2010. *MMWR*. 2011;60(44):1513–1519.
174. Sanders-Jackson AN, Cappella JN, Linebarger DL, Piotrowski JT, O'Keeffe M, Strasser AA. Visual attention to antismoking PSAs: Smoking cues versus other attention-grabbing features. *Hum Commun Res*. 2011;37(2):275–292.
175. Lee S, Cappella JN. Distraction effects of smoking cues in antismoking messages: Examining resource allocation to message processing as a function of smoking cues and argument strength. *Media Psychol*. In press. 2014.
176. Borland R, Yong HH, Siahpush M, et al. Support for and reported compliance with smoke-free restaurants and bars by smokers in four countries: Findings from the International Tobacco Control (ITC) Four Country Survey. *Tob Control*. 2006;15 Suppl 3:iii34–iii41.
177. Centers for Disease Control and Prevention. Adult Tobacco Survey—19 states, 2003–2007. *MMWR*. 2010;59(SS-3):1–75.
178. Gay M, Jackson J, Esterl M. New York City Extends Smoking Ban to E-Cigarettes. *The Wall Street Journal*. December 19, 2013.
179. Davies A. Sorry Smokers, You Can't Use Electronic Cigarettes On Airplanes. 2013; February 27:<http://www.businessinsider.com/you-cant-smoke-e-cigarettes-in-planes-2013-2>. Accessed April 1, 2014.
180. Bandura A. *Social Learning Theory*. Englewood Cliffs, New Jersey: Prentice Hall; 1977.

181. Hodge JG, Jr., Collmer V, Orenstein DG, Millea C, Van Buren L. Reconsidering the legality of cigarette smoking advertisements on television public health and the law. *J Law Med Ethics*. 2013;41(1):369–373.
182. World Health Organization. Electronic nicotine delivery systems, including electronic cigarettes. Seoul, Republic of Korea: Conference of the Parties to the WHO Framework Convention on Tobacco Control; 2012.
183. Jolly D. European Parliament Approves Tough Rules on Electronic Cigarettes. *The New York Times*. February 26, 2014.
184. DiFranza JR, Richards JW, Paulman PM, et al. RJR Nabisco's cartoon camel promotes Camel cigarettes to children. *JAMA*. 1991;266(22):3149–3153.
185. Fischer PM, Schwartz MP, Richards JW, Jr., Goldstein AO, Rojas TH. Brand logo recognition by children aged 3 to 6 years. Mickey Mouse and Old Joe the Camel. *JAMA*. 1991;266(22):3145–3148.
186. Centers for Disease Control and Prevention. Current Cigarette Smoking Among Adults—United States, 2005–2012. *MMWR*. 2014;63(2):29–34.
187. Fishbein M. Great expectations, or do we ask too much from community-level interventions? *Am J Public Health*. 1996;86(8):1075–1076.
188. Sheeran P. Intention—behavior relations: A conceptual and empirical review. *Eur Rev Soc Psych*. 2002;12(1):1–36.
189. Lopes M. E-cigarettes: A burning question for U.S. regulators. *Reuters*. December 11, 2013.
190. Smith D, Bansal-Travers M, O'Connor RJ, Goniewicz ML, Hyland AJ. Perceptions about e-cigarette advertising and interest in product trial among US adults: results from a pilot study Annual Meeting of the Society for Research on Nicotine and Tobacco; February 5–8, 2014; Seattle, WA.
191. Farrimond HR, Joffe H. Pollution, peril and poverty: a British study of the stigmatization of smokers. *J Community App Soc*. 2006;16(6):481–491.
192. Shiffman S, Brockwell SE, Pillitteri JL, Gitchell JG. Use of smoking-cessation treatments in the United States. *Am J Prev Med*. 2008;34(2):102–111.
193. Hsu R, Myers AE, Ribisl KM, Marteau TM. An observational study of retail availability and in-store marketing of e-cigarettes in London: potential to undermine recent tobacco control gains? *BMJ Open*. 2013;3(12):e004085.
194. Vonder Haar M. Nielsen data reflects emerging e-cig leaders. *Tobacco E-News*. November 13, 2013.

195. NJOY Rechargeable Express Kits. 2014; <http://www.njoy.com/express-kits/rechargeable-express-kits.html>. Accessed March 1, 2014.
196. Blu Premium100 E-Cigarette Starter Kit. 2014; <http://www.blucigs.com/starter-kit-premium100-black.html>. Accessed March 1, 2014.
197. Krieger N, Rowley DL, Herman AA, Avery B. Racism, sexism, and social class: Implications for studies of health, disease, and well-being. *Am J Prev Med*. 1993;9(6, Suppl):82–122.
198. Moore GC, Benbasat I. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Inform Sys Res*. 1991;2(3):192–222.
199. Richtel M. E-Cigarettes, by other names, lure young and worry experts. *The New York Times*. March 5, 2014.