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Understanding Smoking Cessation Intention and Behavior Focused on Motives for E-cigarette Use

액상형 전자담배 사용 동기 중심의

일반담배 금연의지 및 행동 이해

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윤 원 정

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지도 교수 조 성 일

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위 원 유 승 현 (인)

위 원 서 홍 관 (인)

위 원 조 성 일 (인)

Abstract

Understanding Smoking Cessation Intention and Behavior Focused on Motives for E-cigarette Use

Wonjeong Yoon

Department of Public Health Science

Graduate School of Public Health

Seoul National University

Background

The effectiveness of e-cigarette use in smoking cessation is one of the major determinants of evaluating the public health impact of e-cigarettes, but it remains controversial. If concurrent use is a temporary condition to completely switch to e-cigarettes or quit all tobacco products, it could contribute to reducing the burden of tobacco use; Whereas, if it's a long-term behavior to complement ongoing cigarette smoking or purely for entertainment, it may lead to more addictions and consumption into new habits and further greater health risks than either single-use. Given the importance of concurrent use behavior in determining the public health impacts of e-cigarettes, understanding the main motives of e-cigarette use among cigarette smokers and correlated behavioral characteristics is essential. Therefore, this study

aims to understand the smoking cessation intention and behavior focused on motives for e-cigarette use to promote tobacco cessation in the adult population.

Methods

Nationwide, cross-sectional data from the seventh Korea National Health and Nutrition Examination Survey (the 7th KNHANES, 2016–2018) and the International Tobacco Control (ITC) Korea Surveys conducted in 2016 and 2020 were utilized. Participants are adults (≥19 years old) cigarette smokers in South Korea. The main variables include e-cigarette use, motivation for using e-cigarettes, and intention to quit smoking. Multivariate logistic regressions were conducted to address categorical variables adjusted for socio-demographic characteristics. All analyses incorporated weights and strata to account for complex survey design, using SAS ver. 9.4. software.

Results

The first study investigated the associations between e-cigarette use status and tobacco quitting behaviors based on the stages of change model. The results suggested that current and former e-cigarette users were significantly more likely to be early-stage (i.e., 'Pre-contemplation' and 'Contemplation' stages) than never users, while not to be in the advanced stage (i.e., 'Preparation' and 'Action' stages). Current users were particularly less likely to be in the 'Maintenance' stage compared to never users.

The second study identified the associations between e-cigarette use and tobacco quitting behaviors considering the reasons for using e-cigarettes.

Instrumental motivation such as cessation, health, and social influence was related to intention to quit smoking and/or reduction in cigarette smoking. Intrinsic motivation such as curiosity, taste, and enjoyment was generally not associated with both reduction in and quitting intention of smoking. In comparison between the 2016 and 2020 data, fewer smokers use e-cigarettes for instrumental motives, while more smokers use e-cigarettes for intrinsic motives. For the quit-composite classification, more than half (60.3%) of smokers use e-cigarettes neither to quit nor cut down on smoking in 2020.

The third study explored the complex associations between e-cigarette use, tobacco quitting behaviors, and perceived gaps in risk and regulation between the two products. There are gaps between cigarettes and e-cigarettes on risk perception and exposed indoor ban, and these gaps were significantly linked to e-cigarette use and intention to quit cigarette. For instance, smokers who perceived e-cigarette as less harmful, and less addictive than cigarette were more likely to be concurrent users but likely to have intention to quit cigarette. Smokers who were exposed complete ban on both cigarette and e-cigarette in public places were less likely to be concurrent users and more likely to have intention to quit cigarette. Smokers who were exposed to the complete ban on cigarette only were not likely to have intention to quit cigarette.

Conclusion

E-cigarettes might promote quit attempts and short-term quitting in some smokers, but their negative role of inducing smokers to continue cigarette smoking without immediate quit intention is dominant at the population level. Furthermore, the main

drivers of concurrent use go beyond the instrumental motives toward intrinsic motives, which commonly have no quit-intention of smoking. Given that the perceived gaps in risk and regulation between the two products have been linked with concurrent use, closing these gaps is important to prevent the undermining of existing tobacco control efforts and unintended public health consequences of e-cigarettes. Collectively, it is skeptical that e-cigarette use can substitute tobacco cigarette smoking at the population level, which is predicated on their net public health benefits.

Keyword: E-cigarette use, smoking cessation, quitting behaviors, dual-use, tobacco control policy, public health impact

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CHAPTER 1.

Introduction

1.1. Background

1.1.1. Dominant patterns of e-cigarette use in adults

Tobacco control is one of the greatest public health achievements in the 21st century, according to the Centers for Disease Control and Prevention (CDC) [1]. The global prevalence of cigarette smoking decreased from 26.9% in 2000 to 20.2% in 2015 [2], potentially averting countless tobacco-related deaths worldwide [3-5]. Indeed, many countries including South Korea have recorded historically low smoking rates [2, 6], and some are even aiming to bring the value to near-zero by 2040 or sooner [7].

With the decline of cigarette smoking, new tobacco-based and nicotine products have emerged intensively over the past decade, such as liquid electronic cigarettes (e-cigarettes) and heated tobacco products (HTP) [8]. In particular, the e-cigarette was first developed in 2003 by the Chinese pharmacist Hon Lik [9]. E-cigarettes are battery-powered devices that deliver nicotine via vaporized solution (e-liquid) instead of tobacco combustion as in conventional smoking [10]. E-liquid is available in various nicotine strengths, and its inhalation process does not contain toxic substances from tobacco combustion (e.g., tar, corban monoxide) [9, 10]. From these features, they have been implicitly and explicitly marketed as effective smoking cessation aids and less harmful alternatives to cigarette smoking [11-14], thereby effectively appealing to existing cigarette smokers.

Although the health and behavioral effects of e-cigarettes remain controversial and their potential long-term risks are still unknown [15-18], the popularity of e-cigarette use has risen rapidly over the past decade, since the introduction of e-cigarettes on the global market in 2006 [19]. The number of e-

cigarette users worldwide increased more than fivefold, from 7 million in 2011 to 41 million in 2018 [20], and is expected to value at 55 million in 2021 [21]. The global sales of e-cigarettes reached $20 billion in 2021 compared to $2 billion in 2012 [22, 23]. They are projected to expand to more than $40 billion by 2023 [24].

South Korea is one of the countries where e-cigarette use rapidly gained popularity since its introduction in 2007 [25]. The e-cigarette imports more than tripled to $1.95 million in 2010 than 2008, reaching $18.89 million in 2015 [25, 26]. The majority (94%) of adult smokers were aware of e-cigarettes in 2016 [27]. The prevalence of lifetime and current use of e-cigarettes among adults peaked in 2015 at 12.3% and 4.2%, respectively (Figure 1-1) [28]. In 2016, the estimate decreased slightly to 10.6% and 2.3%, for each; but has remained relatively stable since then, reporting 11.0% and 3.2% in 2020 [28]. In 2020, 5.2% of males and 1.1% of females currently use the e-cigarette.

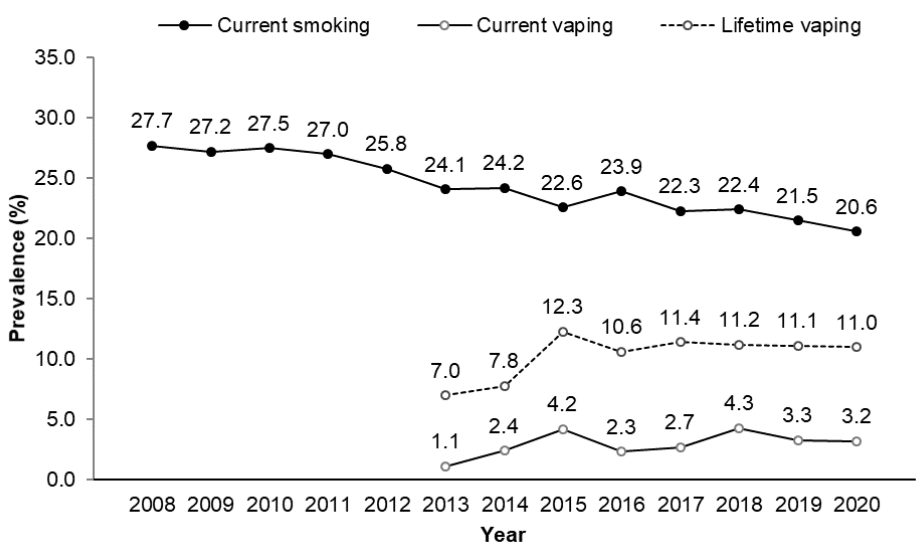


Figure 1-1. Prevalence of cigarette and e-cigarette use among Korean adults
(Source: the Korea National Health and Nutrition Examination Survey, 2008-2020)

According to the smoking status, the prevalence of e-cigarette use is highest in current smokers (male: 10.7%; female: 9.2%), followed by former smokers (1.9%; 1.1%) and non-smokers (0.2%; 0.0%) (Table 1-1) [29]. From the same data, a study on e-cigarette use patterns from 2013 to 2018 showed that the prevalence of concurrent use of conventional cigarette and e-cigarette among Korean adults has increased from 1.8% to 5.7% for males; and from 0.2% to 0.8% for females [30].

Table 1-1. Prevalence of e-cigarette use by smoking status among Korean adults

Current EC use	Never smokers (Initial EC use)	Current smokers (Concurrent use)	Former smokers (Complete switch)
Males (%)	0.2%	10.7%	1.9%
Females (%)	0.0%	9.2%	1.1%

(Source: the Korea National Health and Nutrition Examination Survey, 2016-2018)

Several population-based studies have shown that most e-cigarette users are concurrent users with conventional ones [31-36]; 65% in Canada [32], 70% in the United States [33], and 77% in South Korea [34]. Although the use of e-cigarettes among non-current smokers is also increasing recently, especially among youth and young adults [37]. 'concurrent use' of e-cigarette and conventional cigarette is still the dominant pattern of e-cigarette use in the adult population [38-40]. Given the important public health goal of reducing harm from tobacco products and the growing interest in the potential impacts of e-cigarettes, it is important to closely understand e-cigarette use behaviors among adult smokers.

1.1.2. Public health importance of concurrent use behavior

The positive and negative potential of concurrent use behaviors on public health and tobacco control has been fiercely debated [40-45]. Given the important public health goals of reducing harm from tobacco products and growing interest in the potential impact of e-cigarettes, it is necessary to closely understand the health consequences of concurrent use behavior. Major factors of the public health consequences of e-cigarette use among smokers include (1) toxicity/health risks, (2) effectiveness for smoking cessation, and (3) addictiveness of e-cigarette use [40].

1.1.2.1. Toxicity and health risks

Assuming the relative risks of e-cigarettes compared to regular cigarettes, some studies argue that concurrent use does not increase health risks induced from e-cigarette use [45-47]. This is because the consumption of conventional cigarettes may be partially substituted with e-cigarettes [48, 49]. Recent research have shown that concurrent users have a lower likelihood of cardiovascular diseases than exclusive smokers [50]. Furthermore, several studies claim that smokers who switch completely to e-cigarettes may achieve harm reduction [51, 52].

In contrast, some studies have shown that concurrent use has comparable exposure to toxicants and biomarkers with exclusive smoking [46]. Others suggested that concurrent use may be linked with greater health risks than either single use of tobacco products [52-55]. Even under the assumption of the relative risk of e-cigarettes, some reported there were no significant changes in the amount of conventional cigarette smoking among concurrent users, and the total nicotine consumption and tobacco dependence may increase than exclusive use [56]. Also,

even with predominant vapers, it is emphasized that even one cigarette per day may be enough to reach exposure thresholds for adverse health effects [57, 58]. Consistent with this, recent studies have argued that such concurrent use is associated with a higher risk of cardiovascular disease and pulmonary disease than exclusive users of each product [59, 60]. Furthermore, there have been concerns that even if concurrent users successfully completely switch to e-cigarettes, e-cigarettes are not harmless and there is still insufficient evidence to determine their potential long-term effects [15-18, 52]. Recently, the potential novel risks of e-cigarette use when inhaling components of e-liquids have also been proposed [61, 62].

1.1.2.2. Effectiveness for smoking cessation

Some experts have noted that e-cigarettes could help smokers quit cigarette smoking [63-65] and may be more effective than existing nicotine products [66, 67]. In that respect, concurrent use may be a temporary condition to cigarette (or tobacco) cessation [66, 68, 69] and accelerate the reduction in smoking prevalence, resulting in net public health benefits [70-72].

On the other hand, others insisted e-cigarettes may not contribute to cigarette cessation. Some were concerned they could rather delay or impede cigarette cessation—by curbing the use of proven cessation methods or sustaining a nicotine addiction [73]. Others suggested that concurrent use was associated with higher tobacco dependence than either single use of tobacco product [74]. From this respects, the status of concurrent use often persists for a long-term behavior despite the desire to quit cigarette [75]. Additionally, some papers have reported that frequent e-cigarette use has a high risk of inducing relapse in smoking, even if

concurrent users have completely replaced e-cigarettes [76]. This implies that concurrent users will need to quit e-cigarettes after cigarette cessation to ultimately achieve harm reduction.

1.1.2.3. Addictiveness of e-cigarette use

Although this factor is more frequently addressed for exclusive e-cigarette users than concurrent users, it is also related to the above-mentioned smoking cessation effectiveness. This is because none of the randomized controlled trials (RCT) studies supporting the effectiveness of e-cigarettes reported information on nicotine cessation until the end of observation [77].

Some studies observed that current exclusive e-cigarette users were less dependent on e-cigarette than on their cigarettes prior to switching, with self-reported items (e.g., time-to-first-use after waking, considering addicted, strong cravings, difficulty refraining from using, and feeling like they really needed) [78, 79]. However, other studies have reported that e-cigarette users may have a higher addiction than conventional smokers [80, 81]. Some suggested that e-cigarette-specific characteristics such as various devices, nicotine concentration, and controllability of liquid nicotine inhalation rate may affect users' nicotine addiction [82]. There is a concern that a complete switch to e-cigarette use in smokers could be another means of permanent nicotine dependence [66, 77].

Collectively, in order to achieve the goal of minimizing health risks of concurrent use, there is a need to identify ways to (1) optimize harm reduction among concurrent users (concurrent use), (2) increase complete cigarette cessation (completely switching) and including strategies to (3) encourage e-cigarette cessation after stopping cigarette (both products cessation) (Figure 1-2) [83]. In addition, all these processes should be more beneficial than reducing or quitting conventional cigarettes.

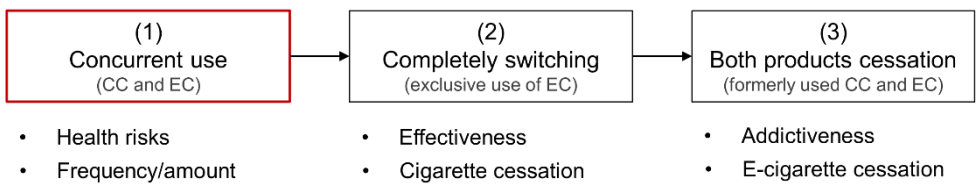


Figure 1-2. Main determinants of health consequences of concurrent use

1.1.3. Intention as a strong predictor of concurrent use behavior

Behavioral motivation and intention is an important component of the net impact of concurrent use on public health and tobacco control. According to the long-standing theory of planned behavior, intention to quit smoking is one of the strongest predictors of smoking cessation behavior and is recognized as the first step in considering behavioral action [84]. In that respect, cognitive factors of concurrent users may link with their subsequent behavior, including not only the cigarette quitting behavior but also the usage patterns of the two products, and e-cigarette quitting behavior [85-87].

Although concurrent use with the purpose of smoking cessation is somewhat controversial [88, 89], it is clear that concurrent use with purely recreational motives but not an attempt to quit or substantially reduce cigarette smoking poses a greater threat to public health [90, 91]. Furthermore, there is concern that concurrent use for circumventing conventional cigarette regulations may undermine existing efforts to tobacco control and even renormalize cigarette use [92-94]. Despite this importance, the behavioral motivation and intention of concurrent users have received limited attention compared to their behavioral outcomes.

Therefore, it is a priority to closely examine the cognitive factors of concurrent users, which would contribute to the goal of minimizing the net harm to the public induced by the complex usage behavior.

1.1.4. Research gaps and approach of current study

Most previous studies investigating the effectiveness of e-cigarettes for smoking cessation have been restricted to smokers who are planning to quit, or they have not considered smokers' quit intentions [95]. However, given that e-cigarette is marketed as a consumer product rather than utilized as an approved smoking cessation aid, the existing approach does not fully represent the real-world effectiveness of e-cigarette use for smoking cessation [85, 96]—especially in the context of e-cigarettes not being allowed as a smoking cessation aid (e.g., South Korea) [73].

Several scholars stated that the following two questions should be distinguished [73, 96-98]: "Are e-cigarettes effective when used as part of an organized cessation attempt?"; and "What effect is the use of e-cigarettes having on smoking cessation in the real-world as they are actually used?". In other words, the 'effectiveness of e-cigarette use for smoking cessation' indicates not only whether e-cigarette use encourages smokers who want to quit smoking (i.e., *individual perspectives*), but also whether e-cigarette use achieves positive impacts on net smoking cessation rates by substituting conventional smoking (i.e., *population perspective*) [97-99]. It is also emphasized that it should encompass unintended consequences, such as delaying/interfering with smoking cessation, using otherwise quit to stay smoking, or renormalizing conventional smoking [98-101].

Based on Figure 1-2 depicting the consensus on concurrent use, the positive impact of concurrent use of e-cigarettes among adult smokers on public health includes the following assumptions and potential unintended consequences (Table 1-2):

1) Smokers concurrently use e-cigarette aimed to quit smoking.

→ (Motivation for using e-cigarette)

2) Concurrent users have a strong intention to completely switch.

→ (Intention to quit cigarette)

3) E-cigarette use is a merely mean of ceasing all tobacco products.

→ (Intention to quit e-cigarette)

4) E-cigarette use contributes to increasing smoking cessation rates.

→ (Social norms of cigarette)

This study attempted to investigate whether concurrent use is ultimately in the process of cigarette/tobacco cessation among Korean adults focusing on the motives and intention to quit smoking. This would contribute to identifying the unintentional consequences corresponding to each of these premises to achieve net benefits on public health/tobacco cessation.

Table 1-2. Potential consequences of concurrent use from the individual and population perspectives

Intended consequences	Unintended consequences
• Concurrent users who intend to quit smoking achieve smoking cessation (***Individual perspectives***)	• Concurrent users who intend to quit smoking intervene in smoking cessation (***Individual perspectives***)
• Smokers initiate e-cigarette (concurrent use) with cigarette cessation motives	• Smokers initiate e-cigarette (concurrent use) without cigarette cessation motives
• Concurrent users have intention to quit cigarette smoking (completely switch)	• Concurrent users have no intention to quit cigarette smoking (complete switch)
• Complete switcher intend to quit e-cigarette use (both products cessation) • E-cigarette - a means of ceasing all tobacco	• Complete switcher not intend to quit e-cigarette use (both products cessation) • E-cigarette - a substitute for cigarette
• Re-engaging smokers in cessation efforts	• Renormalization of smoking in society
⇓	⇓
Population perspectives Increasing smoking cessation rate (Net impacts = intended > unintended)	***Population perspectives*** Decreasing/less increasing smoking cessation rate (Net impacts = intended < unintended)

1.2. Research Objectives and Structure of Thesis

The purpose of this dissertation is to explore the concurrent use behavior of e-cigarette use among Korean adult smokers, focusing on their motivation and intention to quit smoking, and ultimately to understand the effectiveness of e-cigarettes in smoking cessation from the population perspective. The specific research questions and aims for the following chapters are (Table 1-3):

Research question 1: Do concurrent users more related greater intention to quit cigarette than exclusive smokers? (Chapter 2)

In Chapter 2, I aimed to identify the association between e-cigarette use and smoking cessation intention/behavior. In this study, I utilized the modified SOC (Stages of Change) model describing the motivational stages covering smoking cessation intention/behavior. The results will contribute to identifying whether concurrent users have a higher likelihood of having intention and advanced motivational stages of cigarette quitting than exclusive cigarette users.

Research question 2: What is the main motivation for e-cigarette use among concurrent users and their associations with intention to quit tobacco products? (Chapter 3)

In Chapter 3, I aimed to in-depth analyzed the association between the motives of e-cigarette use and the smoking/vaping cessation intention, considering the diversified motives for using e-cigarettes. I classified the motivations for e-cigarette use into instrumental reasons (i.e., cessation/health and social influence) that are dependent on cigarette use behavior and intrinsic reasons (i.e., experiment and recreation) that

are independent of cigarette use behavior. The results will contribute to identifying the main drivers of concurrent use among Korean adults and their likelihood of intending to continue concurrent use, completely switch to e-cigarette, or both products cessation.

Research question 3: Are the perceived regulation/harm on cigarettes related to intention to quit cigarette in concurrent users? (Chapter 4)

In Chapter 4, I aimed to investigate the complex associations between the perceived regulation and harm of cigarette and e-cigarette use or the smoking cessation intention. While existing tobacco regulations encourage smokers to quit cigarette, it may also be related to unintended consequences for some concurrent users, such as smoke-free laws. The findings from this study will contribute to understanding the potential consequences of concurrent use in tobacco control and informing to establish the strategies to promote tobacco cessation.

Based on the above contents, Chapter 5 concludes the thesis by briefly discussing the limitations of this study and the desired direction for future research.

Table 1-3. Summary of key variables and main analyses

	Key variables and main analyses
Study 1 (Chapter 2)	Intention to quit CC
Study 2 (Chapter 3)	Motivation for EC use Motivation for EC use & Intention to quit CC Motivation for EC use & Intention to quit EC
Study 3 (Chapter 4)	Perceived harm/regulation of CC & Intention to quit CC

1.3. Scope of Dissertation and Terminology

1.3.1. Tobacco products

New tobacco-based and nicotine products other than conventional cigarettes have emerged intensively over the past decade (Figure 1-3). Representative products include e-cigarettes and HTPs.

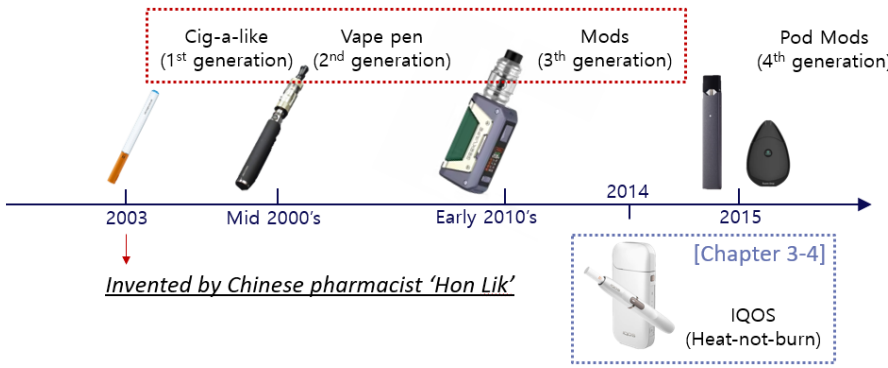


Figure 1-3. The emergence of new tobacco products in global market

The e-cigarette was first developed in 2003 by the Chinese pharmacist Hon Lik [9] and described in a patent application as "an electronic atomization cigarette that functions as substitutes for quitting smoking and cigarette substitutes" [39]. However, contrary to the original intention, the major traditional tobacco companies had begun to enter the e-cigarette market since then. Along with this, the type and number of products have been exponentially increasing. The generations of device have been designated as [102]: the 1st generation devices ("cig-a-like") mimic conventional cigarettes and are often disposable, as it is neither rechargeable nor refillable; the 2nd generation devices ("vape-pen") resemble pens and tend to be bigger than the first generation. They have prefilled or refillable cartridges and are

rechargeable; the 3rd generation devices ("Tank" or "box mod") have fillable tanks that less resemblance to cigarettes and are rechargeable. They allow the user to control many features (e.g., components customization, voltage-wattage setup, and heating temperature); the most recent 4th generation ("pod mod") devices look like the compact capsule or USB drives that include disposable or refillable pod that contains the heating element and the liquid, such as JUUL launched in 2015 [103].

Regardless of their appearance and design, the devices generally consist of four components [104]: 'a cartridge' that contains the liquid solution (e-liquid), 'a heating element' to transform the liquid solution into an aerosol, 'battery' to power the heating element, and 'mouthpieces' to inhale the aerosol. E-liquid is typically made up of propylene glycol, vegetable glycerin, nicotine, flavors, and other chemicals, although available without nicotine [17]. It is also called "Electronic Nicotine Delivery Systems (ENDS)", "Electronic Non-Nicotine Delivery Systems (ENNDS)", or "Nicotine Vaping Products (NVP)".

HTPs were developed by Philip Morris International, a well-known tobacco company in the US, and commercialized under the brand IQOS [105]. The product delivers nicotine to users by heating the tobacco leaves instead of burning. It is also called "Heat-not-burn". Table 1-4 summarizes the characteristics and distinctions of tobacco products. Compared to conventional cigarette, both e-cigarette and HTP have in common that they are devices powered by electricity with no burning process of tobacco leaves. Compared to HTP, e-cigarette not used tobacco leaves but are able to customize their liquid component, flavor, and nicotine concentration. E-liquid is

available in various nicotine strengths, and its inhalation process does not contain toxic substances from tobacco combustion (e.g., tar, corban monoxide) [9, 10].

According to studies so far, the most frequent reason for using HTP in the adult population is because it is less harmful than cigarettes [106-108], and the most common reason for using liquid e-cigarettes—similar but slightly different—is to control existing cigarette use behavior (e.g., to quit or reduce smoking) [109].

This dissertation focused on the first to third generations of liquid e-cigarette introduced since 2007 in South Korea, covering various device types and nicotine concentrations. This paper does not deal with the latest liquid e-cigarette, called 'JUUL' released by Pax Labs in 2017. It was introduced in Korea in May 2019 and withdrawn before Oct 2020, so the survey years do not overlap [110]. Also, it has a very different feature from previous generations in that it uses nicotine salts as opposed to free-base nicotine [111]. Meanwhile, HTPs were released in the Korean market in 2017, when relatively later than e-cigarettes [112]. HTPs were analyzed in Chapters 3 and 4 utilizing 2020 data, to compare with e-cigarettes.

Table 1-4. Characteristics and distinctions of tobacco products

	Tobacco products		
	Conventional cigarette	**Liquid electronic cigarette**	**Heated tobacco product**
Brand/type	Malboro, ESSE	1st~3rd gen, JUUL	IQOS
Source	Fire	Electricity	Electricity
Phase	Solid	Liquid	Solid
Ingredients	Tobacco leaves	Tobacco based nicotine	Tobacco leaves
Nicotine	Contained	Contained†	Contained
Korea		2007~ (JUUL: 2019~)	2017~
Abbr.	CC [113]	EC [113, 114]	HTP [114]

† Nicotine is often optional for e-liquid

Previously reported statistics on tobacco product use in Korea showed that conventional cigarettes were the most common, followed by HTPs and e-cigarettes. Among Korean adults, the prevalence of tobacco products in 2020 was 20.6% for conventional cigarettes, followed by HTPs at 5.1%, e-cigarette at 3.2% [115, 116]. A Korean study found that among tobacco product users, cigarette users accounted for 89.2%, HTP users 37.5%, and e-cigarette users 25.8% (i.e., exclusive use 3.7%; multiple uses 22.1%) [34]. Although e-cigarettes do not account for a large proportion of tobacco use among Korean adults, their market size has been gradually increasing [117]. In addition, most e-cigarettes on the market are not captured in the market size as tobacco products because they use nicotine extracted from tobacco stems or roots, or synthetic nicotine [118]. Considering online sales as well, the actual market size of e-cigarettes might be much larger than expected. From this aspect, the use of e-cigarettes continues to be worth noting from a long-term perspective.

1.3.2. Tobacco quitting behavior

The majority of smokers mainly relied on tobacco cigarettes in the past, the status of cigarette product use could be simply presented as: "never smoking–current smoking–former smoking" (Figure 1-4). With this one-dimensional schematic model, current smokers who want to quit tobacco have no other options except being former smokers, so tracking smokers' quitting behavior and identifying successful cigarette quitters were not as challenging.

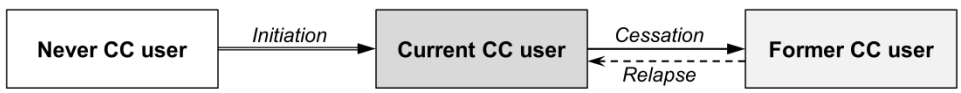


Figure 1-4. The schematic model for cigarette use status

However, after the emergence of e-cigarettes, the status of product use became very complex and the behavioral options for current smokers have expanded. Some smokers who want to quit smoking often become dual-users of both tobacco and e-cigarettes or complete switchers from conventional to e-cigarette, instead of immediately becoming former smokers, hoping that e-cigarette will help them quit tobacco and stay cessation. To understand tobacco-quitting behavior in response to changing circumstances, it is necessary to develop a two-dimensional (2D) schematic model that considers both conventional cigarette and e-cigarette use statuses.

1.3.3. Schematic model

I propose a two-dimensional schematic model that intuitively presents the possible transitions in conventional cigarette and e-cigarette using statuses (Figure 1-5). In the schematic model, the cigarette use status and e-cigarette use status are arranged in columns and rows, respectively. Each status is classified into three categories: never use, current use, and former use. There are a total of nine states in this model that combine using statuses from two different types of products (Table 1-5).

All individuals start as: never users of either product (colored white); and may become current users of either product only (colored dark-grey); concurrent users (colored darkest grey); or former users of either or both products (colored light-grey).

Possible transitions between states are classified into product initiation, cessation, and relapse: 1) firstly, the initiation is the flow from never use state to the current state, and it is indicated by double-solid arrows; 2) secondly, the cessation is the flow from a current use state to former use, and it is indicated by single-solid arrows; and 3) thirdly, the relapse is the flow from former use state to current use state, and it is indicated by single-dashed arrows. Regarding possible transitions, I assumed that switching the state of two products at the same time is impossible, and only consider the relapse of the ever used product after becoming non-current use of both products states.

Table 1-5. Classification of cigarette and e-cigarette user groups

	Never CC user	Current CC user	Former CC user
Never EC user	Never user (never used either product)	CC-only user (never used EC)	Former CC user (never used EC)
Current EC user	EC-only user (never used CC)	Concurrent users of CC+EC	EC-only user (formerly used CC)
Former EC user	Former EC user (never used CC)	CC-only user (formerly used EC)	Former user (formerly used both product but currently use neither)

CC: conventional cigarette; EC: liquid e-cigarette

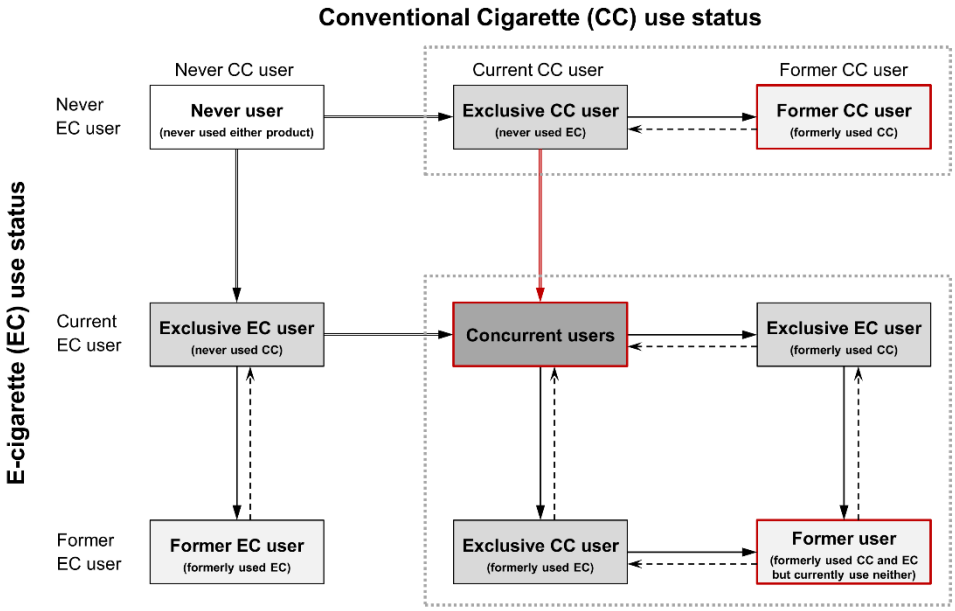


Figure 1-5. The schematic model for cigarette and e-cigarette use statuses

The current study focused on current and former CC users (i.e., the second and third columns in this model) across e-cigarette use status. The center of the model, which is the state of 'concurrent use' of both types of products, is available to come from either exclusive cigarette users or exclusive e-cigarette users. The concurrent use came from exclusive e-cigarette users and is frequently observed among the adolescent population—that is, also well-known as 'gateway' effects [119]. However, there is little evidence in the general adult population on the association between e-cigarette use and subsequent cigarette smoking among never smokers [120]. Two PATH studies analyzed this transition in the adult population, one suppressed the reporting of this estimation because the values were too small and the other reported 0.5% [121, 122]. According to Korean studies using large population-based data, the prevalence of current e-cigarette use among never smokers was less than 0.2% and thus very sparse [30, 35, 123].

Thus, based on existing statistical data, this study assumed that adult smokers' concurrent use may be largely attributable to cigarette smokers and that the transition from exclusive e-cigarette users (never smokers) might negligibly small. This dissertation did not cover the transition between each state, nevertheless, this schematic model for complex patterns and possible changes in product use statuses can intuitive understanding of where the specific status of each product's quitting intention is aimed at.

CHAPTER 2.

E-cigarette Use and Smoking Cessation Intention and Behavior

2.1. Introduction

With the growing popularity of e-cigarettes, their efficacy in substituting for cigarette smoking has emerged as a major public health concern [40, 42, 124]. E-cigarettes were initially promoted as smoking cessation tools [39], and so the most common reasons for using e-cigarettes by adults are related to cigarette quitting behaviors, such as to quit smoking or to manage withdrawal symptoms [125, 126].

However, claims about the positive and negative effects of e-cigarettes use on quitting smoking are still in conflict [40]. For example, 1) some experts suggest that e-cigarettes can help smokers quit smoking and maintain abstinence [66, 68, 69] and 2) may be more effective than conventional nicotine products [66, 67]. By contrast, other experts warn that e-cigarettes do not contribute to smoking cessation [63-65] and may rather delay or impede smoking cessation—by curbing the use of proven cessation methods or sustaining a nicotine addiction during periods of abstinence [73].

Smoking cessation outcomes are often assessed in a binary manner (i.e., cessation or not), focusing on the transition from current to former smokers [127, 128]. However, in principle, smoking cessation is not a single event, but a dynamic process involving a series of behavioral changes [129]. According to the stages of change (SOC) model, which is a theoretical framework for smoking cessation behavior, a smoker's status toward cigarette quitting smoking consists of five motivational stages: pre-contemplation (PC), contemplation (C), preparation (P), action (A), and maintenance (M) [130, 131]. Each stage is determined by cigarette quitting behavioral factors, including current behavior, past quit attempts, intention

to quit, and duration of quitting, and changes in these factors can cause progression or regression [132]. Although its conceptual validity has been questioned by some scholars [133-135], this model has the unique advantage of being sensitive to all changes in the smoking cessation process, which is not possible using traditional dichotomous cessation outcomes [127, 128]. In particular, the SOC model allows to measure the motivational state before smoking cessation behavior by simultaneously considering past attempts and intention to quit smoking in the future [131].

Despite its potential utility, few studies have considered the SOC model in relation to liquid e-cigarette use. Moreover, to the best of my knowledge, no previous study has covered all five stages of the model; most have considered three [86, 136-139] or four [140, 141] stages. In this study, I extend the scope of previous studies to the full stages of the SOC model and explored the relationship between e-cigarette use and smoking cessation behavior. Specific objectives were: 1) to examine the associations between e-cigarette use and cigarette quitting behavioral factors (i.e., current behavior, past quit attempts, intention to quit, and the duration of quitting) involved in cigarette cessation stages, and 2) to examine the relationship between the e-cigarette use and each cigarette cessation stage. The results provide insight into the e-cigarette use and intentional stages in smoking cessation and facilitate the use of the SOC model in research on the real-world effectiveness of e-cigarette use considering cigarette quitting intention and behavior.

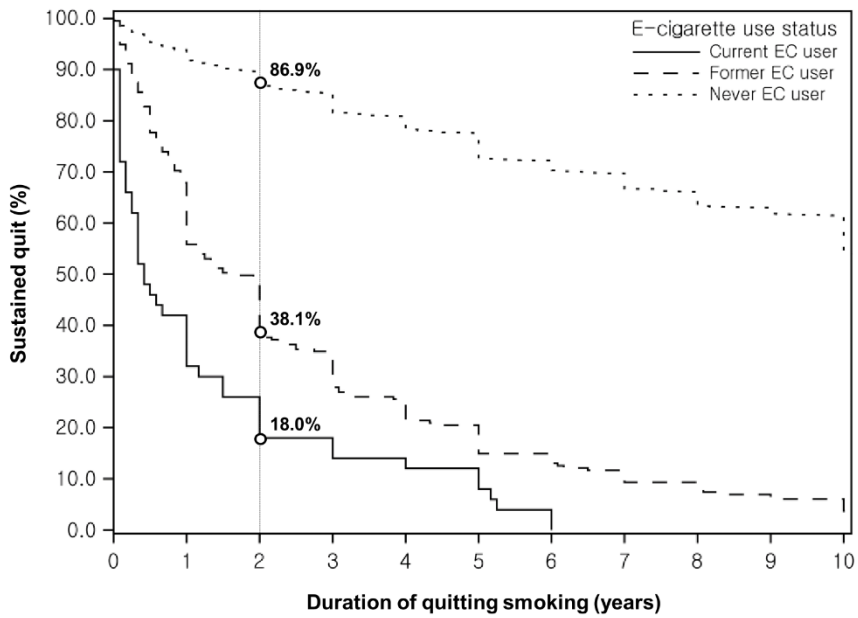
2.2. Methods

2.2.1. Data and sample

This study used a pooled dataset from the seventh Korea National Health and Nutrition Examination Survey (the 7th KNHANES) from 2016 to 2018. The KNHANES is a nationwide cross-sectional survey conducted by the Korea Centers for Disease Control and Prevention (KCDC). This survey collects health-related information on Koreans using health behavior surveys, health examinations, and a nutritional survey [142]. Interviews were conducted by trained medical staff and health interviewers. A representative sample was selected using stratified multistage probability sampling from 192 survey districts in Korea [142]. Of the participants (n=24,269) in the seventh KNHANES, 19,389 adults (≥19 years old) were eligible for this study. Participants who responded, "don't know" or "refused" (n=1,139) for main study factors such as e-cigarette use status, smoking status, cigarette quitting behaviors and sociodemographic characteristics were excluded. Of the remaining 18,250 respondents, the analytic sample was restricted to 3,929 recent smokers to examine the relationship between e-cigarette use and the stages of change in smoking cessation. They included current smokers defined as those who had smoked ≥100 cigarettes in their lifetimes and reported currently smoking "every day" or "some days", and former smokers defined as those who had smoked ≥100 cigarettes in their lifetimes but reported currently smoking "not at all" and had stopped smoking in the past two years (hereafter referred to as 'recent former smokers').

Recent former smokers were defined by the cut-off value of 2 years since cigarette quitting as in some previous studies by Li and by Gravely, et al [143-146].

Cut-off with longer period will include more individuals in the maintenance stage. However, e-cigarettes are relatively new products and the cut-off should not be too long. Empirical evidence shows that 60–90% of smoking relapse in cigarette quitters occurred within the first year since quitting, and 15% of the rest (about 80% of total relapses) in the second year [143-146]. Therefore, I considered 2 years cut-off would capture most of the quitting behaviors. Our data also identified that about 82.0% of current e-cigarette users and 61.9% of former e-cigarette users were concentrated among cigarette quitters in those who stopped smoking within the last 2 years (Figure 2-1).



No. of former smokers											
Current EC user	50	16	9	7	6	4	0	0	0	0	0
Former EC user	215	120	82	60	46	32	28	20	17	13	8
Never EC user	3304	3032	2872	2697	2587	2399	2323	2204	2094	2043	1787

Figure 2-1. Probability of sustained cigarette cessation over the quitting smoking duration by e-cigarette use status

This is a plot displaying unadjusted percentages of sustained quit (event) over the quitting period (time) according to e-cigarette use status. The estimates were computed using SAS PROC LIFETEST with the Kaplan-Meier method. The small circle indicates the percentage of sustained quitting at 2 years (i.e., cut-off values of 'recent former smoker' in this study) of current, former, and never e-cigarette users. The values can be calculated as the number of former smokers who have sustained cigarette cessation for more than 2 years divided by the total number of former smokers at the initiation time.

2.2.2. Variable

2.2.2.1. E-cigarette use

E-cigarette use was assessed using the following two questions: “Have you ever used an e-cigarette in your lifetime?” and “Have you used an e-cigarette in the last month?” Respondents were classified into: “never e-cigarette users” who answered “no” to the first question; “current e-cigarette users” who answered “yes” to the first question and “yes” to the second question; and “former e-cigarette users” who answered “no” to the second question.

2.2.2.2. Cigarette quitting behaviors

Four cessation-related behavioral factors were used to measure the SOC: current behavior, past-year quit attempts, intention to quit, and duration of quitting. Current behavior was dichotomized into current smoking (i.e., current smoker) and non-current smoking (i.e., recent former smoker) [73]. Past quit attempts were assessed among current smokers using the question, “In the last year, have you ever stopped smoking for at least 24 hours, because you were trying to quit? (yes or no).” The intention to quit smoking was measured in current smokers using the question, “Are you planning to quit smoking? (within the next month, within the next 6 months, sometime in the future beyond 6 months, or no plan to quit).” The duration of quitting was investigated in recent former smoker using the question, “How long has it been since you quit smoking (monthly unit responses)?”

2.2.2.3. Stages of change in smoking cessation

The stages of change in smoking cessation was the main outcome variable. Based on the above four quitting behavioral factors, the traditional SOC in smoking cessation

was classified into the following five stages: 1) Precontemplation (PC): current smokers who are not planning on quitting within the next 6 months; 2) Contemplation (C): current smokers who are planning on quitting within the next 6 months; 3) Preparation (P): current smokers who are both planning on quitting within the next month and have quit attempts in the past year; 4) Action (A): recent former smokers who quit within the last 6 months; 5) Maintenance (M): recent former smokers who quit more than 6 months ago [130, 131]. However, this traditional SOC model has the known problem that individuals in the PC and C stages are heterogeneous according to whether they made a quit attempt in the past year [132, 147]. Complementing this issue, this study separated the individuals who had not made a quit attempt in the past year from the PC and C stages and classified them as the 'No attempt' (NA) stage. A detailed classification of this extended SOC model is presented as a flowchart in Figure 2-2.

In this SOC model extended to six stages along with the NA stage, individuals in the PC, C, and P stages are defined as current smokers who recently attempted to quit smoking. Notably, past quit attempts reported by current smokers in themselves imply that the respondent's recent attempt to quit smoking was unsuccessful [148]. Specifying this characteristic in the process of quitting smoking makes it possible: 1) to distinguish 'failed quitting attempts' from 'no attempt' and 'successful quit', and 2) to compare the intentional status after failed attempts in parallel. The specific pattern of e-cigarette use (e.g., concurrent use, complete switching, and both products cessation) across the extended stages of smoking cessation are summarized in the Figure 2-3.

2.2.2.4. Covariate

The sociodemographic variables under study were sex (male, female), age group (19–34, 35–49, ≥50 years), educational level (college or more, high school, less than high school), income level (high, top 25%; middle; low, bottom 25%), and employment status (yes, no). Cigarette smoking characteristics included amount smoked (≥21, 11–20, 0–10 cigarettes/day), age of smoking initiation (<19, ≥19 years), and years smoked (≥20, 10–20, <10 years). These factors were treated as categorical variables in the analysis.

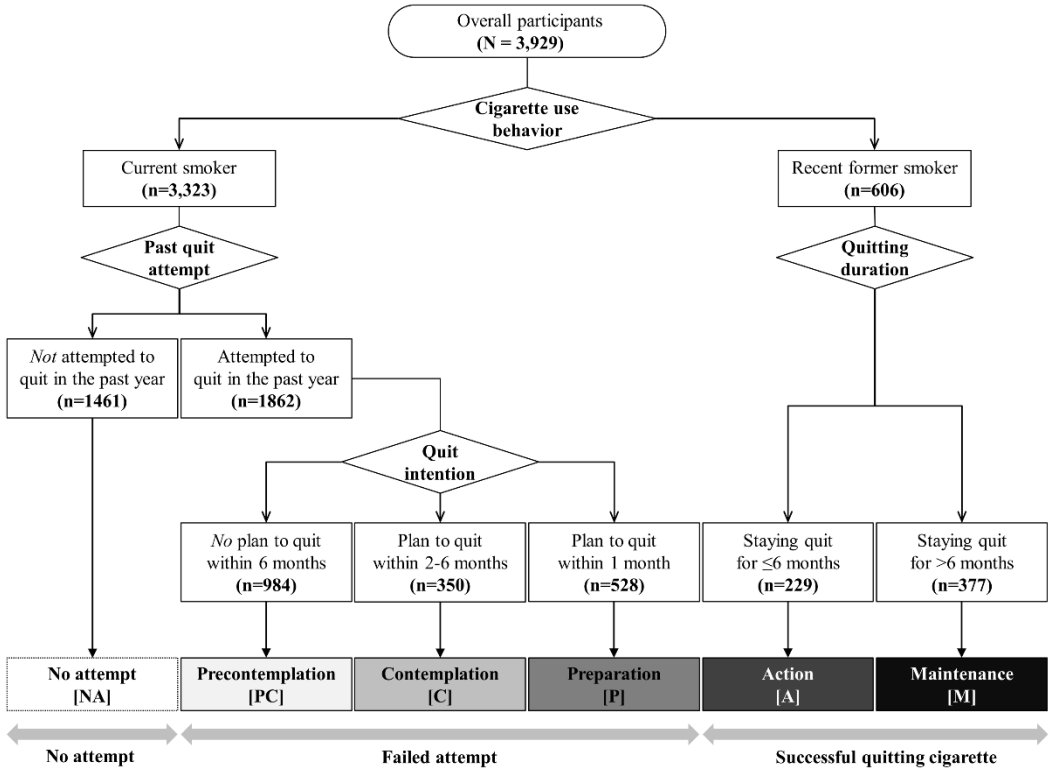


Figure 2-2. Flow chart for the extended classification of the stages of change in cigarette cessation

*Compared to the traditional SOC model, the model proposed in this study is expanded to reflect past-year quit attempts. This model isolated individuals who had not made a quit attempt of cigarette in the past year from the 'Precontemplation' (PC) and 'Contemplation' (C) stages and set them as the 'No attempt' (NA) stage for the expanded SOC model.

	The stages of change in conventional cigarette (CC) cessation					
E-cigarette (EC) use status	**No quit attempt**	**Failed quit attempt**			**Successful quit attempt**	
	No attempt	**Precontemplation**	**Contemplation**	**Preparation**	**Action**	**Maintenance**
	• Current smoker • *Not attempted to quit in the past-year (a)*	• Current smoker • *Attempted to quit in the past-year (b)* • No plan to quit within 6 months	• Current smoker • *Attempted to quit in the past-year (c)* • Plan to quit within 2-6 months	• Current smoker • Attempted to quit in the past-year • Plan to quit within the next month	• Recent former smoker • Stopped within the last 6 months	• Recent former smoker • Stopped more than 6 months ago
Never EC use	Current cigarette smoking				Past cigarette smoking	
Current EC use	Concurrent use of both cigarette and e-cigarette				Complete switching from cigarette to e-cigarette	
Former EC use	Exclusive cigarette use (with e-cigarette use history)				Both product cessation	

Figure 2-3. Patterns of e-cigarette use by the modified stages of change in cigarette cessation

*Modification (in italics) from the original model was made by excluding those with no attempt (a) from the 'Precontemplation' and 'Contemplation' stages, leaving only those with failed quit attempt in these two stages (b and c). Stages are shaded darker for more progressed cessation stages.

2.2.3. Statistical analysis

This study applied sampling weights to account for the complex sampling design of the survey [39]. Frequency analysis was performed with weighted percentages (%) to describe the distribution of samples according to e-cigarette use status. The chi-square test was performed to test the bivariate associations of e-cigarette use with cessation-related behavioral factors and the cigarette cessation stages, with a significance level of P <.05. A multivariate logistic regression analysis was conducted to explore the associations between e-cigarette use and cigarette cessation outcomes, adjusting for sociodemographic variables and smoking characteristics. The survey year was also included as a covariate because the rates of e-cigarette use may differ significantly according to the survey year. The results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Statistical analyses were conducted using SAS ver. 9.4. software (SAS Institute, Cary, NC, USA), using Proc Surveyfreq and Proc Surveylogistic. The goodness-of fit test was performed using Proc Surveylogistic with 'link=glogit' and 'link=clogit' phrases.

The sensitivity analysis was performed to assess the impact of unmeasured confounders on the association of e-cigarette use and smoking cessation stages. Several methods of sensitivity analysis have been proposed and advanced, including Greenland's external adjustment [149] and Rosenbaum's method [150]. In particular, VanderWeele and Ding recently reported the method without assumption, generalizing the sensitivity analysis [151]. This method has the advantage that the potential effects of unmeasured confounders can be derived as a single summary value, called 'E-value'. The E-value refers to the minimum strength of the relationship that an unmeasured confounder needs to have with both e-cigarette use

and the smoking cessation stage to fully explain away the observed relationship. Larger E-values provide stronger evidence that observed associations are robust to unmeasured confounders; smaller E-values provide weaker evidence. I computed E-values for point estimates and confidence intervals, using R package ‘EValue’.

2.2.4. Ethics

The Seoul National University Institutional Review Board approved this study (IRB No. E2103/001-003).

2.3. Results

Table 2-1 shows the sample characteristics among overall and according to e-cigarette use status. Of participants, 85.9% were male and 30.6% were young adults. The participants consists of 353 (10.1%) current users, 881 (24.8%) former users, and 2,695 (65.0%) never users. There were significant differences among these three groups in sociodemographic variables and smoking characteristics (P <.05). Regarding sociodemographic variables, current and former e-cigarette users tended to be male, younger, have higher education and income levels, and be employed. Concerning smoking characteristics, former e-cigarette users engaged in heavy smoking. E-cigarette users noted that they started smoking at a younger age.

Table 2-1. Sample characteristics, overall and by e-cigarette use status

	Overall (n=3,929)		Current EC user (n=353)		Former EC user (n=881)		Never EC user (n=2,695)		
	n	%	n	%	n	%	n	%	*P*
Sex									
Male	3290	85.9	308	88.6	752	87.5	2230	84.8	.050[†]
Female	639	14.1	45	11.4	129	12.4	465	15.2	
Age group (years)									
19–34	902	30.6	137	45.1	358	48.5	407	21.5	<.001
35–49	1388	36.6	153	41.1	345	37.0	890	35.8	
50+	1639	32.8	63	13.8	178	14.5	1398	42.8	
Education level									
College or more	1400	38.2	175	47.6	362	41.5	863	35.5	<.001
High school	1477	40.5	139	41.9	377	46.0	961	38.2	
Less than high school	1052	21.3	39	10.4	142	12.5	871	26.3	
Income level									
High	988	26.6	122	35.4	238	26.3	628	25.3	<.001
Moderate	1965	52.6	187	53.3	475	57.0	1303	50.8	
Low	976	20.8	44	11.4	168	16.7	764	23.9	
Employment									
Yes	2785	73.3	282	81.2	666	76.3	1837	70.9	<.001
No	1144	26.7	71	18.8	215	23.7	858	29.1	
Amount smoked[‡] (cigarettes/day)									
21+	272	6.8	24	6.4	72	7.4	176	6.7	.018
11–20	1756	45.4	166	46.4	439	50.3	1151	43.3	
0–10	1901	47.8	163	47.3	370	42.3	1368	50.0	
Smoking duration (years)									
>20 years	2564	58.5	180	46.2	421	42.0	1963	66.8	<.001
11–20 years	810	23.0	100	27.7	254	29.8	456	19.7	
≤10 years	555	18.5	73	26.1	206	28.3	276	13.5	
Age started smoking (years)									
<19	1696	46.4	195	57.0	469	55.1	1032	41.4	<.001
≥19	2229	53.6	158	43.0	412	44.9	1659	58.6	
E-cigarette use status									
Current EC use	353	10.1							
Former EC use	881	24.8							
Never EC use	2695	65.0							

Values are unweighted numbers, weighted percentages, and p-values by chi-square test.
[†] The p-value was marginally significant ($P = .0499$)
[‡] Amount smoked for former smokers was assessed retrospectively
EC: e-cigarette

2.3.1. Prevalence of cigarette quitting behaviors and cessation stages

Table 2-2 shows the prevalence of quitting behaviors and cessation stages among all participants. The participants included 3,323 (85.1%) current smokers and 606 (14.9%) recent former smokers. Of current smokers, more than half (56.0%) have made quit attempts in the past year and about one-third (33.5%) planned to quit smoking within the next 6 months. Of recent former smokers, nearly two-third (62.4%) reported quitting for longer than 6 months. Based on the stages of change in smoking cessation, majority (62.3%) of overall participants were in NA or PC stage, and followed by P (13.2%), C (9.7%), M (9.3%) and A (5.6%), stages.

Table 2-2. Percentages of cigarette quitting behaviors and cessation stages

	n	%
Total	3929	
Current behavior		
Current smoker	3323	85.1
Recent former smoker (≤2 years)	606	14.9
Past-year quit attempt of cigarette†		
No	1461	44.0
Yes	1862	56.0
Intention to quit smoking†		
Not within 6 months	2235	66.5
Within 2–6 months	456	14.8
Within 1 month	632	18.7
Duration of quitting smoking‡		
≤6 months	229	37.6
7–24 months	377	62.4
Stages of change of smoking cessation		
No attempt	1461	37.5
Precontemplation	984	24.8
Contemplation	350	9.7
Preparation	528	13.2
Action	229	5.6
Maintenance	377	9.3

Values are unweighted numbers and weighted percentages.
† Only asked of current smokers (n=3,323)
‡ Only asked of recent former smokers (n=606)

2.3.2. Associations between e-cigarette use and cigarette quitting behaviors

2.3.2.1. Current behavior of cigarette quitting

Table 2-3 presents the prevalence and odds ratio of cigarette cessation outcomes by e-cigarette use status. Current quitting behavior did not significantly differ by e-cigarette use stats (P = .2106). 11.5% of current users being former smoking and 14.6% and 15.5% of former and never users, respectively. Multivariate regression analysis showed that current e-cigarette users were significantly less likely to be former smokers (aOR = 0.64, 95% CI = 0.41–0.98) than never users. Former e-cigarette users also showed lower likelihood of former smoking than never users (aOR = 0.86, 95% CI = 0.66–1.12), but not statistically significant.

2.3.2.2. Past-year quit attempts

The percentages of past quit attempts differed by e-cigarette use status (P = .0199) (Table 2-3). About 61% of current e-cigarette users and 59% of former users had quit attempts in the past year, compared to 54% of never users. This difference remained in a multivariate regression analysis adjusting for covariates. Current and former e-cigarette users were more likely to report prior attempts to quit smoking (current: aOR = 1.44, 95% CI = 1.08–1.92; former: aOR = 1.35, 95% CI = 1.11–1.65) than never users.

2.3.2.3. Intention to quit smoking

There were no significant differences in intention to quit within 1 month by e-cigarette use status (P = .0739) (Table 2-3). About one-fifth (19.9%) of never users planned to quit within the next month, and 18.3% and 15.6% of current and former

users, for each. In a multivariate analysis controlling for covariates, current e-cigarette users were non-significantly more likely to report intention to quit smoking within the next month (current: aOR = 1.06, 95% CI = 0.72–1.57) than never users. Former e-cigarette users even reported negative results (aOR = 0.86, 95% CI = 0.66–1.12) for intention to quit compared to never users, although it is not significant.

2.3.2.4. Duration of quitting smoking

According to e-cigarette use status, current users showed a significantly lower proportion (32.1%) of long-term cigarette abstinence compared to former users (63.9%) and never e-cigarette users (65.4%) (P = .0004) (Table 2-3). This difference remained after adjusting for covariates. Current e-cigarette users were less likely to maintain smoking abstinence for >6 months (aOR = 0.20, 95% CI = 0.09–0.43) than never e-cigarette users. Former e-cigarette users did not significantly differ from never users in terms of long-term abstinence (aOR = 0.87, 95% CI = 0.53–1.45).

Table 2-3. Associations between e-cigarette use and cigarette quitting behaviors

	Former smoking			Past attempt to quit smoking†			Intention to quit smoking†			Long-term (>6 month) quitting smoking‡		
	%	aOR	(95% CI)	%	aOR	(95% CI)	%	aOR	(95% CI)	%	aOR	(95% CI)
E-cigarette use status												
Current EC user	11.5	**0.62***	**(0.39–0.96)**	60.7	**1.44***	**(1.08–1.93)**	18.3	1.08	(0.73–1.59)	32.1	**0.21*****	**(0.10–0.45)**
Former EC user	14.6	0.83	(0.64–1.09)	59.3	**1.36****	**(1.11–1.65)**	15.6	0.86	(0.66–1.12)	63.9	0.89	(0.53–1.49)
Never EC user	15.5	1.00	Ref.	53.9	1.00	Ref.	19.9	1.00	Ref.	65.4	1.00	Ref.
	P = .2106			*P* = .0199			*P* = .0739			*P* = .0004		

Values are weighted percentages, adjusted odds ratios, 95% confidential intervals, and p-values according to chi-square test.
Multivariate models were adjusted for all covariates and survey year.
† Only asked of current smokers (n=3,323)
‡ Only asked of recent former smokers (n=606)
* *P* <.05; ** *P* <.01; *** *P* <.001; Bold type = *P* <.05
aOR: adjusted odds ratio; CI: confidence interval; Ref: reference; EC: e-cigarette

2.3.3. Association between e-cigarette use and cigarette cessation stages

Figure 2-4 shows the prevalence of stages of change in cigarette smoking cessation among current, former, and never e-cigarette users (Table 2-4 shows the raw estimate with frequencies). Overall, the distribution of the cigarette cessation stages varied by the e-cigarette use status (P <.001) (Table 2-4). Current e-cigarette users had higher proportions of the PC (27.9%), C (11.4%), P (14.4%) and A (7.8%) stages than never users (24.2%, 7.8%, 13.6%, and 5.4%, for each), and former e-cigarette users had higher proportions of the PC (25.2%), and C (13.9%) stages than never users (24.2%, and 7.8%, respectively). Never e-cigarette users had higher proportions of the M (10.1%) stages than current and former e-cigarette users (3.7% and 9.3%, for each).

Table 2-4. Percentages of cigarette cessation stages by e-cigarette use status

	Current EC user (n=353)		Former EC user (n=881)		Never EC user (n=2,695)		
	n	%	n	%	n	%	*P*
Stages of change							
No attempt	128	34.8	302	34.8	1031	38.9	<.001
Precontemplation	88	27.9	233	25.2	663	24.2	
Contemplation	42	11.4	111	13.9	197	7.7	
Preparation	54	14.4	102	11.5	372	13.6	
Action	27	7.8	48	5.3	154	5.4	
Maintenance	14	3.7	85	9.3	278	10.1	

Values are unweighted frequencies, weighted percentages, and p-values according to chi-square test. EC: e-cigarette

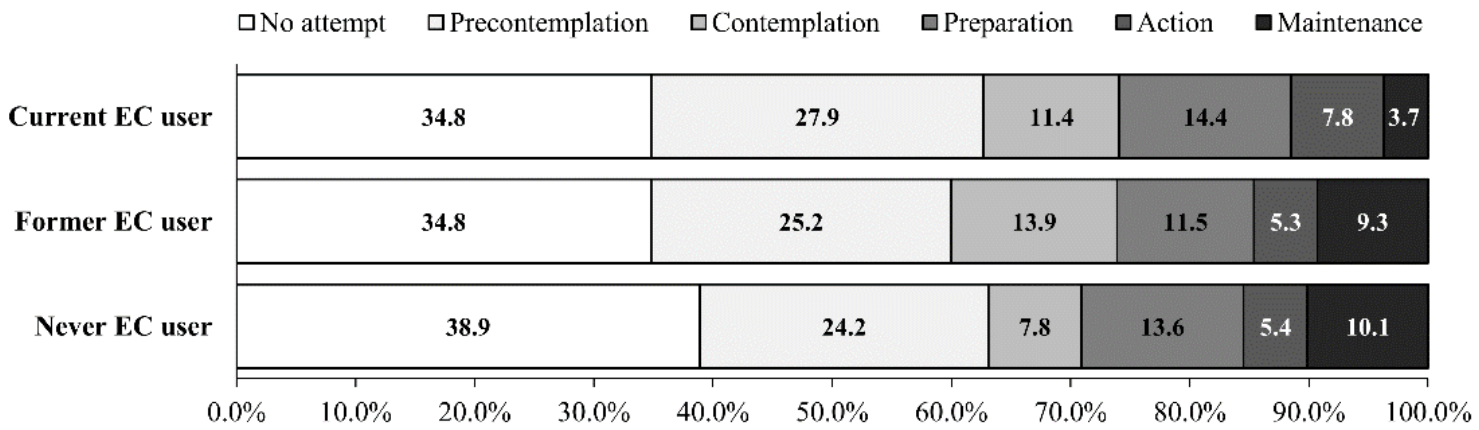


Figure 2-4. Distribution of the cigarette cessation stages by e-cigarette use status

This is a stacked bar graph showing the distribution of percentages of cessation stages among current (n=353), former (n=881), and never (n=2,695) e-cigarette users. EC: e-cigarette

Regrading to the relationship between e-cigarette use and smoking cessation stage, a model selection procedure is performed to assess goodness-of fit using Akaike's information criterion (AIC) [114]. Table 2-5 shows the results from the goodness-of-fit model for the relationship between e-cigarette use and smoking cessation stage using Akaike's information criterion (AIC) [152]. The following 4 models were performed for each of the cumulative logit model and the generalized logit model: 1) multivariate models were unadjusted; 2) multivariate models were adjusted for survey year; 3) multivariate models were adjusted for survey year and socio-demographics (age, sex, education level, income level, and employment); and 4) multivariate models were adjusted for survey year, socio-demographics, and cigarette smoking characteristics (amount, initiation age, and year smoked) (Table 2-6). Finally, out of the 8 models, Model 4 in the generalized logit model with the smallest AIC value (AIC = 12131.62) was determined to be the most fitted.

According to the results, the AIC of the generalized logit model was better than the cumulative logit model in all variable selection. This means that it is appropriate to interpret the 'Cigarette cessation stages', which is an outcome variable, as nominal rather than ordinal. Also, as the number of input variables increased, the model fit tended to improve. In particular, when socio-demographics and smoking characteristic variables were added, the decrease in AIC value was the larger than survey year did. Therefore, when analyzing the relationship between e-cigarette use and smoking cessation stage, it is necessary to assume that the smoking cessation stage is nominal, and also consider the influence of the survey year, demographic variables, and smoking characteristics variables in this relationship.

Table 2-5. Model fit statistics of ordinal and multinomial logistic regressions

	Model 1 (crude)	Model 2 (survey year)	Model 3 (socio-demographics)	Model 4 (smoking characteristics)
Ordinal (cumulative logit)				
df	2	4	12	17
AIC	12494.22	12495.06	12456.27	12378.74
SC	12538.15	12551.55	12562.97	12516.81
-2 Log L	12480.22	12477.06	12422.27	12334.74
Multinomial (generalized logit)				
df	10	20	60	85
AIC	12452.21	12435.11	12401.14	12131.62
SC	12546.35	12592.01	12809.09	12696.43
-2 Log L	12422.21	12385.11	12271.14	11951.62

Model 1: Multivariate models were unadjusted
Model 2: Multivariate models were adjusted for survey year
Model 3: Multivariate models were adjusted for survey year and socio-demographics (age, sex, education level, income level, and employment)
Model 4: Multivariate models were adjusted for survey year, socio-demographics, and smoking characteristics (amount, initiation age, and year smoked)
df: degrees of freedom; AIC: Akaike information criterion; SC: schwarz criterion

Table 2-6. Variable selection for associations between e-cigarette use and cigarette cessation stages

	Stages of change in conventional cigarette smoking cessation											
	Ordinal		Multinomial (vs No attempt)									
	Later stage		Precontemplation		Contemplation		Preparation		Action		Maintenance	
E-cigarette use status	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Model 1: crude												
Current EC user	1.01	(0.82–1.25)	1.29	(0.93–1.79)	1.65*	(1.10–2.49)	1.18	(0.80–1.76)	1.62	(0.94–2.78)	0.41**	(0.22–0.75)
Former EC user	1.09	(0.94–1.26)	1.17	(0.93–1.45)	2.01***	(1.51–2.68)	0.95	(0.72–1.25)	1.10	(0.74–1.62)	1.03	(0.76–1.39)
Never EC user	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
Model 2: survey year												
Current EC user	1.03	(0.83–1.27)	1.31	(0.94–1.83)	1.70*	(1.13–2.57)	1.26	(0.85–1.87)	1.61	(0.93–2.78)	0.40**	(0.22–0.74)
Former EC user	1.08	(0.94–1.25)	1.16	(0.93–1.45)	1.99***	(1.49-2.65)	0.94	(0.71–1.24)	1.09	(0.73–1.61)	1.03	(0.76–1.40)
Never EC user	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
Model 3: socio-demographic												
Current EC user	0.98	(0.78–1.22)	1.35	(0.96–1.90)	1.48	(0.96–2.30)	1.29	(0.85–1.95)	1.58	(0.88–2.83)	0.37**	(0.20–0.69)
Former EC user	1.05	(0.90–1.22)	1.19	(0.94–1.51)	1.72***	(1.28–2.31)	0.95	(0.71–1.26)	1.07	(0.70–1.64)	0.96	(0.70–1.33)
Never EC user	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
Model 4: smoking characteristics												
Current EC user	1.02	(0.81–1.27)	1.43*	(1.01–2.01)	1.59*	(1.02–2.48)	1.46	(0.95–2.25)	1.62	(0.89–2.94)	0.35**	(0.19–0.66)
Former EC user	1.10	(0.95–1.29)	1.29*	(1.01–1.64)	1.90***	(1.40–2.57)	1.14	(0.85–1.53)	1.08	(0.70–1.66)	0.94	(0.66–1.31)
Never EC user	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.

Model 1: Multivariate models were unadjusted
Model 2: Multivariate models were adjusted for survey year
Model 3: Multivariate models were adjusted for survey year and socio-demographics (age, sex, education level, income level, and employment)
Model 4: Multivariate models were adjusted for survey year, socio-demographics, and smoking characteristics (amount, initiation age, and year smoked)
* P <.05; ** P <.01; *** P <.001
OR: odds ratio; CI: confidence interval; Ref: reference; EC: e-cigarette

Table 2-7 provides the results of sensitivity analysis using E-value for associations between e-cigarette use and smoking cessation stages. E-values were calculated for point estimates and confidence intervals for each of the adjusted odds ratios estimated for the association between e-cigarette use and smoking cessation stages, under the different sets of measured covariates in Table 2-6. The results showed that the E-value tended to be larger in the generalized logit model than in the cumulative logit model, and also increased as more covariates were adjusted. In the final model based on generalized logit with all covariates adjusted (Model 4), the range of E-value for Estimate was 1.21 to 2.77, and for Confidence bound was 1.08 to 1.76, excluding the 1.00 (null) value. Most E-value were close to 1, indicating that unmeasured confounders (e.g., cigarette dependence, cigarette quitting history, cigarette quitting self-efficacy) could easily explain the observed associations between e-cigarette use and stage of change in smoking cessation.

Table 2-7. Sensitivity analysis: E-values for associations between e-cigarette use and cigarette cessation stages

	Stages of change in conventional cigarette smoking cessation											
	Ordinal		Multinomial (vs No attempt)									
	Later stage		Precontemplation		Contemplation		Preparation		Action		Maintenance	
E-cigarette use status	E-value	(CI-bound)	E-value	(CI-bound)	E-value	(CI-bound)	E-value	(CI-bound)	E-value	(CI-bound)	E-value	(CI-bound)
Model 1: crude												
Current EC user	1.08	(1.00)	1.53	(1.00)	1.89	(1.28)	1.39	(1.00)	1.86	(1.00)	2.50	(1.58)
Former EC user	1.26	(1.00)	1.38	(1.00)	2.19	(1.76)	1.19	(1.00)	1.28	(1.00)	1.14	(1.00)
Never EC user	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)
Model 2: survey year												
Current EC user	1.14	(1.00)	1.55	(1.00)	1.93	(1.32)	1.49	(1.00)	1.85	(1.00)	2.54	(1.60)
Former EC user	1.24	(1.00)	1.37	(1.00)	2.17	(1.74)	1.21	(1.00)	1.26	(1.00)	1.14	(1.00)
Never EC user	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)
Model 3: socio-demographic												
Current EC user	1.11	(1.00)	1.60	(1.00)	1.73	(1.00)	1.53	(1.00)	1.83	(1.00)	2.67	(1.70)
Former EC user	1.18	(1.00)	1.41	(1.00)	1.95	(1.52)	1.19	(1.00)	1.22	(1.00)	1.17	(1.00)
Never EC user	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)
Model 4: smoking characteristics												
Current EC user	1.11	(1.00)	1.68	(1.08)	1.83	(1.11)	1.71	(1.00)	1.86	(1.00)	2.77	(1.76)
Former EC user	1.28	(1.00)	1.53	(1.08)	2.10	(1.65)	1.34	(1.00)	1.24	(1.00)	1.21	(1.00)
Never EC user	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)	1.00	(Ref.)

E-values are calculated as described by VanderWeele and Ding.
CI: confidence interval; Ref: reference; EC: e-cigarette

Table 2-8 show the logit estimates for proportional and non-proportional odds model for the stages of change in cigarette smoking cessation, the dependent variable in this study. The proportional odds assumption is that the dependent variable has a constant order, yielding the identical estimates across categories. For the smoking cessation stages, a single value of odds ratio is derived for each model: NA-PC, PC-C, C-P, P-A, A-M. On the other hand, the non-proportional odds assumption is that the dependent variable is not ordered, allowing the estimate to vary across categories. Accordingly, a set of odds ratios of categories number – 1 is generated by comparing different levels of the dependent variable with a reference level: NA vs PC/C/P/A/M.

The results of the proportional odds model showed no significant relationship between e-cigarette use and stage of change in smoking cessation (P = .558), while the results of the non-proportional odds model showed a significant relationship (P <.001). E-cigarette use has a significant positive relationship with the early stages of smoking cessation, including PC and C stages, and a negative relationship with the later stage, such as M stage. For covariates, the younger age group was significantly less likely to be in the later stage in the proportional odds model, but was significantly more likely to be in the C stage in the non-proportional odds model. Smoking initiation age was not related to the smoking cessation stage in the proportional odds model (P = .816), but had a significant relationship in the non-proportional model (P = .023), and was highly likely to be in the M stage. These findings suggest that proportional odds models allow simple and useful interpretation of odds ratios, whereas non-proportional odds models are considerably more complex, but also make them more flexible.

Table 2-8. Logit estimates of the proportional and non-proportional odds model for the cigarette cessation stages

	Stages of change in conventional cigarette smoking cessation											
	Ordinal		Multinomial (vs No attempt)									
	Later stage		Precontemplation		Contemplation		Preparation		Action		Maintenance	
	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)
E-cigarette use status												
Current EC user	1.02	(0.81–1.27)	1.43*	(1.01–2.01)	1.59*	(1.02–2.48)	1.46	(0.95–2.25)	1.62	(0.89–2.94)	0.35**	(0.19–0.66)
Former EC user	1.10	(0.95–1.29)	1.29*	(1.01–1.64)	1.90***	(1.40–2.57)	1.14	(0.85–1.53)	1.08	(0.70–1.66)	0.94	(0.66–1.31)
Never EC user	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	P = .558		*P* <.001									
Sex												
Male	0.96	(0.79–1.17)	1.19	(0.89–1.57)	1.06	(0.71–1.59)	1.05	(0.74–1.49)	0.89	(0.56–1.41)	1.01	(0.67–1.54)
Female	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	P = .688		*P* = .830									
Age group (years)												
19–34	0.53***	(0.39–0.73)	0.89	(0.54–1.45)	2.11*	(1.09–4.09)	0.96	(0.52–1.78)	0.27**	(0.12–0.61)	0.18***	(0.10–0.32)
35–49	0.81*	(0.67–0.98)	1.07	(0.82–1.40)	1.45	(0.99–2.12)	0.74	(0.51–1.07)	0.53*	(0.32–0.87)	0.65*	(0.43–0.96)
50+	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	P <.001		*P* <.001									
Education level												
College or more	1.30*	(1.06–1.59)	0.73*	(0.54–1.00)	0.97	(0.62–1.52)	1.42	(0.97–2.08)	1.45	(0.86–2.43)	1.62*	(1.05–2.51)
High school	1.10	(1.92–1.31)	0.95	(0.72–1.26)	1.07	(0.72–1.58)	1.60**	(1.12–2.28)	1.18	(0.76–1.84)	0.89	(0.59–1.33)
Less than high school	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	P = .028		*P* <.001									
Income level												
High	1.03	(0.84–1.27)	1.01	(0.75–1.35)	0.98	(0.61–1.58)	1.03	(0.70–1.51)	1.07	(0.64–1.77)	1.11	(0.74–1.69)
Moderate	0.90	(0.75–1.08)	0.81	(0.63–1.04)	0.97	(0.64–1.47)	0.92	(0.66–1.29)	0.93	(0.61–1.44)	0.76	(0.51–1.13)

(Continue)

Low	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	$P = .214$		$P = .543$									
Employment												
Yes	0.84*	(0.71–0.99)	1.03	(0.80–1.32)	1.03	(0.74–1.45)	0.76*	(0.58–0.99)	0.86	(0.56–1.32)	0.68*	(0.48–0.95)
No	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	$P = .036$		$P = .081$									
Amount smoked[a] (cigarettes/day)												
21+	0.63***	(0.47–0.86)	0.38***	(0.26–0.57)	0.31**	(0.15–0.63)	0.07***	(0.03–0.16)	1.50	(0.81–2.78)	1.62	(0.96–2.73)
11–20	0.70**	(0.61–0.82)	0.58***	(0.47–0.72)	0.53***	(0.38–0.73)	0.30***	(0.22–0.40)	1.12	(0.79–1.58)	0.99	(0.73–1.34)
0–10	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	$P < .001$		$P < .001$									
Smoking duration (years)												
≥20 years	0.47***	(0.33–0.66)	1.05	(0.64–1.72)	1.27	(0.63–2.57)	1.27	(0.64–2.49)	0.30**	(0.14–0.64)	0.12***	(0.07–0.22)
10–20 years	0.71*	(0.54–0.94)	0.86	(0.58–1.27)	1.03	(0.61–1.76)	1.35	(0.81–2.25)	0.71	(0.39–1.31)	0.30***	(0.18–0.50)
<10 years	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	$P < .001$		$P < .001$									
Age started smoking (years)												
<19	0.98	(0.86–1.13)	0.94	(0.78–1.15)	0.84	(0.64–1.11)	0.83	(0.64–1.07)	0.67*	(0.46–0.98)	1.41*	(1.05–1.90)
≥19	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.
	$P = .816$		$P = .023$									

Values are adjusted odds ratios, 95% confidential intervals, and p-values according to chi-square test.
Multivariate models were adjusted for all covariates and survey year.
* $P < .05$; ** $P < .01$; *** $P < .001$
aOR: adjusted odds ratio; CI: confidence interval; Ref: reference; EC: e-cigarette

Figure 2-5 shows the results of multivariate analyses between e-cigarette use and each stage in smoking cessation controlling for significant covariates. Both current and former e-cigarette users were significantly more likely to be in the PC (current: aOR = 1.44, 95% CI = 1.02–2.03; former: aOR = 1.29, 95% CI = 1.02–1.65) and C stages (current: aOR = 1.60, 95% CI = 1.03–2.48; former: aOR = 1.90, 95% CI = 1.40–2.57), but not to the P and A stages. Current users have highest odds of being A stage, whereas were significantly less likely to be in the M stage (aOR = 0.31, 95% CI = 0.13–0.74) compared to never users. Former users showed that the likelihood of each stage of quitting smoking decreased after the C stage. They have lower odds of being in the M stage (aOR = 0.98, 95% CI = 0.10–0.98) than never users, although it is non-significant. The raw values with CIs are listed in the Table 2-5 (i.e., non-proportional logit model).

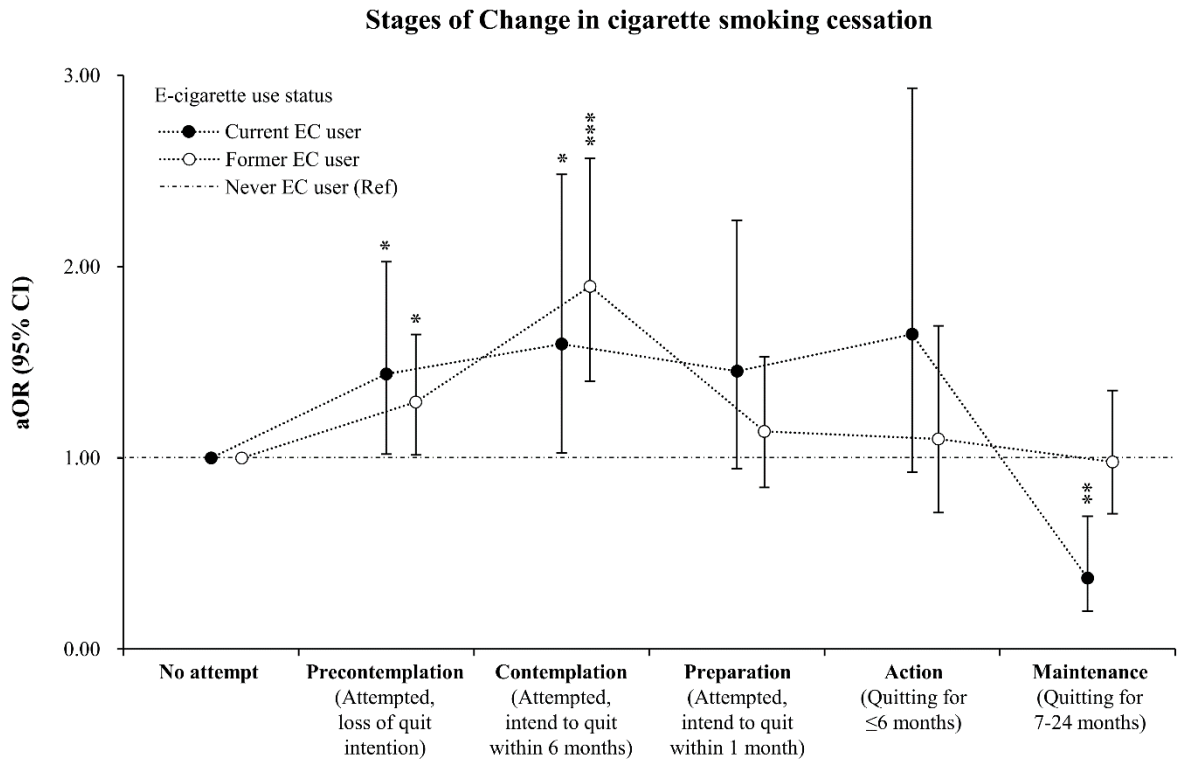


Figure 2-5. Odds ratios for the cigarette cessation stages by e-cigarette use status

Dots represent odds ratio and horizontal lines represent 95% confidence intervals. * P <.05; ** P <.01; *** P <.001; aOR: adjusted odds ratio; CI: confidence interval; Ref: reference; EC: e-cigarette

2.3.4. Potential confounders of cigarette quitting intention and behaviors

Figure 2-6 show the association between the intention to quit smoking and current e-cigarette use according to socio-demographic and smoking characteristics. From this subgroup analysis, it was confirmed that the relationship between intention to quit smoking and e-cigarette use was not significant in the most subgroups of socio-demographic characteristics (i.e., sex, education and income level) except for age. According to the subgroup by age, smokers over the age of 34 years shown the positive relationship between the intention to quit smoking within 1 month or 6 months and currently using e-cigarette. There was significant heterogeneity between age-specific subgroups between adults who 19–34 years old and adults who older than 34 years (*P*-heterogeneity = .048).

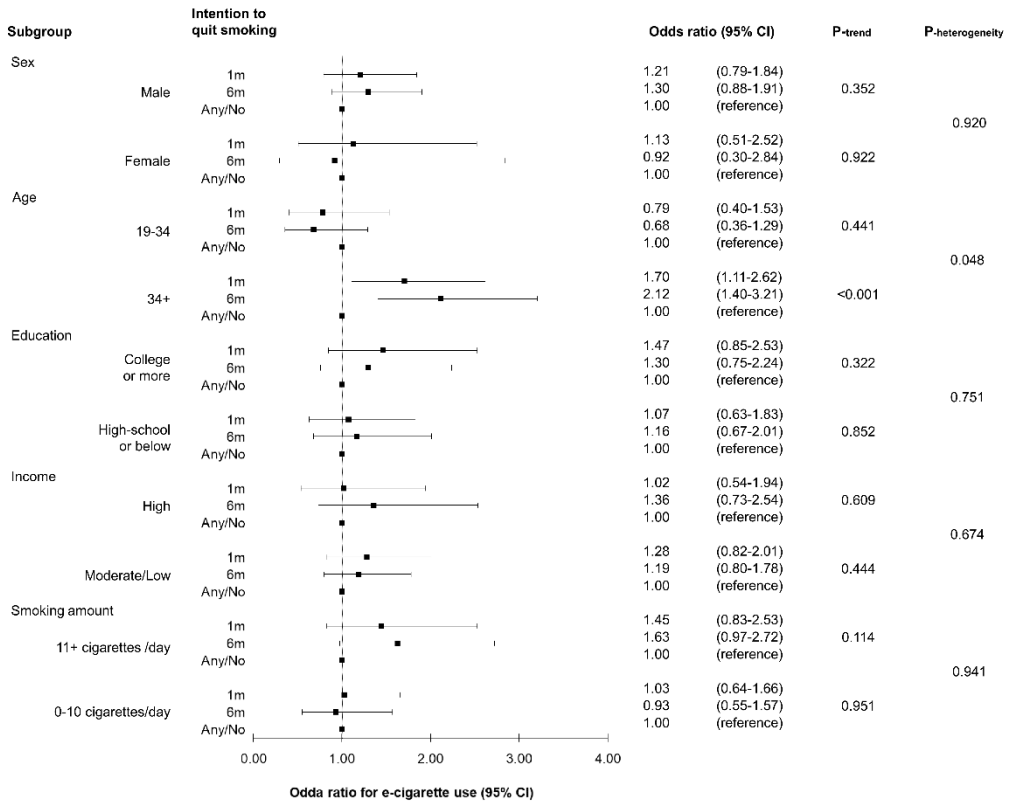


Figure 2-6. Subgroup analysis: association between the intention to quit smoking and e-cigarette use according to individual characteristics

Intention to quit smoking indicate: plan to quit smoking within the next month (1m), within the next 6 months (6m), sometime in the future beyond 6 months (any), or no plan to quit (no). P for heterogeneity calculated by means of the interaction term.

Table 2-9 shows the percentages of e-cigarette use intensity and device and liquid characteristics. Most e-cigarette users (71.1%) were currently using e-cigarette less than weekly. Cartridge/pod types were most common and followed by open-tank type (38.6%; 28.3%). More than half users (58.8%) consumed e-liquid containing nicotine. Regarding to e-cigarette use intensity, two-third (61.8%) of disposable or cartridge/pods users consumed 0.5 or less per day. More than half (51.2%) of tank users consumed e-liquid users more than 2.0 mL per day.

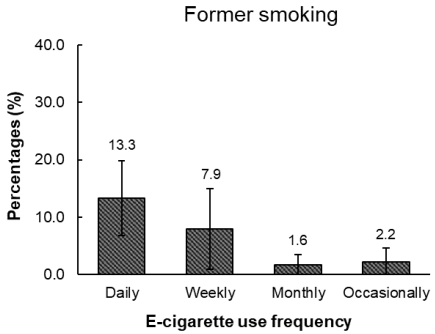
Figure 2-7 shows the associations between e-cigarette use intensity and cigarette quitting characteristics. Percentages of being former smoking were significantly different by e-cigarette use frequency (P <.001). More frequent e-cigarette users were more likely to being former smokers. Number of cartridge/pods used per day and mL of e-liquid used per day were not significantly related to cigarette quitting characteristics. The raw values with confidential intervals given in Table 2-10.

Table 2-9. Percentages of e-cigarette use intensity

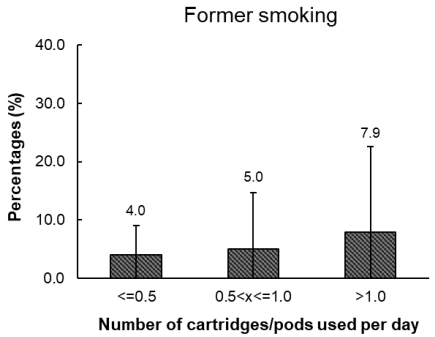
	n	%
Total	1239	
Frequency		
Daily	409	14.4
Weekly	456	14.5
Monthly	197	35.9
Less than monthly	222	35.2
Device characteristics (n=1,239)		
Disposable	196	16.4
Cartridge/pods	601	38.6
Tank	362	28.3
Others/unknown	125	16.7
Number of cartridges/pods used per day (n=386)†		
≤0.5	223	61.8
0.5<x≤1.0	99	21.8
>1.0	64	16.4
mL of e-liquid consumed per day (n=69)†		
≤1.0	24	20.7
1.0<x≤2.0	16	28.0
>2.0	29	51.2
Liquid characteristics (n=1,239)		
Nicotine-containing e-liquid	847	58.8
Nicotine-free e-liquid	286	19.9
Unknown	151	21.3

Values are unweighted numbers and weighted percentages.
† Only asked of at least weekly users

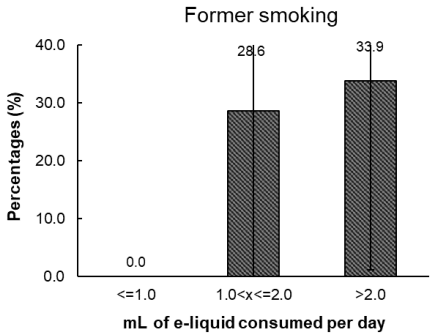
(a)


Former smoking
Percentages (%)
40.0
30.0
20.0
10.0
0.0
13.3
7.9
1.6
2.2
Daily
Weekly
Monthly
Occasionally
E-cigarette use frequency

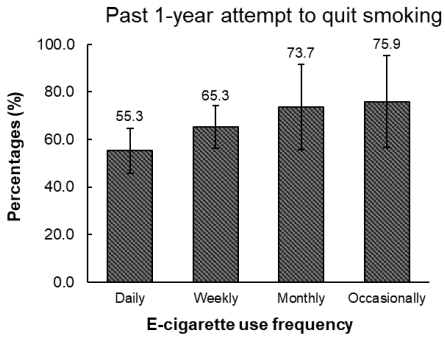
(b)


Former smoking
Percentages (%)
40.0
30.0
20.0
10.0
0.0
4.0
5.0
7.9
<=0.5
0.5<x<=1.0
>1.0
Number of cartridges/pods used per day

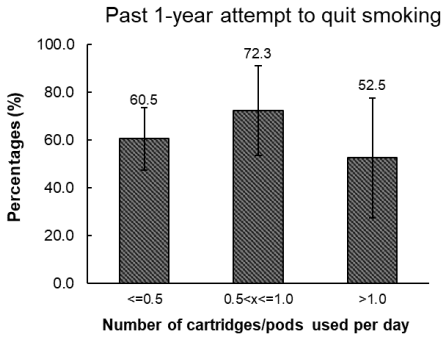
(c)


Former smoking
Percentages (%)
40.0
30.0
20.0
10.0
0.0
0.0
28.6
33.9
<=1.0
1.0<x<=2.0
>2.0
mL of e-liquid consumed per day

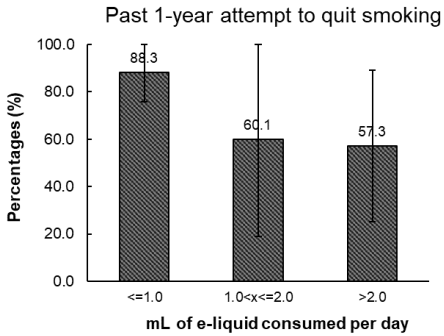
(d)


Past 1-year attempt to quit smoking
Percentages (%)
100.0
80.0
60.0
40.0
20.0
0.0
55.3
65.3
73.7
75.9
Daily
Weekly
Monthly
Occasionally
E-cigarette use frequency

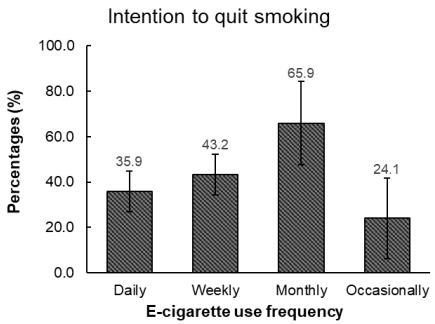
(e)


Past 1-year attempt to quit smoking
Percentages (%)
100.0
80.0
60.0
40.0
20.0
0.0
60.5
72.3
52.5
<=0.5
0.5<x<=1.0
>1.0
Number of cartridges/pods used per day

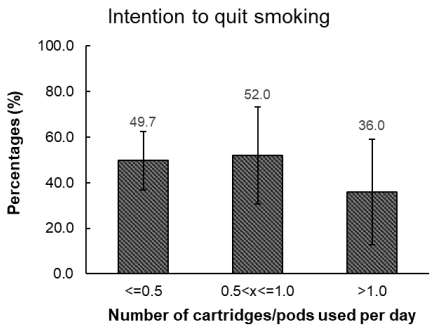
(f)


Past 1-year attempt to quit smoking
Percentages (%)
100.0
80.0
60.0
40.0
20.0
0.0
88.3
60.1
57.3
<=1.0
1.0<x<=2.0
>2.0
mL of e-liquid consumed per day

(g)



(h)



(i)

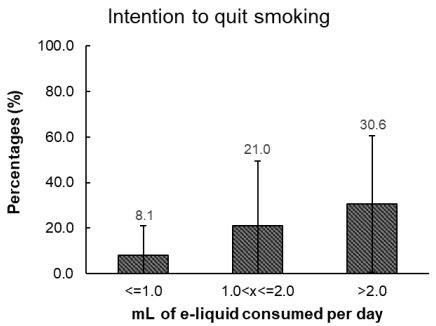


Figure 2-7. Percentages of cigarette quitting behaviors by e-cigarette use intensity

Bars represent weighted percentages and horizontal lines represent 95% confidence intervals.

Table 2-10. Associations between e-cigarette use intensity and cigarette quitting behaviors

	Former smoking			Past attempt to quit smoking†			Intention to quit smoking†			Long-term (>6 months) quitting smoking‡		
	%	LCI	UCI	%	LCI	UCI	%	LCI	UCI	%	LCI	UCI
Frequency	(n=1,239)			(n=1,207)			(n=1,207)			(n=32)		
Daily	13.3	6.8	19.8	55.3	45.8	64.8	35.9	26.8	44.9	32.4	9.7	55.1
Weekly	7.9	0.9	14.9	65.3	56.4	74.2	43.2	34.4	52.1	39.6	0.0	89.6
Monthly	1.6	0.0	3.4	73.7	55.6	91.7	65.9	47.6	84.3	100.0	100.0	100.0
Occasionally	2.2	0.0	4.7	75.9	56.7	95.2	24.1	6.4	41.8	64.4	13.9	100.0
	P <.001			*P* = .401			*P* <.001					
Device characteristic	(n=1,239)			(n=1,207)			(n=1,207)			(n=32)		
Disposable	2.4	0.0	6.4	74.9	48.4	100.0	29.4	0.0	59.6	46.8	0.0	100.0
Cartridge/pods	3.6	1.1	6.0	66.9	51.0	82.8	53.6	37.5	69.8	57.1	24.0	90.2
Tank	7.6	2.6	12.5	62.7	47.8	77.6	41.1	26.5	55.7	42.8	6.5	79.2
Others/unknown	3.3	0.0	7.9	88.4	76.0	100.0	40.6	0.0	82.1	48.5	0.0	100.0
	P = .293			*P* = .212			*P* = .625			*P* = .945		
Number of cartridges/pods used per day§	(n=386)			(n=381)			(n=381)			(n=5)		
≤0.5	4.0	0.0	9.0	60.5	47.5	73.5	49.7	36.9	62.6	70.7	0.0	100.0
0.5<x≤1.0	5.0	0.0	14.6	72.3	53.5	91.2	52.0	30.8	73.2	0.0	0.0	0.0
>1.0	7.9	0.0	22.6	52.5	27.3	77.7	36.0	12.7	59.2	0.0	0.0	0.0
	P = .826			*P* = .449			*P* = .563					
mL of e-liquid consumed per day§	(n=69)			(n=64)			(n=64)			(n=5)		
≤1.0	0.0	0.0	0.0	88.3	75.6	100.0	8.1	0.0	20.9	0.0	0.0	0.0
1.0<x≤2.0	28.6	0.0	63.1	60.1	19.0	100.0	21.0	0.0	49.3	59.6	0.0	100.0
>2.0	33.9	1.2	66.6	57.3	25.3	89.2	30.6	0.7	60.5	0.0	0.0	0.0
				P = .260			*P* = .386					

(Continue)

Liquid characteristic	(n=1,239)			(n=1,207)			(n=1,207)			(n=32)		
Nicotine-containing	4.1	1.9	6.4	68.9	58.9	78.9	54.2	42.8	65.5	25.1	2.4	47.8
Nicotine-free	6.2	0.0	12.7	70.6	45.6	95.5	29.2	7.2	51.2	92.1	78.7	100.0
	P = .724			*P* = .910			*P* = .206			*P* = .001		

Values are weighted percentages and 95% confidential intervals (lower LCI; upper UCI).

† Only asked of current smokers

‡ Only asked of recent quitters

§ Only asked of at least weekly users

2.4. Discussion

This study investigated the relationship between e-cigarette use (i.e., current, former, and never use) and cigarette quitting behavior using all stages of the SOC model. Through the investigation, I could reveal that the SOC model provides detailed and comprehensive information on the role of e-cigarette use in smoking cessation. E-cigarette use was positively associated with past quit attempts, while not with former smoking, intention to quit, and longer duration of quitting. Based on the cessation stages, e-cigarette use may be closely linked with the early-stage but not with late-stage in the entire process of smoking cessation: both current and former e-cigarette users were more likely to be in the PC and C stages, while not to be in the P and A stages, and particularly current users were less likely to be in the M stage than never users. The following paragraphs will discuss the potential positive and negative role of e-cigarette use in smoking cessation process based on the findings. The terms used in this discussion for a specific pattern of e-cigarette use (e.g., concurrent use, complete switching, and non-current use) can referred to the Figure 2-1.

A previous Korean research using data from 2013-2015 reported that e-cigarette use was related to the stronger readiness for smoking cessation (i.e., Precontemplation < Contemplation < Preparation stages) [136]. Inconsistent with previous study, this paper, which used data from 2016-2018, observed that current e-cigarette use was significantly related with Precontemplation and Contemplation stages, but not with Preparation stage. Here, current e-cigarette users in the Precontemplation and Contemplation stages represents the remaining concurrent users who have no immediate intention to quit smoking even though they have recently attempted to quit smoking. I further raise the possibility that such a positive

relationship between e-cigarette use and the P stage in previous works may be the effect of past quitting attempts evaluated only in the P stage. Considering that more than two-thirds (69.9%) of concurrent users are in the NA or PC stages, concurrent use is no longer indicates a greater readiness to quit smoking in adult smokers. This implies the possibility that many e-cigarette users in Korean adults will be stuck in a state of concurrent use [153, 154].

A recent study stated that the cessation term is one of the important indicators for estimating the effectiveness of e-cigarette use [155]. The results from the current study verify this, suggesting that current e-cigarette users were significantly less likely to be complete switching to e-cigarette when quitting period was ignored, but had the highest odds to be in the A stage and significantly less likely to be in the M stage in the SOC model when a 6-month quitting period was considered. These results imply that e-cigarette use may contribute to short-term ($\leq$6 months) quitting as reported in previous studies [63, 69]. On the other hand, I also suggest that the positive relevance of e-cigarette use with quitting smoking may be limited to a short period ($\leq$6 months). Indeed, one cohort study showed that the effect of e-cigarette use on smoking cessation was significant only for 6-month, not for 12-months or 18-months of smoking abstinence [138]. Future works will require tracking abstinence for at least longer than six months since completely switching from cigarette to e-cigarette and better if the results were compared across the multiple periods of abstinence.

The negative association between current e-cigarette use and the M stage can be interpreted as both positive or negative impacts of e-cigarette use on long-

term (>6 months) quitting: the former is that current e-cigarette users in the A stage also stopped using e-cigarettes (i.e., non-current use of either cigarettes or e-cigarettes) in the M stage; the latter is that they relapsed to current smoking (i.e., concurrent use or exclusive smoking with e-cigarette use history) before reaching the M stage. Meanwhile, other results from this study for former e-cigarette users provide important clues for comparing the magnitude of these two possible scenarios; former e-cigarette users were slightly less likely to be in the M stage (i.e., non-current use of either cigarettes or e-cigarettes), and significantly concentrated in the PC and C stages (i.e., exclusive smoking with e-cigarette use history) than never users. These infer that some e-cigarette users may achieve long-term success in quitting cigarettes, while most return to cigarette smoking with no more have intention to quit within the next month.

Collectively, e-cigarette use may be positively related to making quit attempts and possibly to short-term quitting, but more strongly related to current smoking with no immediate intention for future attempts in the general population. Due to the difficulty of quitting, smokers generally repeated the short-term abstinence and failed quit attempts [156]. Unfortunately, these multiple quit attempts do not always result in successful quitting and sometimes negatively affect to smoker's further motivation to quit smoking [157]. Although this study could not distinguish whether e-cigarettes were used in recent quit attempts, the collective set of results suggest that e-cigarette use is possibly linked with failed quit attempts with a weakened intention to quit. Given other finding that former e-cigarette users were tended to be heavier smokers than current and never users, these results support the concern that e-cigarettes use may have unintended consequences, including

perpetuating nicotine addiction and reducing motivation to quit smoking [73, 87, 153]. In this regard, the high prevalence of e-cigarette use among adult smokers will not contribute to a decrease in smoking rate at the population level.

From the perspective of SOC, traditional outcome measures of smoking cessation are sensitive only to transition from the P to the A stages (i.e., making a quit attempts) or the A to the M stages (i.e., smoking abstinence) [127]. Compare to the binary cessation outcomes, the SOC model has a unique power to detect the initial changes in current smokers, and long-term failure of cessation [127]. Given that majority of e-cigarette users no more have a strong intention to quit smoking than never users, more attention is needed on e-cigarette users' intentional changes for quitting smoking. Moreover, long-term failures are diluted by short-term success in quitting, so binary cessation outcomes without sufficiently long observational periods may overestimate the positive effects of e-cigarette use on quitting smoking. Therefore, the full SOC model can be a valuable alternative to cessation outcomes for measuring the efficacy of e-cigarette use in quitting smoking in the real-world setting [158, 159]. In particular, the current study proposed an extended SOC model reflecting prior quit attempts, complementing the heterogeneity of past quit attempts in the PC and C stages in the traditional SOC model. Applying this expanded SOC model makes it possible to designate smokers who have attempted to quit within the past year but no longer plan to quit smoking immediately. As for e-cigarette users, such stagnant status contains important clues about their 'sustained concurrent use' and 'smoking relapse'. Therefore, the results using this extended SOC model will provide insights for future empirical studies tracking the cessation behavior of e-cigarette users.

The effectiveness of e-cigarettes in quitting smoking is one of the determinants of their overall public health impact [40]. To maximize the positive impact of e-cigarette use on smoking cessation at the population level, completely switching from cigarette to e-cigarettes rather than concurrent use and, ultimately, cessation of both products should be encouraged. Concurrent users who even have no immediate intention to quit smoking can rather increase the negative impact, so their proportion in the total e-cigarette users and the underlying motivation for use should be investigated in the future.

According to the subgroup analysis, there was no significant association between cigarette quitting intention and e-cigarette use for all smokers and most socio-demographic subgroups. However, in the age group over 34 years of age, the intention to quit smoking was positively related to current e-cigarette use, which is different from the 19–34 years old group. This implies that the age group over 34 years of age may have an interaction with cigarette quitting intention. The insignificant association between e-cigarette use and intention to quit smoking in the overall adult smoker may be linked with higher prevalence of e-cigarette use in younger adults. Accordingly, it is necessary to confirm that the reasons/motivation for using e-cigarette may differ according to age groups.

There are several limitations to this study. First, due to the cross-sectional nature of the data, this study could not determine the temporal context between e-cigarette use and smoking cessation outcomes. Herein, former smoking status among e-cigarette users does not indicates smoking cessation induced by e-cigarette use. Even though, the large-scale nationwide cross-sectional analysis provides

population-level insight into the cigarette quitting status of e-cigarette users [68]. Second, this study could not adjust for other e-cigarette-related factors, such as the frequency or duration of e-cigarette use, motivation for use, or the nicotine levels in e-cigarette solutions, because the information was not available. Additional analyses implies that concurrent users' frequency of tobacco products use and their intention to quit smoking may interact with each other [86] and thereby are important factors in determining their health outcomes. To determine the health effects of e-cigarette use, further research is needed to estimate changes in total consumption of nicotine among concurrent users of e-cigarettes and conventional cigarettes, considering their intention level for cigarette quitting. Third, the small cell counts (i.e., 14) for the M stage in current e-cigarette users may have potential overfitting with high variance of the estimates. Given this statistical issue, the study does not completely rule out the potential for a positive relationship between e-cigarette use and long-term quitting in the discussion. Lastly, the study excluded the long-term (>2 years) former smokers in the analysis, so the results could be limited to explain the relationship between e-cigarettes and success in quitting more than two years. Nevertheless, since former smoker with a longer abstinence period may be less likely to use this relatively new product, restricting participants to those who had quit within recent years could effective in preventing overestimation of the negative relationship between e-cigarette use and long-term quitting.

CHAPTER 3.

Motivation for Using E-cigarette and Intention to Quit Tobacco Products

3.1. Introduction

Most cited reasons for using e-cigarettes are smoking cessation and health concerns both among smokers and the general population in previous studies [109, 125, 160]. This is consistent with the early marketing message of e-cigarettes as an effective smoking cessation aid and a less harmful alternative to cigarettes [11, 12]. However, with the restriction on the unproven therapeutic claims about e-cigarettes [161], e-cigarette companies nowadays promote their products focusing on the device features differentiated from regular cigarettes (e.g., a variety of flavors, better scent, availability, and can use in smoke-free areas) rather than health benefits [162, 163]. Indeed, some recent studies also found that e-cigarettes are being used more intensively by young adults for reasons other than cessation and health, such as better taste/smell, avoidance of smoking controls, and curiosity [164-166]. Based on these findings, several articles suggested that the main reason for using e-cigarettes may go beyond smoking cessation and health concerns [167, 168], but there is limited evidence to support [169, 170].

With the rapid increase in e-cigarette use, the concurrent use of cigarettes and e-cigarettes has also become an emerging issue in public health [40, 171]. Several population-based studies have shown that most e-cigarette users are concurrent users [31-36]; 65% in Canada [32], 70% in the United States [33], and 77% in Korea [34]. Although the use of e-cigarettes among non-current smokers is also increasing recently, this concurrent use is still one of the dominant patterns of e-cigarette use in the adult population [38-40]. Specifically, if concurrent use is a temporary condition to completely switch to e-cigarettes or quit all tobacco products, it could contribute to reducing the burden of tobacco use [88, 89]; Whereas, if it's a

long-term behavior to complement ongoing cigarette smoking or purely for entertainment, it may lead to more addictions and consumption into new habits and further greater health risks than either single-use [90, 91]. Given the importance of concurrent use behavior in determining public health impacts of e-cigarettes, understanding the main motives of e-cigarette use among cigarette smokers and correlated behavioral characteristics is essential.

Existing studies have in common agreed that there are significant differences between goal-oriented reasons and non-goal-oriented reasons in product use behaviors, but specific results were mixed according to outcome behaviors. For example, smokers who use e-cigarettes for goal-oriented reasons (e.g., smoking cessation and harm reduction) were more likely to intend to quit smoking than those for non-goal-oriented reasons (e.g., curiosity) [160, 172]. The former tended to sustain more frequent and stable e-cigarette use than the latter [173-176]. One noteworthy point here is that such product use behaviors (e.g., intention to quit smoking/vaping, frequency and dependence of each product use, and reduction in tobacco/nicotine consumption) can ultimately influence the health outcomes of concurrent users [40]. More detailed and thorough investigations of the association between the reasons for e-cigarette use and smoking and vaping behaviors are necessary to address the public health consequences of shift in main reasons for e-cigarette use.

Therefore, this study aim to explore changes in the main reasons for e-cigarette use in adult smokers, using nationally representative data from the 2016 and 2020 International Tobacco Control (ITC) Korea Surveys. I also examined

whether and how such changes differ by socio-demographic groups and investigated the association between each reason for using e-cigarettes and smoking- and vaping-related behaviors. The results of this study will contribute to revealing the main drivers of concurrent use in the adult population and predicting and addressing their potential impacts on public health.

3.2. Methods

3.2.1. Data and sample

Cross-sectional data came from the ITC Korea Surveys conducted in 2016 (June 7 to July 20) and 2020 (June 18 to 28). The 2016 ITC Korea survey (KOR1) sample was nationally representative of adult population (≥19 years old) of current smokers who reported smoking more than 100 cigarettes in their lifetime and currently smoke at least once a month. A total of 2000 cigarette current smokers were recruited at KOR1 survey by probability sampling of households using dual-frame (landline and mobile phone) random-digit dialing and interviewed via computer-aided telephone interview (CATI) system. The 2020 ITC Korea survey (KRA1) sample was nationally representative of adult population (≥19 years old) of tobacco users, including cigarette-only smokers (CC-only), liquid e-cigarette users (EC-only), heated tobacco products users (HTP-only), concurrent users of cigarette and liquid e-cigarette (CC+EC), concurrent users of cigarette and heated tobacco products (CC+HTP), and never or non-smokers. A total of 4,794 adults, consists of 4,234 any product users (CC and/or EC and/or HTP) and 560 never/non-users, were recruited at KRA1 survey via Rakuten Insight's web panel. Further descriptions of the study methods can be found elsewhere [177-180]. The analytic sample for this study was restricted to current smokers who also currently use liquid e-cigarette in any form (e.g., daily, weekly, less than weekly but occasionally) to identify the main reasons for e-cigarette use in adult cigarette smokers in two survey years. A total of 1,386 concurrent users of cigarette and e-cigarette were analyzed: 165 in 2016 and 1,168 in 2020.

3.2.2. Measures

3.2.2.1. Reasons for e-cigarette use

Reasons for e-cigarette use were assessed using the question "Which of the following are reasons for your using (liquid) e-cigarettes?". The following 14 specific reasons were investigated in common in 2016 and 2020 survey: help quit smoking, help cut down smoking, less harmful than smoking, less harmful to others, help stay smoking, more acceptable than smoking, can use in smoke-free areas, save money than smoking, curiosity, look cool, enjoyment, for the taste, someone offered, and advice from health professionals. All items were surveyed with dichotomous responses of "yes" or "no", with responses of "refused" and "don't know" coded as "no". Responding "yes" to multiple reasons for using e-cigarette is permitted, and each reason is therefore not mutually exclusive. Preliminary correlational analysis indicated that the question items were low to moderately correlated with each other ($r = 0.07–0.46$).

Table 3-1 presents the main themes and survey questions of each reason for using e-cigarette. Several previous studies subdivided reasons for using e-cigarettes into goal-directed reasons and non-goal-oriented reasons [172-176]. However, this classification can be inconsistent in their criteria and interpretation depending on which goal is targeting. Indeed, some studies included taste as goal-oriented [176], while other as non-goal-oriented ones [173]. Accordingly, I propose here that dividing the reasons for using e-cigarettes into *instrumental* (i.e., what is good as a means; substitutable) and *intrinsic* (i.e., what is good in itself; non-substitutable) motivations would more appropriate for the empirical distinction [181]. The former indicates e-cigarette use as a means of achieve some behavioral goals related to

cigarette smoking. The latter indicates e-cigarette use is behavioral goal itself. This categorization will help distinguish the user's needs and underlying motivations. In detail, the instrumental motivation (i.e., generally goal-oriented reasons) included cessation/health (e.g., help quit smoking, help cut down, less harmful than smoking, and less harmful to others) and social influence (e.g., help stay smoking, more acceptable, use in smoke-free area, and more affordable). The intrinsic motivations (i.e., generally non-goal-oriented reasons) included experimental (e.g., curiosity, someone offered, and advice from health professional) and recreational (e.g., enjoyment, taste, look cool) ones. For additional analysis regarding smoking cessation, reasons for vaping also categorized into mutually exclusive ones: "to quit smoking", "to cut down but not to quit smoking", and "neither to quit nor cut down on smoking".

Table 3-1. Survey questions and classification for measures of reasons for e-cigarette use

Themes	Groups	Reasons	Survey questions
Instrumental motivation	Cessation/health	Help quit smoking	They might help me quit smoking ordinary cigarettes.
		Help cut down smoking	Liquid e-cigarettes help me cut down on the number of ordinary cigarettes I smoke.
		Less harmful than smoking	They are less harmful to my health than cigarettes.
		Less harmful to others	They are less harmful to the health of people around me than ordinary cigarettes are.
	Social influence	Help stay smoking	Replacing some of my ordinary cigarettes with liquid e-cigarettes means I don't have to give up smoking ordinary cigarettes altogether.
		More acceptable	Using liquid e-cigarettes is more acceptable than smoking ordinary cigarettes to people around me.
		Use in smoke-free area	I can use liquid e-cigarettes in places where smoking ordinary cigarettes is banned.
		More affordable	I save money by using liquid e-cigarettes instead of smoking ordinary cigarettes.
Intrinsic motivation	Experimental	Curiosity	I was curious.
		Someone offered	Someone offered me one.
		Advice from health professional	A health professional advised me to try them.
	Recreational	Taste	They taste good.
		Enjoyment	I enjoy using liquid e-cigarettes.
		Look cool	Liquid e-cigarettes make me look cool.

3.2.2.2. Smoking and vaping behaviors

Smoking-related behaviors included frequency of use (daily versus non-daily smoking), whether less smoke after daily vaping, and intention to quit smoking. Whether less smoke after vaping was measured among daily vapers using the question: "Since you started using liquid e-cigarettes, do you now smoke more or fewer ordinary cigarettes than previously? (smoke fewer ordinary cigarettes versus no change/smoke more ordinary cigarettes)." Intention to quit smoking was assessed by the question: "Are you planning to quit smoking? (within the next month/between 1–6 months from now/sometimes in the future, beyond 6 months versus not planning to quit)."

Vaping-related behaviors included frequency of use (daily versus non-daily vaping), whether nicotine-containing liquid use, and intention to quit vaping. Whether contains nicotine in e-liquid was measured using question: "Does the e-liquid that you 'currently use most [asked daily or weekly vapers]' / 'used last [asked less than weekly vapers]' contain nicotine?" The responses were classified as 'yes', 'no', and 'refused/don't know'. Here, the e-liquid could come in disposable e-cigarettes, cartridges, pods or bottles. Intention to quit vaping was assessed by question: "Do you plan to continue using liquid e-cigarettes, or do you plan to stop using them in the foreseeable future? (definitely or probably stop versus might or might not continue/definitely or probably continue)."

3.2.2.3. Covariates

Demographic characteristics included: sex (male and female), age (19–24, 25–39, 40–54, 55+), education (high: university degree or higher, moderate: high school or

some university, and low: middle school or lower), annual income level (high: 60+ million KRW (approximately > $53,000 USD), moderate: 30 – <60 million KRW (approximately $26,500 USD – $53,000 USD), low: <30 million KRW (approximately < $26,500 USD), and unknown: respondents refused to answer or answered "Don't know"), and marital status (married: married/common law, never-married: single, and others: separated/divorced/widowed).

3.2.3. Statistical analysis

Univariate and bivariate analyses were used to describe the sample distribution of concurrent users according to the survey years. Multivariate regression analyses were applied to identify changes in reasons for e-cigarette use between 2016 and 2020 among overall and by socio-demographic groups. Prevalence and 95% confidence intervals of each reason were calculated and compared between those two survey years, using Proc Surveylogistics with the Lsmeans statement. Multivariate logistic regression analyses were also performed to assess the associations of each reason for e-cigarette use with smoking and vaping behavioral outcomes (e.g., daily smoking/vaping, less smoke after daily vaping, nicotine-containing vaping, and plan to quit smoking/vaping). All estimates were calculated using sample weights and strata and adjusted for all covariates. The level of statistical significance was set at P <.05. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA).

3.2.4. Ethics

The Seoul National University Institutional Review Board approved this study (IRB No. E2208/004-001).

3.3. Results

Table 3-2 shows the basic characteristics of smokers who currently vaping (i.e., concurrent users) in 2016 and 2020. Most concurrent users were male, 25–39 years of age, and of moderate- and high-income level. In 2020, the proportion of females (13.5% to 26.2%) and those of graduated high school or some university (38.4% to 53.0%) significantly increased, compared to 2016. Regarding smoking characteristics, daily smoking (92.4% to 51.1%) and high dependent smokers (HSI 4–6 scores: 22.9% to 9.8%) decreased between 2016 and 2020. For vaping characteristics, most (65.8% and 82.9%, for each year) of concurrent users reported using e-cigarettes non-daily in both years. An open-tanked type e-cigarette device (46.1%) was most common in 2016, while the cartridge/pods type (41.2%) was the most in 2020.

Table 3-2. Sample characteristics of concurrent users in 2016 and 2020

	2016		2020		
	n	%	n	%	*P*
Total	165		1168		
Sex					
Male	142	86.5	848	73.8	.037
Female	23	13.5	320	26.2	
Age					
19–24	35	21.0	86	11.1	.147
25–39	73	44.7	548	39.6	
40–54	37	23.4	422	33.3	
55+	20	11.0	112	15.9	
Education					
High	100	60.6	961	45.8	.039
Moderate	63	38.4	200	53.0	
Low	2	0.9	7	1.3	
Income					
High	62	37.2	573	42.1	.210
Moderate	53	32.2	453	38.3	
Low	41	24.7	126	17.6	
Unknown	9	5.9	16	2.0	
Marital status					
Married	62	37.5	672	51.6	.063
Single	95	57.7	458	45.9	
Others	8	4.8	33	2.6	
Daily smoking					
Yes	154	92.4	905	51.1	<.001
No	11	7.6	263	48.9	
Heaviness of Smoking Index (HSI)					
0–1	55	32.7	425	38.6	.022
2–3	70	44.4	599	51.6	
4–6	40	22.9	130	9.8	
Daily vaping					
Yes	54	34.2	366	17.1	<.001
No	111	65.8	802	82.9	
Device type of e-cigarette					
Disposable	7	3.9	180	17.1	<.001
Cartridge/pods	25	15.1	554	40.2	
Tank	72	46.1	313	28.8	
Others/unknown	61	34.9	121	13.9	

Values are unweighted frequencies, weighted percentages, and p-values from chi-square test.

3.3.1. Changes in main reasons for e-cigarette use in smokers

Figure 3-1 shows the changes in reasons for e-cigarette use among smokers who also vape currently in 2016 and 2020. The top five reasons for current vaping in 2016 were 'more acceptable' (59.3%), 'help cut down smoking' (53.0%), 'less harmful to others' (51.9%), 'help quit smoking' (47.2%), and less harmful than smoking' (46.5%). In 2020, reasons for current vaping most reported were 'curiosity' (60.2%) and followed by 'less harmful than smoking' (41.4%), 'taste' (35.9%), 'someone offered' (31.7%) , and 'help cut down smoking' (31.2%).

Comparing 2020 to 2016, the reasons for vaping that significantly decreased were: 'help to quit smoking' (47.2% to 28.1%), 'help cut down smoking' (53.0% to 31.2%), 'less harmful to others' (51.9% to 26.9%), 'more acceptable than smoking' (59.3% to 31.0%), 'help stay smoking' (32.8% to 16.1%), and 'convenience' (36.8% to 20.9%) (P <.05). Reasons for using e-cigarettes because of 'less harmful than smoking', 'cost', and 'someone offered' also showed a decrease, but this change was not statistically significant. The reasons that significantly increased were: 'curiosity' (26.5% to 60.2%), 'look cool' (2.6% to 14.1%), 'enjoyment' (9.5% to 29.6%), 'taste' (20.4% to 35.9%), and 'advice from health professionals' (0.4% to 12.8%) (P <.05). Although e-cigarette use motivated by 'look cool' and 'advice from doctor' markedly increased between the two survey years, its significance may have been overestimated due to the small sample size (<10) in 2016, and it was still the least-mentioned reason for e-cigarette use in 2020. (Table 3-3).

Figure 3-2 shows the changes in quit-composite reasons for e-cigarette use between 2016 and 2020. Concurrent users who vaped to quit smoking decreased from 47.2% in 2016 to 28.1% in 2020. Of the remaining concurrent users who did not report smoking cessation as a reason, those who vaped to cut down smoking also decreased from 15.6% to 9.2%. Concurrent users who vaped neither to quit nor cut down smoking increased from 33.5% to 60.3%. The raw values with confidential intervals given in Table 3-3.

Supplementary materials of this chapter show the reasons for HTP use among smokers in 2020. The top five reasons for current HTP use in 2020 were 'curiosity' (64.4%) and followed by 'less harmful than smoking' (38.6%), 'more acceptable' (35.8%), 'enjoyment' (34.8%) and 'help quit smoking' (31.2%) (Supple Fig 3-1). Compare to reasons for e-cigarette use in 2020, 'taste' was not frequent. The raw values with confidential intervals given in supplementary table 3-1.

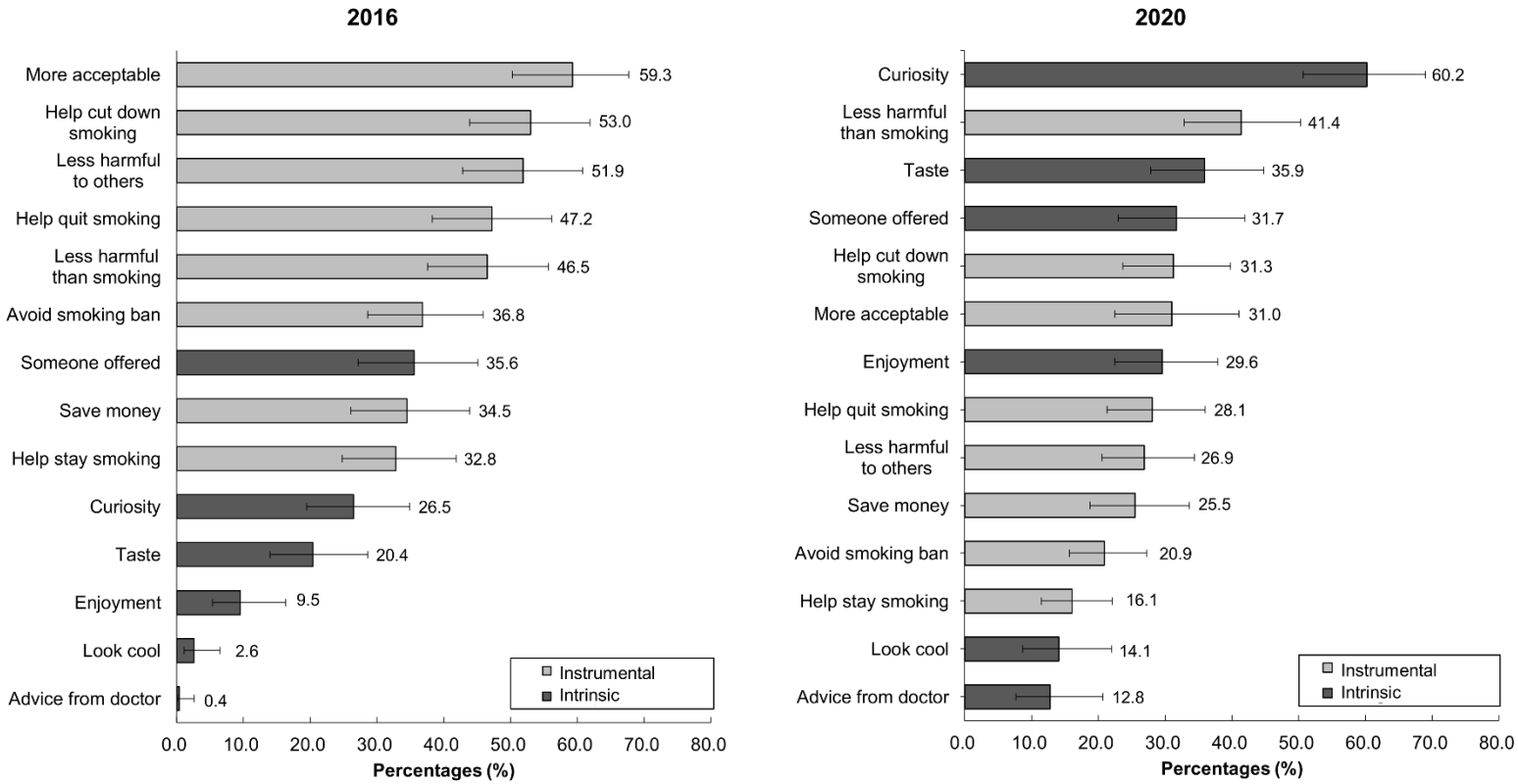


Figure 3-1. Reasons for e-cigarette use among cigarette smokers in 2016 and 2020

The bars represent the percentages and the horizontal lines represent the 95% confidential interval.

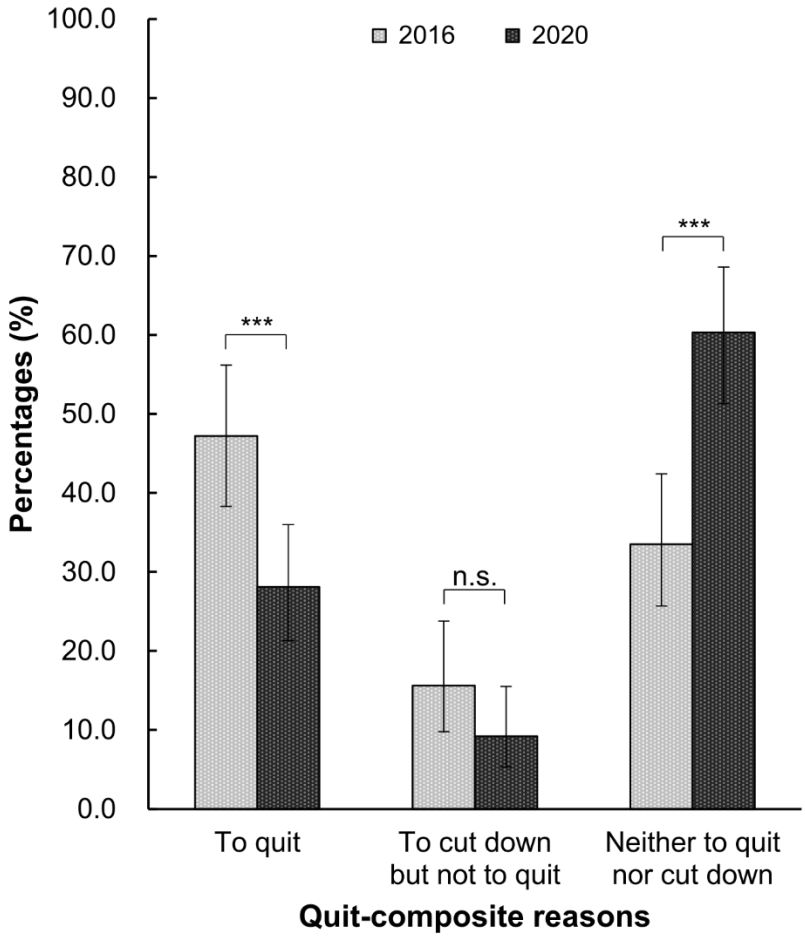


Figure 3-2. Quit-composite reasons for e-cigarette use among cigarette smokers in 2016 and 2020

The bars represent the percentages and the horizontal lines represent the 95% confidential interval. *** P <.001; n.s. indicates not significant (P >.05).

Table 3-3. Changes in reasons for e-cigarette use among cigarette smokers between 2016 and 2020

		2016 (n=165)				2020 (n=1,168)					2020 vs 2016	
		n	%	LCI	UCI	n	%	LCI	UCI	*P*	aOR	95% CI
Reasons for e-cigarette use												
Instrumental motivation												
a. Cessation	Help quit smoking	81	47.2	38.3	56.2	402	28.1	21.3	36.0	.0008	0.44***	0.27–0.71
/health	Help cut down smoking	84	53.0	43.9	61.9	378	31.2	23.7	39.8	.0004	0.40***	0.24–0.66
	Less harmful than smoking	78	46.5	37.6	55.7	477	41.4	32.9	50.3	.4047	0.81	0.49–1.33
	Less harmful to others	85	51.9	42.8	60.8	397	26.9	20.5	34.4	<.0001	0.34***	0.21–0.55
b. Social	Help stay smoking	52	32.8	24.8	41.9	268	16.1	11.5	22.1	.0005	0.39***	0.23–0.66
influence	More acceptable	96	59.3	50.3	67.7	367	31.0	22.5	41.1	<.0001	0.31***	0.18–0.53
	Use in smoke-free areas	66	36.8	28.6	45.9	357	20.9	15.7	27.3	.0011	0.45**	0.28–0.73
	Cost	47	34.5	26.1	43.9	318	25.5	18.8	33.7	.1018	0.65	0.39–1.09
Intrinsic motivation												
c. Experiment	Curiosity	54	26.5	19.5	34.9	652	60.2	50.7	69.0	<.0001	4.20***	2.52–6.98
	Someone offered	52	35.6	27.2	45.1	320	31.7	23.0	41.9	.5379	0.84	0.48–1.47
	Advice from doctor	2	0.4	0.1	2.6	196	12.8	7.7	20.7	<.0001	30.33***	6.11–150.55
d. Recreation	Taste	41	20.4	14.0	28.6	506	35.9	27.9	44.8	.0044	2.19**	1.28–3.76
	Enjoyment	17	9.5	5.4	16.3	333	29.6	22.5	37.9	<.0001	4.00***	2.04–7.84
	Look cool	6	2.6	1.1	6.5	229	14.1	8.7	22.0	.0010	6.05***	2.08–17.55
Quit-composite reasons												
To quit smoking		81	47.2	38.3	56.2	402	28.1	21.3	36.0	.0008	0.44***	0.27–0.71
To cut down (but not to quit)		25	15.6	9.8	23.8	138	9.2	5.3	15.5	.1281	0.55	0.25–1.19
Neither to quit nor cut down		59	33.5	25.7	42.4	628	60.3	51.3	68.6	<.0001	3.01***	1.82–4.96

Multivariate models were adjusted for gender, age group, education, income level, marital status and survey years.

* *P* <.05; ** *P* <.01; *** *P* <.001

LCI: lower confidence interval; UCI: upper confidence interval; aOR: adjusted odds ratio; CI: lower confidence interval

3.3.2. Changes in main reasons for e-cigarette use in smokers by socio-demographic subgroups

Table 3-4 presents the changes in reasons for e-cigarette use between 2016 and 2020 by specific age group. In 2016, the top reason for vaping is 'more acceptable' in younger smokers (aged 19–39), and 'help cut down smoking' in older smokers (aged 40+). In 2020, all age groups most reported 'curiosity' as the reason for vaping. Younger smokers aged 19–24 and 25–39 years mentioned 'for the taste' as followed, and older smokers aged 40–54 years mentioned 'less harmful than cigs' and older smokers aged 55+ years mentioned 'someone offered'.

Comparing 2020 to 2016, the decrease in instrumental motivations, such as 'help to quit smoking', 'help cut down smoking', 'less harmful than smoking', 'less harmful to others', 'more acceptable than smoking', 'help stay smoking', 'convenience' and 'cost', were more pronounced in older-aged smokers. E-cigarette use because of 'less harmful than smoking' and 'cost' only significantly decreased in oldest smokers aged 50+ years. The increase in e-cigarette use for intrinsic motivation, particularly 'enjoyment' and 'taste', was more pronounced in younger smokers aged 19–39 years.

Table 3-4. Changes in reasons for e-cigarette use among cigarette smokers between 2016 and 2020 by age groups

	Year	Age group			
		19–24 (n=121)	25–39 (n=621)	40–54 (n=459)	55+ (n=132)
Reasons for e-cigarette use					
a. Cessation/health					
Help quit smoking (%)	2020	41.3	32.3	20.4	10.4
	2016	34.1	35.8	52.9[3]	73.7[3]
		0.5836	0.6435	**0.0023**	**0.0024**
Help cut down smoking (%)	2020	44.6	30.6	32.1[3]	9.6
	2016	28.9	39.7[3]	59.7[1]	75.8[1]
		0.2235	0.2353	**0.0315**	**0.0022**
Less harmful than smoking (%)	2020	55.7[3]	36.0[3]	46.2[2]	14.7[3]
	2016	43.1	41.1[2]	30.2	73.8[2]
		0.3619	0.5365	0.1523	**0.0163**
Less harmful to others (%)	2020	45.8	27.1	25.4	10.5
	2016	63.5[2]	38.4	52.2	65.2
		0.2385	0.1309	**0.0124**	**0.0098**
b. Social influence					
Help stay smoking (%)	2020	21.8	16.3	19.3	4.5
	2016	24.9	25.6	43.9	19.9
		0.7843	0.1271	**0.0334**	**0.0359**
More acceptable (%)	2020	40.8	35.4	25.9	5.1
	2016	69.0[1]	52.9[1]	58.2[2]	58.2
		0.0472	**0.0406**	**0.0117**	**0.0027**
Use in smoke-free areas (%)	2020	26.7	23.9	21.3	7.4
	2016	51.4	24.9	43.3	24.9
		0.0694	0.8680	**0.0387**	0.1429
Save money vs smoking (%)	2020	30.2	25.7	30.6	4.0
	2016	23.6	21.5	47.1	33.5
		0.5618	0.5250	0.2224	**0.0030**

(Continue)

		Age group			
	Year	19–24 (n=121)	25–39 (n=621)	40–54 (n=459)	55+ (n=132)
c. Experiment					
Curiosity (%)	2020	76.7[1]	65.1[1]	62.0[1]	31.7[1]
	2016	51.6[3]	37.2	14.3	4.0
		0.0879	**0.0016**	**0.0002**	**0.0237**
Someone offered (%)	2020	20.1	28.2	31.6	15.2[2]
	2016	31.3	31.3	31.0	42.7
		0.4507	0.6999	0.9573	0.0960
Doctor advice (%)	2020	3.1	9.6	15.6	1.0
	2016	0.0	0.0	0.0	1.9
		-	-	-	0.5597
d. Recreation					
For the taste (%)	2020	74.1[2]	44.9[2]	19.9	2.8
	2016	34.7	25.6	9.9	0.5
		0.0096	**0.0171**	0.1616	0.0935
Enjoyment (%)	2020	50.4	22.3	23.6	5.1
	2016	3.4	8.5	7.6	3.7
		<.0001	**0.0079**	0.0685	0.7258
Look cool (%)	2020	6.0	9.8	19.3	2.5
	2016	1.6	1.7	3.2	0.0
		0.0909	**0.0281**	0.0514	**<.0001**

Values are weighted prevalence of each reason and the significance of its change between the two survey years.
Uppercase numbers from 1 to 5 indicate the top five reasons in each year.
Bold type = P <.05

Regarding quit-composite reasons, younger smokers (aged 19–39) did not show significant change between 2016 and 2020. In both years, younger smokers most likely to use e-cigarette neither to quit nor cut down. Older smokers (aged 40+) showed significant decline in e-cigarette use to quit smoking, and significant increase in neither to quit nor cut down. More than half of older smokers vape to quit smoking in 2016, while neither to quit nor cut down in 2020. Collectively, smokers in all age groups most likely to use e-cigarette neither to quit nor to cut down cigarettes, ranging from 42.7% to 88.5%, in 2020 (Table 3-5).

Table 3-5. Changes in quit-composite reasons for e-cigarette use among cigarette smokers between 2016 and 2020 by age groups

		Age group			
	Year	19–24 (n=121)	25–39 (n=621)	40–54 (n=459)	55+ (n=132)
Quit-composite reasons					
To quit cigs	2020	41.3	32.3	20.4	10.4
	2016	34.1	35.8	52.9	73.7
		0.5836	0.6435	**0.0023**	**0.0024**
To cut down, but not to quit	2020	5.5	6.9	9.5	0.8
	2016	1.2	12.5	13.5	3.7
		0.1140	0.1677	0.5822	0.0813
Neither to quit nor cut down	2020	42.7	57.0	62.6	88.5
	2016	61.6	44.8	21.2	9.4
		0.1619	0.1666	**0.0006**	**0.0069**

Values are weighted prevalence of each reason and the significance of its change between the two survey years.
Bold type = $P < .05$

Table 3-6 presents the changes in reasons for e-cigarette use between 2016 and 2020 by sex, education and income level. Comparing 2020 to 2016, the decrease in instrumental motivation, such as 'help to quit smoking', 'help cut down smoking', 'less harmful than smoking', 'less harmful to others', 'more acceptable than smoking', 'help stay smoking', 'convenience' and 'cost', were more pronounced in male and higher socio-economic groups. The increase in e-cigarette use for intrinsic motivation, particularly recreational motives was more pronounced in male, higher educational and both high- and low-income level groups.

Regarding quit-composite reasons, e-cigarette use to quit smoking decreased in all socio-demographic subgroups, and therefore most likely to use e-cigarette neither to quit nor to cut down cigarettes, ranging from 54.4% to 77.7%, in 2020 (Table 3-7).

Table 3-6. Changes in reasons for e-cigarette use among cigarette smokers between 2016 and 2020 by socio-demographics

		Sex		Education		Income	
	Year	Male (n=990)	Female (n=343)	High (n=1,052)	Low (n=276)	High (n=635)	Low (n=673)
Reasons for e-cigarette use							
a. Cessation/health							
Help quit smoking (%)	2016	49.6	23.9	51.9	36.6	48.1	41.9
	2020	28.3	17.7	27.1	24.5	24.9	26.7
		0.0005	0.648	**0.0005**	0.1766	**0.0106**	**0.0267**
Help cut down smoking (%)	2016	53.1	22.7	55.2	44.2	56.3	43.8
	2020	31.7	15.2	36.4	20.9	37.0	22.7
		0.0011	0.5508	**0.0158**	**0.0118**	0.068	**0.0018**
Less harmful than smoking (%)	2016	47.5	29.8	46.2	42.4	47.1	39.7
	2020	43.8	22.9	47.9	31.0	48.8	31.6
		0.5775	0.6195	0.8211	0.2335	0.8677	0.2424
Less harmful to others (%)	2016	51.9	45.2	47.4	58.0	53.3	48.1
	2020	31.1	14.2	31.3	22.4	26.2	27.9
		0.0009	**0.0351**	**0.0196**	**0.0002**	**0.0040**	**0.0038**
b. Social influence							
Help stay smoking (%)	2016	32.7	20.2	33.1	30.2	41.3	26.0
	2020	14.3	21.0	16.5	15.7	14.9	18.7
		0.0002	0.9683	**0.0067**	0.0543	**0.0006**	0.229
More acceptable (%)	2016	59.3	60.6	57.9	59.7	62.6	54.5
	2020	30.4	27.2	32.4	27.4	28.2	29.4
		<.0001	0.1118	**0.0009**	**0.0019**	**0.0011**	**0.0009**
Use in smoke-free areas (%)	2016	38.5	24.9	34.0	38.8	39.9	35.5
	2020	22.7	15.8	22.2	22.9	20.0	25.7
		0.0030	0.5000	**0.0478**	0.0629	**0.0131**	0.1383
Save money vs smoking (%)	2016	34.8	8.0	33.1	20.7	20.5	38.5
	2020	23.0	29.0	30.9	12.4	23.7	24.8
		0.0362	0.2273	0.7481	0.1862	0.6892	**0.0469**

(Continue)

		Sex		Education		Income	
	Year	Male (n=990)	Female (n=343)	High (n=1,052)	Low (n=276)	High (n=635)	Low (n=673)
c. Experiment							
Curiosity (%)	2016	28.1	13.2	26.4	28.5	15.7	37.4
	2020	53.1	89.1	56.2	66.6	49.0	70.1
		<.0001	**<.0001**	**0.0002**	**0.0001**	**<.0001**	**<.0001**
Someone offered (%)	2016	29.7	4.08	38.3	16.0	27.6	34.3
	2020	22.2	46.8	28.5	19.5	25.4	32.3
		0.1816	0.9582	0.2036	0.6318	0.8077	0.8008
Doctor advice (%)	2016	0.5	0.0	0.0	0.6	0.0	0.9
	2020	10.6	4.3	19.1	3.1	15.4	8.7
		<.0001	**<.0001**	**<.0001**	0.0513	**<.0001**	**0.0018**
d. Recreation							
For the taste (%)	2016	16.4	30.0	16.7	19.8	13.4	21.4
	2020	34.1	27.6	34.9	31.0	31.7	36.6
		0.0005	0.8834	**0.0066**	0.1742	**0.0161**	**0.0317**
Enjoyment (%)	2016	9.7	0.1	11.8	3.4	5.1	8.0
	2020	26.5	16.3	29.9	19.0	29.8	19.3
		0.0004	**<.0001**	**0.0035**	**0.0075**	**0.0006**	**0.0175**
Look cool (%)	2016	2.0	5.7	1.8	2.6	3.4	1.7
	2020	13.0	16.5	18.3	7.0	17.6	12.2
		0.0017	0.3173	**0.0009**	0.1993	**0.0190**	**0.0017**

Values are weighted prevalence of each reason and the significance of its change between the two survey years.
Bold type = $P < .05$

Table 3-7. Changes in quit-composite reasons for e-cigarette use among cigarette smokers between 2016 and 2020 by socio-demographics

		Sex		Education		Income	
	Year	Male (n=990)	Female (n=343)	High (n=1,052)	Low (n=276)	High (n=635)	Low (n=673)
Quit-composite reasons							
To quit cigs	2016	49.6	23.9	51.9	36.6	48.1	41.9
	2020	28.3	17.7	27.1	24.5	24.9	26.7
		0.0005	0.648	**0.0005**	0.1766	**0.0106**	**0.0267**
To cut down, but not to quit	2016	13.8	7.1	13.4	9.4	18.3	11.4
	2020	9.8	1.6	13.9	1.7	15.1	4.6
		0.3404	0.1999	0.9174	**0.0016**	0.6788	0.0556
Neither to quit nor cut down	2016	32.7	59.8	29.7	43.3	28.1	43.8
	2020	59.1	77.7	54.4	71.8	56.4	66.9
		<.0001	0.2973	**0.0009**	**0.0043**	**0.0073**	**0.0017**

Values are weighted prevalence of each reason and the significance of its change between the two survey years.
Bold type = $P < .05$

3.3.3. Associations between the reasons for e-cigarette use and smoking behaviors

Table 3-8 suggests the relationships between each reason for e-cigarette use and smoking behavioral outcomes including daily smoking, whether less smoke after daily vaping, and intention to quit smoking. Reasons for e-cigarette use related to daily smoking were 'to quit cigarettes' (aOR = 2.01, 95% CI = 1.05–3.83) and 'less harmful to others' (aOR = 2.55, 95% CI = 1.27–5.12), and those related to non-daily smoking were 'look cool' (aOR = 0.38, 95% CI = 0.16–0.91) and 'advice from health professional' (aOR = 0.30, 95% CI = 0.13–0.68). Reasons for e-cigarette use related to reduction in smoking amount included: 'help quit smoking' (aOR = 2.44, 95% CI=1.05–3.83), 'help cut down smoking' (aOR = 6.32, 95% CI = 2.75–14.53), 'less harmful than smoking' (aOR = 3.39, 95% CI = 1.53–7.49), 'less harmful to others' (aOR = 3.53, 95% CI = 1.56–8.02), 'more acceptable' (aOR = 3.39, 95% CI = 1.39–8.23), 'help stay smoking' (aOR = 3.28, 95% CI = 1.42–7.58), 'cost' (aOR = 4.10, 95% CI = 1.59–10.57) and 'enjoyment' (aOR = 2.73, 95% CI = 1.11–6.74). Smokers who use e-cigarettes because of 'help quit smoking' (aOR = 2.53, 95% CI = 1.43–4.49), 'help cut down smoking' (aOR = 2.63, 95% CI = 1.48–4.66), 'less harmful than smoking' (aOR = 1.96, 95% CI = 1.11–3.46), 'cost' (aOR = 2.14, 95% CI = 1.18–3.90), 'look cool' (aOR = 2.42, 95% CI = 1.02–5.75) 'someone offered' (aOR = 2.01, 95% CI = 1.04–3.91) and 'advice from doctors'(aOR = 2.57, 95% CI = 1.02–6.46) tended to have the intention to quit cigarette smoking.

For quit-composite reasons, concurrent users who vape 'to quit smoking' were significantly more likely to daily smoking (aOR = 2.21, 95% CI = 1.13–4.32), reduce their smoking amount (aOR = 3.47, 95% CI = 1.35–8.94), and have the

intention to quit smoking (aOR = 2.94, 95% CI = 1.60–5.41) compared to ‘to neither to quit nor cut down’. Concurrent users who vape ‘to cut down but not to quit cigarettes’ were significantly less cigarette smoking after daily vaping (aOR = 3.53, 95% CI = 1.06–11.75) than those who vape ‘to neither to quit nor cut down’, but not significantly different in daily smoking and the intention to quit smoking.

Table 3-8. Associations between reasons for e-cigarette use and smoking behavioral outcomes among concurrent users

	Smoking behaviors					
	Daily smoking		Less smoking after daily vaping (n=420)		Intention to quit smoking	
	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)
Reasons for e-cigarette use						
a. Cessation/health						
Help quit smoking	**2.01***	**(1.05–3.83)**	**2.44***	**(1.08–5.50)**	**2.53****	**(1.43–4.49)**
Help cut down smoking	1.45	(0.72–2.95)	**6.32*****	**(2.75–14.53)**	**2.63*****	**(1.48–4.66)**
Less harmful than smoking	1.67	(0.86–3.23)	**3.39****	**(1.53–7.49)**	**1.96***	**(1.11–3.46)**
Less harmful to others	**2.55****	**(1.27–5.12)**	**3.53****	**(1.56–8.02)**	1.51	(0.87–2.63)
b. Social influence						
Help stay smoking	1.64	(0.75–3.60)	**3.28****	**(1.42–7.58)**	1.05	(0.58–1.89)
More acceptable	0.92	(0.45–1.88)	**3.39****	**(1.39–8.23)**	1.20	(0.70–2.03)
Use in smoke-free areas	1.68	(0.85–3.34)	1.77	(0.81–3.87)	1.19	(0.70–2.04)
Cost	1.02	(0.52–2.00)	**4.10****	**(1.59–10.57)**	**2.14***	**(1.18–3.90)**
c. Experiment						
Curiosity	1.57	(0.75–3.31)	1.03	(0.42–2.52)	1.63	(0.92–2.90)
Someone offered	0.53	(0.27–1.08)	1.15	(0.45–2.93)	**2.01***	**(1.04–3.91)**
Advice from doctor	**0.30****	**(0.13–0.68)**	0.79	(0.25–2.46)	**2.57***	**(1.02–6.46)**
d. Recreation						
Taste	1.83	(0.89–3.76)	1.20	(0.55–2.65)	0.71	(0.40–1.26)
Enjoyment	0.81	(0.35–1.86)	**2.73***	**(1.11–6.74)**	1.05	(0.53–2.10)
Look cool	**0.38***	**(0.16–0.91)**	0.77	(0.27–2.21)	**2.42***	**(1.02–5.75)**
Quit-composite reasons						
To quit smoking	**2.21***	**(1.13–4.32)**	**3.47***	**(1.35–8.94)**	**2.94*****	**(1.60–5.41)**
To cut down, but not to quit	1.63	(0.52–5.11)	**3.53***	**(1.06–11.75)**	1.90	(0.81–4.45)
Neither to quit nor cut down	Ref.		Ref.		Ref.	

Multivariate models were adjusted for gender, age group, education, income level and survey year.

* P <.05; ** P <.01; *** P <.001; Bold type = P <.05

aOR: adjusted odds ratio; CI: confidence interval; Ref: reference

3.3.4. Associations between the reasons for e-cigarette use and vaping behaviors

Table 3-9 suggests the relationships between each reason for vaping and vaping behavioral outcomes including daily vaping, whether nicotine-containing liquid use, and intention to quit vaping. Reasons for vaping closely linked with daily vaping included: 'help quit smoking' (aOR = 2.46, 95% CI = 1.54–3.92), 'less harmful than smoking' (aOR = 1.71, 95% CI = 1.06–2.77), 'less harmful to others' (aOR = 1.69, 95% CI = 1.04–2.75), 'more acceptable' (aOR = 1.98, 95% CI = 1.20–3.27) 'help stay smoking' (aOR = 2.02, 95% CI = 1.18–3.48), 'enjoyment' (aOR = 3.37, 95% CI = 1.95–5.81) and 'taste' (aOR = 2.41, 95% CI = 1.44–4.04). Only the 'curiosity' was negatively related to daily vaping (aOR = 0.56, 95% CI = 0.34–0.91). Smokers who use e-cigarettes because of 'curiosity' (aOR = 2.73, 95% CI = 1.36–5.50), 'enjoyment' (aOR = 4.87, 95% CI = 1.93–12.30), and 'taste' (aOR = 3.71, 95% CI = 1.88–7.34) were highly more likely to use nicotine-containing liquid in their vaping. Most of the reasons for vaping were not significantly associated with a high likelihood of the intention to quit vaping, except for 'curiosity' (aOR = 2.16, 95% CI = 1.26–3.68). Vaping for 'help stay smoking' (aOR = 0.35, 95% CI = 0.19–0.67), 'advice from doctor' (aOR = 0.19, 95% CI = 0.07–0.47), 'enjoyment' (aOR = 0.27, 95% CI = 0.14–0.50) and 'look cool' (aOR = 0.34, 95% CI = 0.14–0.82) was less likely to have the intention to quit vaping.

For quit-composite reasons, concurrent users who vape 'to quit smoking' (aOR = 2.57, 95% CI = 1.53–4.33) were significantly more likely to daily vaping compared to 'to neither quit nor cut down'. Concurrent users who vape 'to cut down

but not to quit cigarettes' were not significantly different from those who vape 'to neither to quit nor cut down' in vaping behavioral outcomes.

Table 3-9. Associations between reasons for e-cigarette use and vaping behavioral outcomes among concurrent users

	Vaping behaviors					
	Daily vaping		Nicotine-containing vaping		Intention to quit vaping	
	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)
Reasons for e-cigarette use						
a. Cessation/health						
Help quit smoking	**2.46*****	**(1.54–3.92)**	1.26	(0.68–2.31)	1.35	(0.80–2.26)
Help cut down smoking	1.64	(1.00–2.69)	0.96	(0.46–2.03)	0.95	(0.56–1.62)
Less harmful than smoking	**1.71***	**(1.06–2.77)**	1.15	(0.58–2.28)	0.77	(0.45–1.33)
Less harmful to others	**1.69***	**(1.04–2.75)**	1.39	(0.73–2.62)	1.38	(0.83–2.29)
b. Social influence						
Help stay smoking	**2.02***	**(1.18–3.48)**	1.35	(0.68–2.68)	**0.35****	**(0.19–0.67)**
More acceptable	**1.98****	**(1.20–3.27)**	1.14	(0.43–3.08)	1.29	(0.66–2.50)
Use in smoke-free areas	1.26	(0.76–2.10)	1.45	(0.76–2.76)	0.93	(0.53–1.62)
Cost	1.45	(0.89–2.35)	1.67	(0.82–3.40)	0.56	(0.31–1.01)
c. Experiment						
Curiosity	**0.56***	**(0.34–0.91)**	**2.73****	**(1.36–5.50)**	**2.16****	**(1.26–3.68)**
Someone offered	0.57	(0.32–1.03)	0.88	(0.39–2.00)	1.42	(0.74–2.76)
Advice from doctor	0.72	(0.33–1.59)	0.88	(0.23–3.29)	**0.19*****	**(0.07–0.47)**
d. Recreation						
Taste	**2.41*****	**(1.44–4.04)**	**3.71*****	**(1.88–7.34)**	0.71	(0.39–1.30)
Enjoyment	**3.37*****	**(1.95–5.81)**	**4.87*****	**(1.93–12.30)**	**0.27*****	**(0.14–0.50)**
Look cool	0.73	(0.34–1.58)	0.78	(0.24–2.54)	**0.34***	**(0.14–0.82)**
Quit-composite reasons						
To quit smoking	**2.57*****	**(1.53–4.33)**	1.07	(0.54–2.09)	1.33	(0.77–2.29)
To cut down, but not to quit	1.18	(0.52–2.68)	0.54	(0.17–1.70)	0.92	(0.38–2.26)
Neither to quit nor cut down	Ref.		Ref.		Ref.	

Multivariate models were adjusted for gender, age group, education, income level and survey year.

* P <.05; ** P <.01; *** P <.001; Bold type = P <.05

aOR: adjusted odds ratio; CI: confidence interval; Ref: reference

3.4. Discussion

This study investigated the changes in reasons for e-cigarette use among adult smokers, using the 2016 and 2020 ITC Korea Surveys. There were two major patterns of change: a decrease in instrumental motivation related to smoking cessation and health (e.g., help quit smoking, help cut down smoking) and social influence (e.g., more acceptable, convenience); and an increase in intrinsic motivation related to recreational (e.g., enjoyment and taste) and experimental (e.g., curiosity) purposes. The decrease in instrumental motivation was particularly pronounced among older smokers, and the increase in intrinsic motivation was especially pronounced among younger smokers. Furthermore, smokers' product use behaviors (i.e., daily smoking/vaping, less smoke after vaping, nicotine-containing liquid use, and intention to quit smoking/vaping,) were significantly dependent on their reasons for using e-cigarettes. A summary of the significant results of this study is provided in Table 3-10.

Table 3-10. Summary of significant results by the reasons for e-cigarette use among concurrent users

		Changes	Significant age group	Smoking behaviors			Vaping behaviors		
		2020 (vs 2016)		Daily smoking	Less smoke	Quit smoking	Daily vaping	Nicotine containing	Quit vaping
Reasons for e-cigarette use									
Instrumental motivation (Cessation/health)	Help quit smoking	Decrease	40–54, 55+	+	+	+	+		
	Help cut down smoking	Decrease	40–54, 55+		+	+			
	Less harmful than smoking	Similar			+	+	+		
	Less harmful to others	Decrease	40–54, 55+	+	+		+		
Instrumental motivation (Social influence)	Help stay smoking	Decrease	40–54, 55+		+		+		–
	Perceived acceptability	Decrease	All groups		+		+		
	Convenience	Decrease	40–54						
	Cost	Similar			+	+			
Intrinsic motivation (Experimental)	Curiosity	Increase	25–39, 40–54, 55+				–	+	+
	Someone offered	Similar				+			
	Advice from doctor	Increase	19–24, 25–39, 40–54	–		+			–
Intrinsic motivation (Recreational)	Taste	Increase	19–24, 25–39				+	+	
	Enjoyment	Increase	19–24, 25–39		+		+	+	–
	Look cool	Increase	25–39, 55+	–		+			–
Quit-composite reasons									
To quit smoking		Decrease	40–54, 55+	+	+	+	+		+
To cut down (but not to quit)		Similar			+				
Neither to quit nor cut down		Increase	40–54, 55+	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

+ = significantly positive association (aOR > 1.00)
– = significantly negative association (aOR < 1.00)

Comparing 2020 to 2016, fewer smokers use e-cigarettes to control their smoking behavior (e.g., help quit smoking, and help cut down smoking), while more smokers use e-cigarettes because of product interest (e.g., curiosity, taste, and enjoyment). The results from 2016 data showed that smoking cessation or health concerns were the main reasons for e-cigarette use, as with most previous studies of adult population [109, 125, 160]. However, nearly all those reasons significantly declined in results from 2020. For instance, vaping for smoking cessation reduced from 45.6% to 26.6%, and for cutting down from 50.5% to 28.8%. Instead, 'curiosity' (60.2%) and 'for the taste' (35.9%) were newly included as the main reasons for vaping in 2020, which is closer to the existing results of the adolescent study [166, 175, 182]. This result highlight previous concerns that the main motives for e-cigarette use go beyond cessation and health even in the adult population [167, 168].

From the subgroup analysis, this study also found age-difference in the shifts in the main reasons for vaping. The decrease in cessation/health-related motives was only significant in older smokers (but not in younger smokers); conversely, the increase in e-cigarette use for the recreational purpose was only significant in younger smokers (but not in older smokers). This support prior suggestions that e-cigarettes are being more intensively used by young adults for reasons other than cessation and health, such as better taste/smell, avoidance of smoking controls, and curiosity [125, 165, 183]. Furthermore, it indicates that older smokers also no longer concentrated on cessation motives in using an e-cigarette, even lower than younger smokers in 2020. This is inconsistent with established evidence that older smokers more frequently cited smoking cessation as the reason for using e-cigarettes than younger smokers [160, 183, 184]. Based on these findings,

the age group should be considered as a critical factor in identifying the main motive for using e-cigarettes as well as responding to the future changes in motives of e-cigarette use.

The age-difference is significant in motivation for e-cigarette use. E-cigarette use for other motives than quitting smoking is concentrated in younger adults, who will become the next-generation adult population. The results of the subgroup analysis also suggested that the relationship between the intention to quit smoking and e-cigarette use was only significant in the older adults. These results collectively infer that young adults are leading the change in reasons for e-cigarette use in the net population. To establish effective regulation on e-cigarette, policy makers and administers should be focused on younger adult considering their main motives for e-cigarette demand.

Smoker's reasons for e-cigarette use serve as a strong predictor of their smoking and vaping behaviors. Here, I present four groups of reasons according to related product use behaviors: (1) cessation/health (e.g., to quit, to cut down, and less harmful than smoking), (2) social influence (e.g., more acceptable, and help stay smoking), (3) experimentation (e.g., curiosity), and (4) recreation (e.g., enjoyment and taste). First, smokers who vape for (1) cessation/health tended to report both reduction in cigarette smoking and intention to quit smoking, but likely to daily vaping. This is consistent with the prior findings that e-cigarette uses for goal-oriented reasons (e.g., smoking cessation) related to decreases in cigarette smoking and intention to quit smoking [160, 172] and also to frequent and stable e-cigarette use [173-176]. Second, smokers who vape because of (2) social norms tended to

report reduction in cigarette smoking, but no intention to quit smoking. They also tended to daily vaping. Third, smokers who vape for (3) experimental and (4) recreational reasons were generally not associated with both reduction in and quitting-intention of smoking. In particular, (3) experimental reasons related to non-daily vaping. This is in line with previous findings that non-goal-oriented reasons (e.g., curiosity) would relate to experimentation, with infrequent use of e-cigarette use [173-176]. Different from this, (4) recreational reasons closely linked to daily and nicotine-containing vaping. Vaping for enjoyment was negatively associated with intention to quit vaping, which could infer continued use.

Our study found that the highest reason for using e-cigarette in 2020 was curiosity among all age groups. Curiosity has generally been classified in previous studies as an initiation of experimental use [176, 185] that does not imply continued use of e-cigarettes. However, curiosity indicates interest in tobacco products, particularly greater for new ones [186, 187], and may also serve as an early risk factors for later e-cigarette use behavior [188-190]. Although little is known about how curiosity about e-cigarette use develops and shifts to non-experimental reasons (i.e., recreational motives), some studies have shown that curiosity is related to exposure to e-cigarette advertisements and perceived benefits [188, 191-194]. This finding implies that the potential role of curiosity acting as a mediator between marketing and consumer use behavior [195]. This is in line with the tobacco company's marketing strategy to steer attempts to use e-cigarettes from people who were initially uninterested in them [196, 197]. Furthermore, curiosity about e-cigarettes among those who already smoke conventional cigarettes suggests

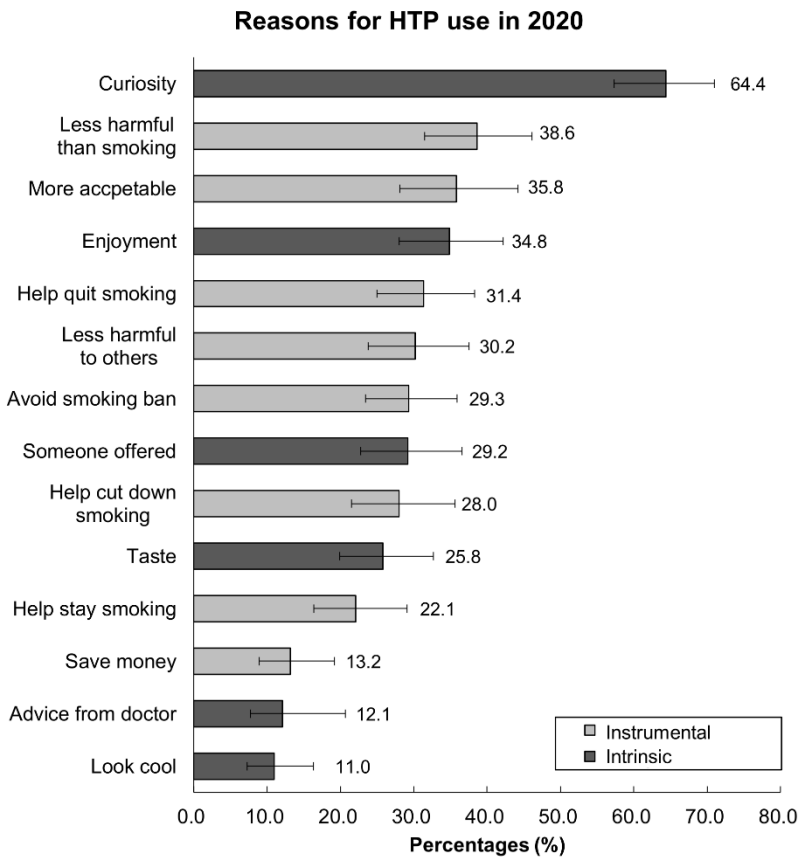
independent interest in tobacco products [185, 198], which is an important measure from a public health context.

Collectively, findings from this study deliver a strong message that the smokers' primary motives for e-cigarette use have shifted from instrumental ones such as cessation and health to intrinsic ones such as curiosity, taste, and enjoyment. For the quit-composite classification, more than half (60.3%) of smokers use e-cigarettes neither to quit nor cut down on smoking in 2020. This indicates that most concurrent users no more aimed to completely switch from cigarettes to e-cigarettes and even not substitute some smoking consumption with vaping. From the population perspective, this reinforces the potential for negative impacts of concurrent use on tobacco control and public health [38, 90]. Although the decrease in e-cigarette use motives to cessation benefits might be intended consequences, growing use of e-cigarette with the interest in its feature has more concern to the public health perspective.

This study has some limitations. First, the list of reasons for using e-cigarettes is not exhaustive, and other important reasons may have been missed. Nevertheless, this study deals with a total of 14 reasons, which is relatively broad compared to the previous studies. Second, this study used self-report data, which can induce social desirability biases in responding to reasons. Third, because the study is a cross-sectional design, it is not possible to elucidate the corresponding behavioral action for the stated motives (e.g., smokers who intended to quit ultimately achieve smoking cessation, how curiosity about e-cigarette use develops) and the changes in reasons for using e-cigarette within individuals (e.g., instrumental to intrinsic,

experimental to recreational). In this respect, it should be noted that e-cigarette use due to the ‘curiosity’, which was the main reason for the 2020 results, can be interpreted as a temporary motivation for experimental use as well as continuous trigger for new product use behavior. Future research with longitudinal design would be needed to detect the causal relationships of motives for e-cigarette use with subsequent behavioral changes and their dynamic changes within individuals. Forth, the findings might not generalize to other settings, such as countries with different regulatory environments for e-cigarettes, the prevalence of e-cigarette use, or the demographic distribution of adult smokers. Even so, the current study is a rare examination of changes in e-cigarette use reasons in the same national context, and thus would serve as a useful reference for future studies in other countries.

Supplementary materials



Supplementary figure 3-1. Reasons for HTP use among cigarette smokers in 2020

The bars represent the percentages and the horizontal lines represent the 95% confidential interval.

Supplementary table 3-1. Reasons for HTP use among cigarette smokers in 2020

		2020 (n=1,995)			
		n	%	LCI	UCI
Reasons for HTP use					
Instrumental motivation					
a. Cessation /health	Help quit smoking	664	31.3[5]	25.0	38.3
	Help cut down smoking	683	28.0	21.5	35.6
	Less harmful than smoking	891	38.6[2]	31.5	46.1
	Less harmful to others	767	30.2	23.8	37.5
b. Social influence	Help stay smoking	465	22.1	16.4	29.1
	More acceptable	730	35.8[3]	28.1	44.2
	Use in smoke-free areas	627	29.3	23.4	35.9
	Cost	383	13.2	8.9	19.2
Intrinsic motivation					
c. Experiment	Curiosity	1151	64.4[1]	57.3	71.0
	Someone offered	557	29.2	22.8	36.6
	Advice from doctor	354	12.1	8.2	17.5
d. Recreation	Taste	717	25.8	19.9	32.7
	Enjoyment	749	34.8[4]	28.0	42.2
	Look cool	294	11.0	7.3	16.3
Quit-composite reasons					
To quit smoking		664	31.3	25.0	38.3
To cut down (but not to quit)		265	9.2	6.2	13.3
Neither to quit nor cut down		1056	56.7	49.2	63.9

Values are unweighted frequencies, weighted percentages, and 95% confidential intervals (lower LCI; upper UCI).
Uppercase numbers from 1 to 5 indicate the top five reasons.

CHAPTER 4.

Perceived Harm and Regulation on Cigarette, E-cigarette Use, and Quit Intention of Cigarette Smoking

4.1. Introduction

Tobacco control is one of the greatest public health achievements in the 21st century, according to the Centers for Disease Control and Prevention (CDC) [1]. The global prevalence of tobacco use decreased from 26.9% in 2000 to 20.2% in 2015 [2], potentially averted countless tobacco-related deaths worldwide [3-5]. This achievement in tobacco control was facilitated by the regulations and policies derived from the World Health Organization's Framework Convention on Tobacco Control (WHO FCTC) [199-201], which is the international treaty adopted in 2003 to combat the global tobacco epidemic. The WHO FCTC established a policy package known as MPOWER (i.e., monitor tobacco use, protect from tobacco smoke, offer help to quit, warn about the dangers, enforce marketing bans, and raise taxes on tobacco) to provide national-level guidance on effective strategies for reducing smoking rates [202]. Indeed, many parties that have implemented the MPOWER package recorded historical low smoking rates [2, 6], and some are even aiming to bring the value to near-zero by 2040 or sooner (so-called 'tobacco endgame') [7].

With the decline in cigarette smoking, the tobacco industry has focused on a new emerging nicotine delivery system known as the e-cigarette [8]. E-cigarette first introduced in global market in 2003, and aggressively promoted as an aid for smoking cessation, a safer and cost-effective alternative to smoking, or a way to evade smoke-free policies [203, 204]. In particular, these various marketing messages effectively appealed to a broad spectrum of cigarette smokers with different motives for using them. Several researchers further hypothesized that some smokers may try e-cigarettes in response to existing tobacco control policies, either to quit conventional smoking or to circumvent smoking regulations [184, 205-208].

This is supported by previous observation that the popularity of e-cigarette was higher in countries with more restrictive smoking environments [209]. Additionally, the motivation of e-cigarette use responds to the dynamic external environment (i.e., regulation and marketing) and induced changes in perception. The reason for using e-cigarettes is sensitive to complex regulatory environments: smoking and vaping polices respectively, as well as the gap between them. To prepare for the public health impacts of a rapidly changing tobacco landscape, there is a need to explore the relationship between the comprehensive tobacco control policies and smokers' smoking and vaping behaviors.

Smoker's intention to quit smoking could serve as an early indicator for evaluating the impact of tobacco control policies, because it is one of the strongest predictors of quit attempts and successful cessation [210]. In this respect, it could also an important factor in predicting future behavioral changes of e-cigarette users who currently smoke (i.e., concurrent users). Specifically, concurrent users who have the intention to quit may become complete switchers or non-product users, while those who have not may remain as concurrent users or return to exclusive smokers. Such statuses have potentially heterogeneous consequences for health, so that quitting intention is one of the smoking characteristics that should be described in e-cigarette users. However, the causal relationship (e.g., direction and temporal relationship) between e-cigarette use and quitting intention has not been established and a potentially bi-directional relationship is possible [87, 206, 211-217]. The variable of quitting intention needs to be carefully treated with regard to e-cigarette use.

In this study, I explored the complex relationship between cigarette regulatory environment, e-cigarette use, and intention to quit smoking, using nationally representative samples of adult smokers in Korea. To clarify this association, the study aimed: 1) to identify the perceived harm and indoor ban for each tobacco product (i.e., cigarette and e-cigarette), 2) to investigate the associations between perceived harm and indoor ban on tobacco products and e-cigarette use, and 3) to investigate the associations between perceived harm and indoor ban on tobacco products and the intention to quit smoking by e-cigarette use status. The findings will contribute to developing optimal regulations considering potential unplanned effects of e-cigarette use on tobacco control.

4.2. Methods

4.2.1. Data and sample

Data came from the ITC Korea Surveys conducted in 2020 (June 18 to 28). The 2020 ITC Korea survey (KRA1) sample was nationally representative of adult population (≥19 years old) of tobacco users, including cigarette-only smokers (CC-only), liquid e-cigarette users (EC-only), heated tobacco products users (HTP-only), concurrent users of cigarette and liquid e-cigarette (CC+EC), concurrent users of cigarette and heated tobacco products (CC+HTP), and never or non-smokers. A total of 4,794 adults, consists of 4,234 any product users (CC and/or EC and/or HTP users) and 560 never/non-users, were recruited at KRA1 survey via Rakuten Insight's web panel. Sample weights were constructed based on age, sex, and geographic region. Further descriptions of the study methods can be found elsewhere [178, 180]. The analytic sample for this study was restricted to current smokers who had smoked ≥100 cigarettes in their lifetimes and reported currently smoking at least monthly A total of 3,855 current cigarette users were analyzed.

4.2.2. Measures

4.2.2.1. Perceived risk on cigarette and e-cigarette

The risk perceptions of both products were queried to all cigarette smokers regardless of whether they currently use e-cigarette. Absolute risk perception of cigarettes, absolute risk perception of e-cigarettes, and relative risk perception of e-cigarette compared to cigarettes were evaluated. The absolute risk perception of cigarettes included ‘harmful to health’, ‘harmful to others’, and ‘addictive’. The absolute risk perception of e-cigarette included ‘harmful to health’. As for the

relative perceptions of e-cigarette compared to cigarette, 'harmful to health', 'harmful to others', and 'addictive' were investigated, and responses for each were composed of: equally, less harmful/additive than cigarette, and more harmful/additive than cigarette.

4.2.2.2. Exposure to smoke-free and vape-free laws

The exposure to indoor air laws were investigated for the following questions: "Which of the following best describes the rules about [smoking cigarettes/using liquid e-cigarettes] in [bars and pubs where you live/restaurants or cafés where you live/where you work]? with the answer options of "never allowed anywhere indoors", "allowed only in designated indoor areas", and "allowed indoors without rules or restrictions". Questions for the public places (i.e., bars/pubs, and restaurants/café) were asked to all smokers, and questions for the workplaces were only asked to smokers who are currently working in an indoor building. The level of ban in these three places was classified into "complete ban", "partial or no ban", and these was addressed for each of the conventional cigarettes (smoke-free) and e-cigarette (vape-free).

The regulatory gap between the two products was divided into three categories: "both conventional and e-cigarettes are completely banned", "conventional cigarettes are completely banned but e-cigarettes are not completely banned", and "cigarettes are not completely banned".

4.2.2.3. E-cigarette use

The vaping status was assessed by the following question: "On average, how often do you currently use electronic cigarettes?" Those who respond to any form of

currently uses (daily, weekly, less than weekly but occasionally) were classified as e-cigarette use, and those respond to non-current use (stopped or never used) were classified as non-use.

4.2.2.4. Intention to quit smoking and vaping

The intention to quit smoking was assessed by the questions that "Are you planning to quit smoking?" and the responses were "within the next month", "within the next six months", "sometime in the future, beyond six months", and "not planning to quit". Here, the first two answers that "having plan to quit smoking at least within the next six months" were designated as having intention to quit smoking. Intention to keep using e-cigarette (intention to quit vaping) was assessed by question: "Do you plan to continue using liquid e-cigarettes, or do you plan to stop using them in the foreseeable future? (might or might not continue/definitely or probably continue versus definitely or probably stop)."

4.2.2.5. Covariate

Individual characteristics measures included: age (19–24, 25–39, 40–54, 55+), gender, marital status (married: married, unmarried: separated, divorced, widowed, common-law or single), level of education (low: high school or below, middle: college or university, high: graduate school or more), annual income level (low: < 30 million KRW (approximately < $26,500 USD), middle: 30 – < 60 million KRW (approximately $26,500 USD – $53,000 USD), high: 60+ million KRW (approximately > $53,000 USD)), and heaviness of smoking index (0–1, 2–3, 4–6).

4.2.3. Statistical analysis

Descriptive statistics were used to describe the percentages of relative risks and regulatory gaps among overall smokers. Four models of multiple logistic regressions were performed to present the odds ratios of e-cigarette use and intention to quit smoking. The first model assessed the association between perceived risks on products and e-cigarette use. The second model assessed the association between exposed indoor air laws and e-cigarette use. The third model measured the association between perceived risks on products and the intention to quit. The fourth model measured the association between exposed indoor air laws and intention to quit smoking. All estimates were calculated using sample weights, strata statements and adjusted for covariates. The level of statistical significance was set at $P < .05$. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA), including Proc Surveyfreq and Surveylogistic.

4.2.4. Ethics

The Seoul National University Institutional Review Board approved this study (IRB No. E2103/001-004).

4.3. Results

Table 4-1 show the basic characteristics of cigarette smokers. Majority smokers were male, over 40 aged, married, and high socioeconomic level. About one third (33.3%) of smokers have plan to quit smoking within the next 6 months. Participants consists of 2,701 cigarette only users, and 1,154 concurrent users of cigarette and e-cigarette.

Table 4-1. Sample characteristics of cigarette smokers

	n	%
Total	3855	
Sex		
Male	3055	87.2
Female	800	12.8
Age		
19–24	184	7.3
25–39	1403	29.5
40–54	1632	38.5
55+	636	24.7
Marital status		
Married	2306	52.9
Unmarried	1549	47.1
Education		
Univ degree or more	3067	40.2
High school or less	775	59.8
Income (10,000 won) †		
6000+	1681	31.8
3000–<6000	1574	40.8
Below 3000	526	24.3
Unknown	74	3.1
Heaviness Smoking Index		
0–1	1739	46.2
2–3	1658	39.1
4–6	458	14.7
Plan to quit smoking		
Within 1 month	250	6.9
Within 6 months	1068	26.4
Beyond 6 months	1274	25.6
No plan	1263	41.1
E-cigarette use		
Yes (Concurrent user)	1154	23.6
No (Cigarette-only user)	2701	76.4

Values are unweighted numbers and weighted percentages.
† Annual household income (10,000 won = 10 dollar), won is South Korea's currency

4.3.1. The perception on harm and regulation on tobacco products

Table 4-2 presents the percentages of harm perception and exposure to regulation (i.e., indoor air laws) of cigarette and e-cigarette. Regarding the perceived risk of the use of regular cigarettes and e-cigarettes, one-third (33.5%) of all smokers answered that conventional cigarettes are harmful to their health as a fair amount or great deal. Smokers who agreed that cigarette is harmful to others accounted for nearly two-thirds (65.1%) of respondents. Especially, most of smokers (87.9%) somewhat or very agreed that conventional cigarettes were addictive. The perceive absolute risks of e-cigarette use on health were slightly lower (28.4% vs 33.5%) than those of conventional cigarettes. Absolute risks on others' health and addictiveness were not available from survey data. Instead, as for relative risk perception, about one-fourth smokers believed that e-cigarette use have a lower risk than conventional ones on their health (29.3%), to others health (26.8%), and less addictive (22.3%). More than half of smokers reported that there was no difference in health risks and addictiveness, while some (15%) believe e-cigarette use is more harmful.

Regarding the indoor air law, majority of smokers answered that conventional cigarettes are completely banned in bar/pub (56.6%), restaurant/cafes (67.9%) and workplaces (75.4%). Smokers who reported that e-cigarettes were completely banned in those places were 58.7%, 58.4%, and 68.2%, respectively. The values for complete bans in bar/pub did not differ significantly, while complete ban in restaurants/café and workplaces were slightly lower for e-cigarettes than conventional ones. When assessing the complex perception of the indoor air laws on cigarette and e-cigarettes, around 15% of smokers reported that conventional cigarettes were completely banned but not e-cigarette.

The results for HTP shown in supplementary table 4-1. Regarding the risk perception, Similar to e-cigarette (28.4%), the perceived health risk of HTP were lower than those of conventional cigarettes (28.9% vs 33.5%). As for relative risk perception, smokers who believe that HTP have a weaken risk to their health were 24.5%, similar but slightly lower than results from e-cigarette (29.3%). Regarding the indoor air law, more than half of smokers answered that HTP are completely banned in bar/pub (55.5%), restaurant/cafes (57.5%) and workplaces (67.8%). For both e-cigarettes and HTPs, complete bans in the workplace are more frequently reported than those in public places. Conventional cigarettes were completely banned but not HTP have a value of around 15% in such places.

Table 4-2. Percentages of harm perception and exposure to indoor ban of cigarette and e-cigarette

	CC absolute risk perception	EC absolute risk perception	CC-EC relative risk perception		
			CC > EC	CC = EC	CC < EC
Harm perception	%	%	%	%	%
Harmful to health	33.5 (30.2–36.9)	28.4 (24.5–32.4)	29.3 (25.1–33.5)	53.4 (48.7–58.2)	17.3 (12.0–22.6)
Harmful to others	65.1 (61.7–68.6)	-	26.8 (23.3–30.3)	59.7 (54.9–64.5)	13.5 (8.1–18.9)
Addictive	87.9 (85.4–90.4)	-	22.3 (19.1–25.5)	61.5 (57.5–65.5)	16.2 (12.5–19.8)
			CC-EC complete ban		
	CC complete ban	EC complete ban	CC & EC complete ban	CC only complete ban	CC partial/no ban
Exposed indoor air laws	%	%	%	%	%
Bar/pub	56.6 (52.6–60.7)	58.7 (54.9–2.5)	41.6 (38.0–45.1)	15.1 (12.6–17.5)	43.4 (39.3–47.4)
Restaurant/café	67.9 (64.3–71.6)	58.4 (54.3–62.5)	48.8 (45.0–52.6)	19.1 (15.0–23.3)	32.1 (28.4–35.7)
Workplaces[†]	75.4 (71.2–79.6)	68.2 (63.7–72.7)	61.3 (56.6–66.1)	14.0 (11.5–16.6)	24.6 (20.4–28.8)

Values are weighted percentages with 95% confidence intervals.
[†] Only asked for current working in indoor areas (n=2,716)
CC: conventional cigarette, EC electronic cigarette

4.3.2. Associations between the perception on harm and regulation and e-cigarette use

Table 4-3 suggests the association between the smokers' harm perception on tobacco products and e-cigarette use. Absolute perception of cigarette and e-cigarette were not significantly related to e-cigarette use, but having lower odds of being concurrent users. Relative perception of e-cigarette to conventional cigarette were significant associated with e-cigarette use. Smokers who perceived e-cigarette as less harmful to health (aOR = 3.91, 95% CI = 2.43–6.31), less harmful to others (aOR = 1.84, 95% CI = 1.16–2.93), and less addictive than cigarette (aOR = 2.21, 95% CI = 1.36–3.60) were significantly more likely to being concurrent users.

Table 4-4 shown the association between the smokers' exposed indoor air laws and e-cigarette use. Exposure to indoor air laws shown generally negative associations with concurrent use of smokers. As expected, perceived complete ban on vaping in indoor areas made smokers less likely to use e-cigarettes than partial or no bans. In addition, a complete ban on conventional cigarettes also lowered the likelihood of concurrent use of smokers. Interestingly, when assessing the complex regulation of the two policies, smokers who exposed both cigarette and e-cigarette complete ban in public places were significantly less likely to use e-cigarette: bar/pub (aOR = 0.47; CI = 0.27–0.81) and in restaurant/café (aOR = 0.51; CI = 0.33–0.77).

Table 4-3. Associations between harm perception and e-cigarette use

	E-cigarette use		
	Yes, %	aOR	(95% CI)
Absolute perception of CC			
CC is harmful to health			
A fair amount/a great deal	20.6	0.74	(0.47–1.17)
Not at all/just a little	25.0	1.00	Ref.
CC is harmful to others			
Agree	25.7	1.37	(0.85–2.21)
Disagree/neither	19.6	1.00	Ref.
CC is addictive			
Somewhat/very addicted	22.7	0.79	(0.45–1.40)
Not at all	29.6	1.00	Ref.
Absolute perception of EC			
EC is harmful to health			
Very/extremely	19.3	0.87	(0.44–1.74)
Moderately/slightly/not at all	25.2	1.00	Ref.
Relative perception of EC			
EC is less harmful than CC			
Much/somewhat less harmful	46.3	**3.60*****	**(2.35–5.52)**
Equal/more harmful	16.8	1.00	Ref.
EC is less harmful to other than CC			
Much/somewhat less harmful	34.4	**1.78***	**(1.15–2.76)**
Equal/more harmful	20.7	1.00	Ref.
EC is less addictive than CC			
Much/somewhat less addictive	37.3	**2.05****	**(1.29–3.24)**
Equal/more addictive	20.8	1.00	Ref.

Values are weighted percentages, adjusted odds ratios and 95% confidence intervals. All models were adjusted for covariates.

* P <.05; ** P <.01; *** P <.001; Bold type = P <.05

aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

Table 4-4. Associations between exposure to indoor ban and e-cigarette use

	E-cigarette use		
	Yes, %	aOR	(95% CI)
Smoke-free laws			
Smoke-free in bar/pub			
Complete ban	17.7	**0.52***	**(0.31–0.89)**
Partial/no ban	31.1	1.00	Ref.
Smoke-free in restaurant/café			
Complete ban	19.9	**0.62***	**(0.39–0.98)**
Partial/no ban	31.2	1.00	Ref.
Smoke-free at work			
Complete ban	24.4	0.71	(0.39–1.28)
Partial/no ban	31.7	1.00	Ref.
Vape-free laws			
Vape-free in bar/pub			
Complete ban	20.6	0.76	(0.48–1.21)
Partial/no ban	27.7	1.00	Ref.
Vape-free in restaurant/café			
Complete ban	19.5	**0.58***	**(0.34–0.98)**
Partial/no ban	29.2	1.00	Ref.
Vape-free at work			
Complete ban	24.8	0.79	(0.45–1.38)
Partial/no ban	29.3	1.00	Ref.
Indoor air laws			
Indoor bans in bar/pub			
CC & EC complete ban	16.3	**0.47****	**(0.27–0.81)**
CC only complete ban	21.8	0.67	(0.35–1.28)
CC partial/no ban	31.1	1.00	Ref.
Indoor bans in restaurant/café			
CC & EC complete ban	17.2	**0.51****	**(0.33–0.77)**
CC only complete ban	26.8	0.95	(0.38–2.38)
CC partial/no ban	31.2	1.00	Ref.
Indoor bans at work			
CC & EC complete ban	25.2	0.74	(0.39–1.38)
CC only complete ban	21.1	0.60	(0.32–1.11)
CC partial/no ban	31.7	1.00	Ref.

Values are weighted percentages, adjusted odds ratios and 95% confidence intervals. All models were adjusted for covariates.

* $P < .05$; ** $P < .01$; *** $P < .001$; Bold type = $P < .05$

aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

Supplementary table 4-2 suggests the association between the perception on harm and regulation and HTP use. Both absolute and relative perception of HTP were significantly related to HTP use. Smokers who perceived HTP is harmful to health were less likely to use HTP (aOR = 0.41; 95% CI = 0.27–0.62), and those who believe that HTP is less harmful to health were more likely to concurrently use it (aOR = 3.08; 95% CI = 1.77–5.35). Regarding the indoor air law, HTP use also generally have odds lower than 1.00, indicate negative associations with complete ban. Complete ban on HTP in restaurant/café were negatively related to HTP use (aOR = 0.59; 95% CI = 0.37–0.93), and other places also have odds lower than 1.00 (but not significant). Smokers who perceived both cigarette and HTP were completely banned in bar/pub (aOR = 0.49; 95% CI = 0.31–0.79) and restaurant/café (aOR = 0.52; 95% CI = 0.35–0.78) were significantly less likely to concurrently use HTP.

4.3.3. Perception on harm and regulation and intention to quit smoking and/or vaping

Table 4-5 and 4-6 presents the association between the smokers' harm perception and exposed indoor air laws and intention to quit cigarette smoking. Intention to quit smoking were significantly related to the perception that cigarette is 'harmful to health' (aOR = 2.09, 95% CI = 1.55–2.81) and harmful to others (aOR = 2.00, 95% CI = 1.45–2.77), but not to addictiveness (aOR = 0.66; 95% CI = 0.43–1.02). Relative risk perception generally shown significant relationship with intention to quit smoking. Smokers who believed that e-cigarette is 'less harmful than cigarette' (aOR = 1.48, 95% CI = 1.04–2.10) and 'less addictive than cigarette'(aOR = 1.94, 95% CI = 1.38–2.72) were likely to intend to quit conventional smoking.

For indoor air laws, perceived complete regulation on cigarette in bar/pub were positively related to intention to quit smoking (aOR = 1.49, 95% CI = 1.09–2.03). Exposure to complete ban in restaurant/café also have odds greater than 1.00, but not statistically significant (aOR = 1.15, 95% CI = 0.82–1.62). Exposure to complete ban on cigarette in the workplaces were not related to intention to quit smoking (aOR = 0.99, 95% CI = 0.64–1.53). Regarding the complex consideration of tobacco products, both cigarette and e-cigarette complete ban in bar/pub were positively related to intention to quit smoking (CC-EC: aOR = 1.54, 95% CI = 1.12–2.12; aOR = 1.63, 95% CI = 1.17–2.25) while cigarette-only complete ban were not significantly related to quit intention of cigarette (aOR = 1.36, 95% CI = 0.87–2.13). Although not significant, the likelihood of having intention to quit smoking is greater when both products were completely banned in indoor areas compared to cigarette-only were completely banned (even have an inverse direction of odds).

Table 4-5. Associations between harm perception and intention to quit smoking

	Intention to quit smoking		
	Yes, %	aOR	(95% CI)
Absolute perception of CC			
CC is harmful to health			
A fair amount/a great deal	44.2	**2.09*****	**(1.55–2.81)**
Not at all/just a little	27.8	1.00	Ref.
CC is harmful to others			
Agree	38.3	**2.00*****	**(1.45–2.77)**
Disagree/neither	23.9	1.00	Ref.
CC is addictiveness			
Somewhat/very addicted	31.9	0.66	(0.43–1.02)
Not at all	43.3	1.00	Ref.
Relative perception of EC			
EC is less harmful than CC			
Much/somewhat less harmful	42.2	**1.48***	**(1.04–2.10)**
Equal/more harmful	30.6	1.00	Ref.
EC is less harmful to other than CC			
Much/somewhat less harmful	38.5	1.26	(0.90–1.77)
Equal/more harmful	31.9	1.00	Ref.
EC is less addictive than CC			
Much/somewhat less addictive	47.3	**1.94*****	**(1.38–2.72)**
Equal/more addictive	30.5	1.00	Ref.

Values are weighted percentages, adjusted odds ratios and 95% confidence intervals.
All models were adjusted for covariates.
* P <.05; ** P <.01; *** P <.001; Bold type = P <.05
aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

Table 4-6. Associations between exposure to indoor ban and intention to quit smoking

	Intention to quit smoking		
	Yes, %	aOR	(95% CI)
Smoke-free laws			
Smoke-free in bar/pub			
Complete ban	36.0	**1.49***	**(1.09–2.03)**
Partial/no ban	29.8	1.00	Ref.
Smoke-free in restaurant/café			
Complete ban	33.7	1.15	(0.82–1.62)
Partial/no ban	32.5	1.00	Ref.
Smoke-free at work			
Complete ban	35.3	0.99	(0.64–1.53)
Partial/no ban	37.2	1.00	Ref.
Indoor air laws			
Indoor bans in bar/pub			
CC & EC complete ban	36.4	**1.54****	**(1.12–2.12)**
CC only complete ban	34.8	1.36	(0.87–2.13)
CC partial/no ban	29.8	1.00	Ref.
Indoor bans in restaurant/café			
CC & EC complete ban	35.5	1.27	(0.90–1.80)
CC only complete ban	29.1	0.90	(0.55–1.46)
CC partial/no ban	32.5	1.00	Ref.
Indoor bans at work			
CC & EC complete ban	36.5	1.04	(0.66–1.63)
CC only complete ban	29.9	0.78	(0.44–1.38)
CC partial/no ban	37.2	1.00	Ref.

Values are weighted percentages, adjusted odds ratios and 95% confidence intervals.
All models were adjusted for covariates.
* P <.05; ** P <.01; *** P <.001; Bold type = P <.05
aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

Supplementary table 4-3 presents the association between the perception on harm and regulation on HTP and intention to quit smoking. Relative harm perception of HTP were significantly related to intention to quit smoking (aOR = 1.50; 95% CI = 1.00–2.23), consistent with liquid e-cigarette Regarding the indoor air law, both cigarette and HTPs complete ban in bar/pub were positively related to intention to quit smoking (CC-HTP: aOR = 1.63, 95% CI = 1.17–2.25) while cigarette-only complete ban were not significantly related to quit intention of cigarette (aOR = 1.16, 95% CI = 0.77–1.76). Although not significant, the likelihood of having intention to quit smoking is greater when both products were completely banned in indoor areas compared to cigarette-only were completely banned (even have an inverse direction of odds). This is also in line with the results of liquid e-cigarette.

.Table 4-7 presents the association between the harm perception on e-cigarette and intention to quit e-cigarette (here, assessing as intention to keep using e-cigarette) among concurrent users of cigarette and e-cigarette. Concurrent users who perceived absolute risk on e-cigarette is less likely to intend to keep using e-cigarette. In contrast, those who believed that e-cigarette have lower risks than conventional ones were significantly more likely to intend to keep using vaping. Concurrent users who believed that e-cigarette is 'less harmful than cigarette' (aOR = 2.44, 95% CI = 1.21–4.91), 'less addictive than cigarette' (aOR = 2.31, 95% CI = 1.23–4.34) and 'less addictive than cigarette' (aOR = 2.32, 95% CI = 1.19–4.51) were likely to intend to continue e-cigarette use.

Table 4-7. Associations between harm perception and intention to keep using e-cigarette among concurrent users

	Intention to keep using e-cigarette		
	Yes, %	aOR	(95% CI)
Absolute perception of EC			
EC is harmful to health			
A fair amount/a great deal	20.0	**0.26****	**(0.10–0.70)**
Not at all/just a little	55.6	1.00	Ref.
Relative perception of EC			
EC is less harmful than CC			
Much/somewhat less harmful	61.5	**2.44***	**(1.21–4.91)**
Equal/more harmful	35.5	1.00	Ref.
EC is less harmful to other than CC			
Much/somewhat less harmful	61.7	**2.31****	**(1.23–4.34)**
Equal/more harmful	41.0	1.00	Ref.
EC is less addictive than CC			
Much/somewhat less addictive	59.1	**2.32***	**(1.19–4.51)**
Equal/more addictive	43.0	1.00	Ref.

Values are weighted percentages, adjusted odds ratio and 95% confidence intervals.
All models were adjusted for covariates.
* P <.05; ** P <.01; *** P <.001; Bold type = P <.05
aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

Table 4-8 presents the association between the exposed indoor air laws and intention to quit e-cigarette (here, assessing as intention to keep using e-cigarette) among concurrent users of cigarette and e-cigarette. For indoor air laws, perceived complete regulation on e-cigarette in bar/pub and in workplaces were less likely to intend to keep vaping (aOR = 0.48, 95% CI = 0.26–0.91; aOR = 0.35, 95% CI = 0.16–0.77). Exposure to complete ban in restaurant/café also have odds lower than 1.00, but not statistically significant (aOR = 0.97, 95% CI = 0.48–1.96). Particularly, regarding the complex consideration on indoor air laws, concurrent users who exposed both cigarette and e-cigarette complete ban were generally less likely to intend to continue vaping (bar/pub: aOR = 0.42, 95% CI = 0.21–0.84; restaurant/café: aOR = 0.60, 95% CI = 0.29–1.26; workplaces: aOR = 0.37, 95% CI = 0.16–0.87), while those who exposed cigarette-only complete ban were not significantly related to quit intention of e-cigarette. Although not significant, the likelihood of having intention to keep using e-cigarette is smaller when both products were completely banned in indoor areas compared to cigarette-only were completely banned (even have an inverse direction of odds).

Table 4-8. Associations between exposure to indoor ban and intention to keep using e-cigarette among concurrent users

	Intention to keep using e-cigarette		
	Yes, %	aOR	(95% CI)
Vape-free laws			
Vape-free in bar/pub			
Complete ban	35.0	**0.48***	**(0.26–0.91)**
Partial/no ban	60.3	1.00	Ref.
Vape-free in restaurant/café			
Complete ban	49.6	0.97	(0.48–1.96)
Partial/no ban	45.1	1.00	Ref.
Vape-free at work			
Complete ban	36.7	**0.35****	**(0.16–0.77)**
Partial/no ban	60.9	1.00	Ref.
Indoor air laws			
Indoor bans in bar/pub			
CC & EC complete ban	36.0	**0.42***	**(0.21–0.84)**
CC only complete ban	62.9	1.29	(0.46–3.66)
CC partial/no ban	49.1	1.00	Ref.
Indoor bans in restaurant/café			
CC & EC complete ban	41.5	0.60	(0.29–1.26)
CC only complete ban	37.7	0.97	(0.33–2.85)
CC partial/no ban	57.1	1.00	Ref.
Indoor bans at work			
CC & EC complete ban	34.9	**0.37***	**(0.16–0.87)**
CC only complete ban	60.8	1.09	(0.38–3.14)
CC partial/no ban	60.1	1.00	Ref.

Values are weighted percentages, adjusted odds ratio and 95% confidence intervals.
All models were adjusted for covariates.
* $P < .05$; ** $P < .01$; *** $P < .001$; Bold type = $P < .05$
aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

4.3.4. Differences in cigarette-only users and concurrent users for perceptions of harm and regulation

Table 4-9 shows the socio-demographics and smoking characteristics of cigarette only users and concurrent users of e-cigarette. Compared to cigarette-only users, concurrent users were more likely to female (26.3% vs 8.6%), younger aged (19–24 years: 11.1% vs 6.2%), having higher education and income level (univ degree: 45.6% vs 38.6%; highest income: 42.0% vs 28.7%), and light cigarette smokers (HSI 0–1: 63.2% vs 40.9%).

Table 4-9. Individual characteristics of cigarette-only users and concurrent users

	CC-only user (n=2,701)		CC+EC user (n=1,154)	
	n	%	n	%
Sex				
Male	2217	91.4	838	73.7
Female	484	8.6	316	26.3
Age				
19–24	99	6.2	85	11.1
25–39	861	26.4	542	39.6
40–54	1216	40.1	416	33.4
55+	525	27.3	111	16.0
Education				
Univ degree or more	2128	38.6	939	45.6
High school or less	565	61.4	210	54.4
Income (10,000 won)				
6000+	1116	28.7	565	42.0
3000–<6000	1127	41.6	447	38.3
Below 3000	400	26.3	126	17.7
Unknown	58	3.4	16	2.0
Marital status				
Married	1642	53.4	664	51.4
Unmarried	1059	46.6	490	48.6
Heaviness Smoking Index				
0–1	1191	40.9	548	63.2
2–3	1176	42.6	482	27.8
4–6	334	16.4	124	9.0

Values are unweighted numbers and weighted percentages.
CC: conventional cigarette; EC: electronic cigarette

Table 4-10 provides the perception on risk and regulation pf cigarette only users and concurrent users. Between them, perceived absolute risks on tobacco products were not significantly different, while relative risks on e-cigarette compared to cigarette is significantly different. Concurrent users were more reported that e-cigarette have lower risks than conventional ones, including less harmful to health (45.2% vs 16.1%), less harmful to others (30.5% vs 18.0%), and less addictive (26.8% vs 13.9%) (P <.05). Regarding indoor complete ban, concurrent users were less reported exposed regulation on cigarette in public places and also those on e-cigarette in restaurant/café.

Table 4-11 shows the association between perception on risk and regulation and intention to quit smoking by current e-cigarette use. For cigarette-only users, risk perception and regulatory exposure were significantly related to their intention to quit smoking, except for perceived addictiveness. Cigarette-only-users who perceived smoking is harmful to their health and other health were more likely to have intention to quit (aOR = 2.62, 95% CI = 1.95–3.52; aOR = 2.11, 95% CI = 1.52–2.92). Among cigarette only users, those who believe e-cigarette have lower risks were also more likely to have quit intention of cigarette (health: aOR = 1.84, 95% CI = 1.28–2.65; others health: aOR = 1.57, 95% CI = 1.10–2.23; addictiveness: aOR = 2.70, 95% CI = 1.81–4.00). However, none of the associations between risks perception on cigarette and intention to quit smoking is observed among concurrent users. In other words, concurrent users were not intending to quit cigarette smoking even perceived harms of e-cigarette. Additionally, concurrent users who believed e-cigarette have lower risks than conventional cigarette were less likely to quit cigarette, although the values is not statistically significant.

Table 4-10. Percentages of harm perception and exposure to indoor ban on tobacco products among cigarette-only users and concurrent users

	CC-only user		CC+EC user		
	%	(95% CI)	%	(95% CI)	*P*
Harm perception (%)					
CC is harmful to health	34.8	(31.7–37.9)	29.3	(19.6–39.1)	.307
CC is harmful to others	63.3	(60.2–66.4)	71.0	(61.2–80.9)	.159
CC is addictive	88.8	(86.8–90.9)	84.7	(76.5–93.0)	.293
EC is harmful to health	30.0	(27.1–32.9)	23.3	(8.9–37.7)	.415
EC is less harmful than CC	16.1	(13.9–18.4)	45.2	(32.9–57.5)	<.001
EC is less harmful to others than CC	18.0	(15.5–20.4)	30.5	(21.0–40.0)	.006
EC is less addictive than CC	13.9	(11.5–16.2)	26.8	(18.0–35.5)	.002
	CC-only user		CC+EC user		
	%	(95% CI)	%	(95% CI)	*P*
CC complete ban (%)					
CC complete ban in bar/pub	60.9	(57.8–64.1)	42.7	(31.2–54.2)	.002
CC complete ban in restaurant/café	71.1	(68.2–74.0)	57.5	(45.2–69.8)	.025
CC complete ban at work	77.2	(73.8–80.6)	70.3	(56.9–83.6)	.293
EC complete ban (%)					
EC complete ban in bar/pub	60.9	(57.8–64.1)	51.5	(38.8–64.1)	.148
EC complete ban in restaurant/café	61.5	(58.3–64.6)	48.4	(35.9–60.8)	.034
EC complete ban at work	69.5	(65.9–73.2)	64.5	(50.6–78.4)	.481
CC-EC complete ban (%)					
CC complete ban in bar/pub (*not EC*)	15.4	(13.0–17.7)	14.0	(6.8–21.1)	.128
CC complete ban in restaurant/café (*not EC*)	18.3	(15.7–20.9)	21.8	(6.6–36.9)	.636
CC complete ban at work (*not EC*)	15.0	(12.2–17.8)	11.3	(6.1–16.5)	.235

Values are weighted percentages with 95% confidence intervals, and p-values from chi-square test.
CI: confidential interval; CC: conventional cigarette; EC: electronic cigarette

Table 4-11. Associations between harm perception and intention to quit smoking by current e-cigarette use

	Intention to quit smoking			
	CC-only user		CC+EC user	
	aOR	(95% CI)	aOR	(95% CI)
Absolute perception of CC				
CC is harmful to health				
A fair amount/a great deal	**2.62*****	**(1.95–3.52)**	0.97	(0.48–1.93)
Not at all/just a little	1.00	Ref.	1.00	Ref.
CC is harmful to others				
Agree	**2.11*****	**(1.52–2.92)**	1.88	(0.93–3.81)
Disagree/neither	1.00	Ref.	1.00	Ref.
CC is addictive				
Somewhat/very addicted	0.77	(0.49–1.20)	0.55	(0.23–1.33)
Not at all	1.00	Ref.	1.00	Ref.
Relative perception of EC				
EC is less harmful than CC				
Much/somewhat less harmful	**1.84****	**(1.28–2.65)**	0.56	(0.29–1.08)
Equal/more harmful	1.00	Ref.	1.00	Ref.
EC is less harmful to other than CC				
Much/somewhat less harmful	**1.57***	**(1.10–2.23)**	0.58	(0.27–1.23)
Equal/more harmful	1.00	Ref.	1.00	Ref.
EC is less addictive than CC				
Much/somewhat less addictive	**2.70*****	**(1.81–4.00)**	0.75	(0.37–1.51)
Equal/more addictive	1.00	Ref.	1.00	Ref.

Values are adjusted odds ratios and 95% confidence intervals.
All models were adjusted for covariates.
* P <.05; ** P <.01; *** P <.001; Bold type = P <.05
aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; EC: electronic cigarette

Table 4-12 shows the association between perception on regulation and intention to quit smoking by current e-cigarette use. For cigarette-only users, exposed to smoke-free laws in public places and work places were significantly related to their intention to quit smoking (bar/pub: aOR = 1.55, 95% CI =1.15–2.08; restaurant/café: aOR = 1.66, 95% CI = 1.20–2.31; and workplaces: aOR = 1.83, 95% CI =1.19–2.83). In contrast, concurrent users did not show the positive associations between smoke-free laws and intention to quit cigarette, even less likely to intend to quit smoking when exposed completely ban on cigarette in their workplaces (aOR = 0.36, 95% CI =0.16–0.79).

Particularly, cigarette-only users were significantly likely to have intention to quit cigarette when exposed complete ban on both cigarette and e-cigarette regardless of places (bar/pub: aOR = 1.70, 95% CI =1.24–2.32; restaurant/café: aOR = 1.81, 95% CI = 1.28–2.54; and workplaces: aOR = 1.95, 95% CI =1.25–3.04). One of the unexpected results is that those group also were not likely to have intention to quit smoking when exposed indoor air laws completely banned only conventional one but no e-cigarette compared to partial or no ban on e-cigarette (bar/pub: aOR = 1.17, 95% CI =0.74–1.83; restaurant/café: aOR = 1.32, 95% CI = 0.84–2.08; and workplaces: aOR = 1.43, 95% CI =0.80–2.56), even though showing odds greater than 1.00. For concurrent users of cigarette and e-cigarette, complete ban of cigarette and/or e-cigarette were not significantly related to their intention to quit smoking. Subgroup analysis on the associations between the perception of harm and regulation on cigarette and intention to quit smoking by socio-demographics given in supplementary Table 4-4.

Table 4-12. Associations between exposure to indoor ban and intention to quit smoking by current e-cigarette use

	Intention to quit smoking			
	CC-only user (n=2,701)		CC+EC user (n=1,154)	
	aOR	(95% CI)	aOR	(95% CI)
Smoke-free laws				
Smoke-free in bar/pub				
Complete ban	**1.55****	**(1.15–2.08)**	1.46	(0.77–2.78)
Partial/no ban	1.00	Ref.	1.00	Ref.
Smoke-free in restaurant/café				
Complete ban	**1.66****	**(1.20–2.31)**	0.70	(0.36–1.36)
Partial/no ban	1.00	Ref.	1.00	Ref.
Smoke-free at work				
Complete ban	**1.83****	**(1.19–2.83)**	**0.36***	**(0.16–0.79)**
Partial/no ban	1.00	Ref.	1.00	Ref.
Indoor air laws				
Indoor bans in bar/pub				
CC & EC complete ban	**1.70****	**(1.24–2.32)**	1.14	(0.58–2.23)
CC only complete ban	1.17	(0.74–1.83)	2.58	(1.00–6.65)
CC partial/no ban	1.00	Ref.	1.00	Ref.
Indoor bans in restaurant/café				
CC & EC complete ban	**1.81*****	**(1.28–2.54)**	0.72	(0.35–1.47)
CC only complete ban	1.32	(0.84–2.08)	0.66	(0.27–1.60)
CC partial/no ban	1.00	Ref.	1.00	Ref.
Indoor bans at work				
CC & EC complete ban	**1.95****	**(1.25–3.04)**	0.39	(0.17–0.86)
CC only complete ban	1.43	(0.80–2.56)	0.27	(0.07–0.99)
CC partial/no ban	1.00	Ref.	1.00	Ref.

Values are adjusted odds ratio and 95% confidence intervals.
All models were adjusted for covariates.
* P <.05; ** P <.01; *** P <.001; Bold type = P <.05
aOR: adjusted odds ratio; Ref: reference; CI: confidential interval; CC: conventional cigarette, EC: electronic cigarette

Figure 4-1 show the association between the intention to quit smoking and current e-cigarette use according to perceived of harmfulness and indoor ban on e-cigarette. From this subgroup analysis, it was confirmed that the relationship between intention to quit smoking and e-cigarette use was significantly heterogeneous by smokers' perception of harm and regulation on e-cigarette (*P*-heterogeneity <.001). According to the subgroup by perceived harm, smokers who believed e-cigarette is nor very harmful shown the positive relationship between the intention to quit smoking and currently using e-cigarette (aOR = 2.06, *P* <.001). Subgroup analysis by exposed vape-free laws also shown similar trends. Smokers who reported that e-cigarette is completely banned in indoor areas (except for restaurant/café: aOR = 1.75, *P* = .008) have not shown the positive relationship between the intention to quit smoking and currently using e-cigarette (bar/pub: aOR = 1.03, *P* = .905; workplace: aOR = 1.20, *P* = .562). Smokers who reported that e-cigarette is partial or no banned in indoor areas shown the positive relationship between the intention to quit smoking and currently using e-cigarette (bar/pub: aOR = 3.47, *P* <.001; restaurant/café: aOR = 2.07, *P* = .022, workplaces: aOR = 3.43, *P* <.001).

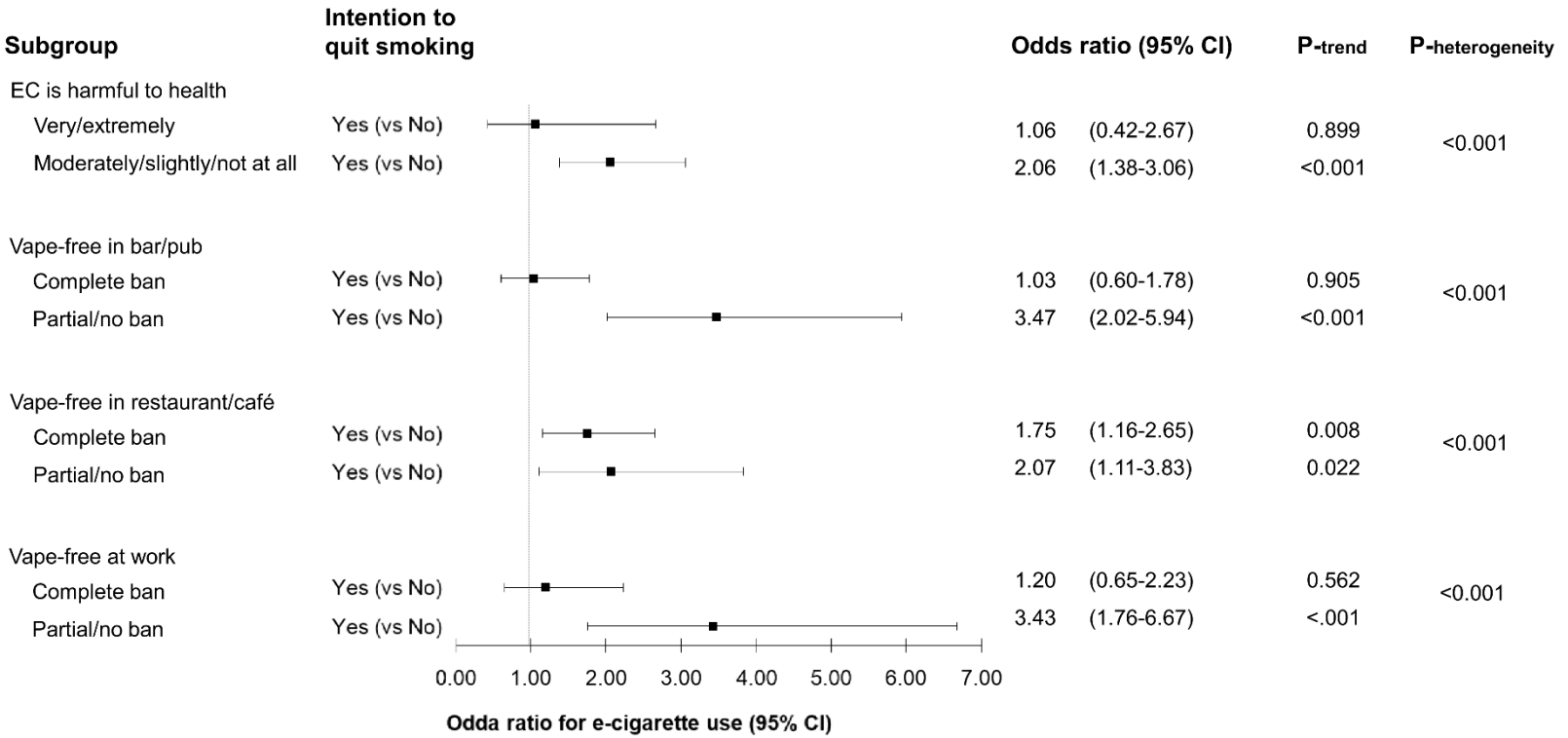


Figure 4-1. Subgroup analysis: associations between the intention to quit smoking and e-cigarette use according to perception on e-cigarette

Intention to quit smoking indicate: plan to quit smoking within the next 6 months (Yes), sometime in the future beyond 6 months or no plan to quit (no).
P for heterogeneity calculated by means of the interaction term.

4.4. Discussion

This study identified the perceived relative risks and exposed regulatory gaps (i.e., indoor ban) between cigarette and e-cigarette, and investigated their associations with e-cigarette use and intention to quit smoking, using nationally representative samples of adult smokers in Korea.

The study suggests that perceived harm and regulation on cigarette were not associated with intention to quit smoking among concurrent users. Concerning the indoor air laws, there are perceived gaps between cigarette and e-cigarette on exposed indoor air policies. Smokers who perceived both cigarette and e-cigarette banned completely in public places were less likely to be concurrent users and more likely to have intention to quit cigarette. In contrast, smokers who perceived cigarette-only banned completely (but not e-cigarette) in public places were no more likely to have intention to quit cigarette. Regarding harm perception, smokers who believed e-cigarette is less harmful than conventional cigarette were more likely to be concurrent users

The study found a gap in exposure to cigarette bans and e-cigarette bans in public places and workplaces. About 15% of smokers report that e-cigarettes are permitted, while regular cigarettes are completely banned in public and workplaces. Given that indoor use of e-cigarettes is illegal in Korea, this gap in self-reported exposure suggests that awareness of the implementation of these laws may have been lacking [218]. Also, in Korea, nicotine-free e-cigarettes are not regulated in non-smoking areas. This exception may have caused confusion among the public, as it is

difficult to distinguish whether it contains nicotine from the outside. A Korean study also reported that 83.5% of smokers who used e-cigarettes in non-smoking area [219].

Existing studies have suggested that regulation of conventional cigarettes may lead to e-cigarette use. Non-smoking areas are typical. Indeed, e-cigarettes are sometimes promoted to be used in areas where smoking is prohibited. However, in my study, exposure to smoke-free areas was not significantly associated with e-cigarette use. There are countries that do not have regulations on the use of e-cigarettes in non-smoking areas, such as Japan and the United States. Studies in such countries have suggested that these regulatory gaps may lead to e-cigarette use [220-222]. My results are consistent with this, and I found that smokers whose local rules prohibit both regular and e-cigarette use are significantly less likely to not use e-cigarettes at the same time.

There was also a gap between public perceptions of the dangers of regular cigarettes and e-cigarettes. The absolute risk perception of regular cigarettes was 33.5%, and the absolute risk perception of e-cigarettes was 28.4%. Regarding relative risk perception, about 20-30% of smokers report that regular cigarettes are more harmful to health/others and addictive than e-cigarettes. About half of smokers consider regular cigarettes to be socially unacceptable, compared to less than 30% for e-cigarettes. This difference in perception is consistent with many existing literatures [223-225]. Most e-cigarette users perceived that e-cigarettes were less harmful than cigarettes [226]. Research has also found that perceptions of less harmful e-cigarettes in certain populations are associated with future e-cigarette use [218].

Considering that smoking cessation and health were the main reasons for using e-cigarettes, exposure by smoking cessation policies that promote smoking cessation behavior and inform the dangers of regular cigarettes can lead to e-cigarette use. However, my research found that smoking cessation policies were not associated with e-cigarette use. There was no significant relationship between the absolute risk perception of regular cigarettes and e-cigarettes, respectively, and the use of e-cigarettes. On the other hand, smokers who perceived that e-cigarettes were less harmful to health, less harmful to others, or less addictive than regular cigarettes were more likely to use e-cigarettes.

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Supplementary materials

Supplementary table 4-1. Percentages of harm perception and exposure to indoor ban of HTP

	HTP absolute risk perception	CC-HTP relative risk perception (CC > HTP)
Harm perception	%	%
Harmful to health	28.9 (25.9–31.9)	24.5 (20.2–28.8)
	HTP complete ban	CC-HTP complete ban (CC only)
Exposed indoor air laws	%	%
Bar/pub	55.5 (51.5–59.5)	15.3 (13.1–17.5)
Restaurant/café	57.5 (53.4–61.6)	17.9 (13.9–21.9)
Workplaces	67.8 (63.3–72.3)	14.0 (11.5–16.6)

Values are weighted percentages with 95% confidence intervals.

Supplementary table 4-2. Associations between harm perception and exposure to indoor ban of HTP and HTP use

	HTP use		
	Yes, %	aOR	(95% CI)
Harm perception			
HTP is harmful to health			
Very/extremely	15.0	**0.41*****	**(0.27–0.62)**
Moderately/slightly/not at all	29.3	1.00	Ref.
HTP is less harmful than CC			
Much/somewhat less harmful	43.3	**3.08*****	**(1.77–5.35)**
Equal/more harmful	19.3	1.00	Ref.
Exposed indoor air laws			
HTP ban in bar/pub			
Complete ban	23.8	0.77	(0.49–1.21)
Partial/no ban	26.9	1.00	Ref.
HTP ban in restaurant/café			
Complete ban	21.6	**0.59***	**(0.37–0.93)**
Partial/no ban	30.1	1.00	Ref.
HTP ban at work			
Complete ban	29.7	0.87	(0.51–1.46)
Partial/no ban	31.3	1.00	Ref.
Indoor bans in bar/pub			
CC & HTP complete ban	20.6	**0.49****	**(0.31–0.79)**
CC only complete ban	14.3	**0.37*****	**(0.22–0.62)**
CC partial/no ban	33.4	1.00	Ref.
Indoor bans in restaurant/café			
CC & HTP complete ban	20.2	**0.52****	**(0.35–0.78)**
CC only complete ban	26.8	0.91	(0.40–2.08)
CC partial/no ban	32.0	1.00	Ref.
Indoor bans at work			
CC & HTP complete ban	29.6	0.73	(0.40–1.31)
CC only complete ban	24.2	0.58	(0.32–1.02)
CC partial/no ban	35.1	1.00	Ref.

Values are weighted percentages, adjusted odds ratios and 95% confidence intervals. All models were adjusted for covariates.

* P <.05; ** P <.01; *** P <.001; Bold type = P <.05

aOR: adjusted odds ratio; Ref: reference; CI: confidential interval; CC: conventional cigarette, HTP: heated tobacco products

Supplementary table 4-3. Associations between harm perception and indoor ban of HTP and intention to quit smoking

	Intention to quit smoking		
	Yes, %	aOR	(95% CI)
Relative perception of HTP			
HTP is less harmful than CC			
Much/somewhat less harmful	40.2	**1.50***	**(1.00–2.23)**
Equal/more harmful	31.0	1.00	Ref.
Indoor air laws			
Indoor bans in bar/pub			
CC & HTP complete ban	38.4	**1.63****	**(1.17–2.25)**
CC only complete ban	29.6	1.16	(0.77–1.76)
CC partial/no ban	29.8	1.00	Ref.
Indoor bans in restaurant/café			
CC & HTP complete ban	37.3	1.04	(0.66–1.63)
CC only complete ban	23.5	0.78	(0.44–1.38)
CC partial/no ban	32.5	1.00	Ref.
Indoor bans at work			
CC & HTP complete ban	37.4	1.07	(0.68–1.68)
CC only complete ban	26.3	0.67	(0.39–1.15)
CC partial/no ban	37.2	1.00	Ref.

Values are weighted percentages, adjusted odds ratios and 95% confidence intervals.
All models were adjusted for covariates.
* P <.05; ** P <.01; *** P <.001; Bold type = P <.05
aOR: adjusted odds ratio; Ref: reference; CI: confidential interval; CC: conventional cigarette, HTP: heated tobacco products

Supplementary table 4-4. Associations between harm perception and exposure to indoor ban of HTP and intention to quit smoking by socio-demographics

	Intention to quit smoking							
	Age		Sex		Education		Income	
	19–39 (n=1,587)	40+ (n=2,268)	Male (n=3,055)	Female (n=800)	High (n=3,067)	Low (n=775)	High (n=1,681)	Low (n=2,100)
	aOR	aOR	aOR	aOR	aOR	aOR	aOR	aOR
Harm perception								
CC is harmful to health								
A fair amount/a great deal	1.03	**3.26*****	**2.34*****	1.42	**1.74****	**2.40*****	**2.05****	**2.13*****
Not at all/just a little	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
EC is less harmful than CC (CC>EC)								
Much/somewhat less harmful	**1.69***	1.21	**1.43***	1.33	1.00	**1.85***	1.07	**1.64***
Equal/more harmful	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Exposed indoor air laws								
Smoke-free in bar/pub								
Complete ban	1.17	**1.76****	**1.58****	0.92	1.23	**1.73***	1.49	1.40
Partial/no ban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Smoke-free in restaurant/café								
Complete ban	1.21	1.15	1.26	0.69	1.11	1.23	0.90	1.40
Partial/no ban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Smoke-free at work								
Complete ban	0.97	0.98	1.04	0.51	0.84	1.13	0.88	1.02
Partial/no ban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Indoor bans in bar/pub								
CC & EC complete ban	1.06	**1.89****	**1.63****	0.97	1.25	**1.84***	1.42	**1.49***
CC only complete ban	1.42	1.36	1.43	0.84	1.17	1.50	1.78	1.18
CC partial/no ban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Indoor bans in restaurant/café								
CC & EC complete ban	1.15	1.33	**1.43***	0.55	1.09	1.49	0.98	1.52
CC only complete ban	1.32	0.70	0.85	1.05	1.18	0.80	0.64	1.15

(Continue)

CC partial/no ban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Indoor bans at work								
CC & EC complete ban	1.10	1.00	1.09	0.58	0.84	1.28	0.89	1.13
CC only complete ban	0.66	0.88	0.87	0.30	0.84	0.61	0.84	0.67
CC partial/no ban	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

Values are odds ratios adjusted for covariates.

* P <.05; ** P <.01; *** P <.001; Bold type = P <.05

aOR: adjusted odds ratio; CI: confidential interval; Ref: reference; CC: conventional cigarette; HTP: heated tobacco products

CHAPTER 5.

Overall Discussion and Conclusion

5.1. Summary

This dissertation explored the concurrent use behavior of e-cigarette use among Korean adult smokers, focusing on their motivation and intention to quit smoking.

The main findings supporting this message were:

① E-cigarette users remain concurrent users with low intentional stages of cigarette quitting. (Intention to quit CC)

② Majority of concurrent users no more aimed at quitting cigarette but experimental and recreational motives regardless of age groups. (Motivation for EC use)

③ Concurrent users for cigarette cessation motives have intention to quit cigarette but intend to keep using e-cigarette and frequently use e-cigarette. (Motivation for EC use & Intention to quit CC/EC)

④ Concurrent users for recreational motives were likely to frequent e-cigarette use and sustained concurrent use. (Motivation for EC use & Intention to quit CC/EC)

⑤ Perceived harm and regulation of cigarette not related to intention to cigarette among concurrent users. (Perceived harm/regulation of CC & Intention to quit CC)

The first study shows that e-cigarette use may be positively related to quitting attempts but is more strongly related to current cigarette smoking with no immediate intention to quit smoking for future attempts. These results imply that the negative role of e-cigarette use on smoking cessation inducing concurrent use or continued smoking with no plan to complete switching to e-cigarette is dominant in the population level.

The second study captured a shift in motivation for using e-cigarette from instrumental ones (e.g., cessation/ health, social influences) to intrinsic ones (e.g., curiosity, taste, and enjoyment). The study also identified that concurrent use behaviors and intention to quit cigarette/e-cigarette differ by motives for using e-cigarette. Particularly, recreational reasons related to frequent e-cigarette use and sustained concurrent use.

The third study suggests that perceived regulations on cigarette were not associated with intention to quit smoking among concurrent users. Smokers who perceived both cigarette and e-cigarette banned completely in public places were less likely to be concurrent users and more likely to have intention to quit cigarette. In contrast, smokers who perceived cigarette-only banned completely (but not e-cigarette) in public places were no more likely to have intention to quit cigarette.

These findings impy concurrent use (cigarette and e-cigarette) may not a temporary condition toward cigarette/tobacco cessation, but rather long-term behavior in the Korean adult population.

5.2. Interpretation and Implication

5.2.1. Interpretation of key findings

Overall, this study attempted to understand the smoking cessation effectiveness of e-cigarettes from the population perspective focusing on behavioral motivation and intention, using representative nationwide data of Korean adults.

The first study measured smoking cessation intentions and behaviors of e-cigarette users compared to non-e-cigarette users. In particular, all stages of the SOC model were used to evaluate the smoking cessation process including the intentional stages of cigarette cessation. A previous Korean research using data from 2013-2015 reported that e-cigarette use was related to the stronger readiness for smoking cessation (i.e., Precontemplation < Contemplation < Preparation stages) [136]. Inconsistent with previous study, this paper, which used data from 2016-2018, observed that current e-cigarette use was significantly related with Precontemplation and Contemplation stages, but not with Preparation stage. Here, current e-cigarette users in the Precontemplation and Contemplation stages represents the remaining concurrent users who have no immediate intention to quit smoking even though they have recently attempted to quit smoking. This implies the possibility that many e-cigarette users in Korean adults will be stuck in a state of concurrent use.

The second study suggested that the primary motivation for using e-cigarettes in adult smokers was beyond smoking cessation and health to other experimental and recreational motives (e.g., curiosity, taste enjoyment). Although concurrent use for cigarette cessation is somewhat controversial [88, 89], concurrent use with purely recreational purposes but not an attempt to quit or substantially

reduce cigarette smoking poses a greater threat to public health [90, 91]. To date, many papers have reported the reasons for e-cigarette use, but this study is an initial finding that captures its change within the same national context [169, 170]. Furthermore, this study suggested that the motivation for using e-cigarettes was closely related to concurrent use behavior, such as frequency of use of each tobacco products and intention to quit them. Previous studies have argued that goal-oriented motives (e.g., smoking cessation and health) are related to frequent and stable e-cigarette use, while non-goal-oriented reasons (e.g., curiosity) are rather temporary and not related to frequent e-cigarette use [173-176]. However, this study further suggested that intrinsic motivation were not related to intention to stop using both products and potentially highly likely to use e-cigarette frequently. Therefore, smokers' motivations for using e-cigarettes are diversifying, which may have different consequences for many concurrent users' behavior and ultimately their health outcomes.

The third study shows that some smokers perceived benefits of e-cigarettes compared to conventional cigarettes, such as less harmful to health and partial allows in indoor areas. Consistent with previous studies, this study suggests that the belief that e-cigarettes are less harmful predicts smokers' concurrent use of e-cigarettes [227-232]. The study also suggested that a complete indoor ban on both cigarette and e-cigarette could lower concurrent use, but cigarette-only complete ban would not. This findings contributes to the lack of evidence on the e-cigarette-inclusive smoke-free policies [221, 233, 234]. One of the new findings was that the relationship between perceived harm and regulation on conventional cigarettes and intention to quit smoking was moderated by smokers' e-cigarette use status. This

supports existing concerns about e-cigarettes' potential to undermine existing efforts to tobacco control and even renormalize cigarette use [92-94]. The collective results of this study present that establishing effective tobacco regulation at the national level has faced complexity with the emergence of new tobacco products, thereby suggesting the need for a balanced regulatory approach for cross-products.

This dissertation conducted supplementary analyses on HTPs as one of the new emerging tobacco products other than e-cigarette (liquid-type). For both products in common, curiosity was the highest motivation for use with more than 60%, followed by less harm than conventional cigarettes with about 40%. This represents the public's interest in and awareness of the benefits of new tobacco products. Meanwhile, one of the frequent reasons for using e-cigarettes is taste, reflecting that the autonomy of e-liquids is crucial in the choice of using e-cigarettes. Perceived acceptability is the frequent reason for using HTP, suggesting that HTP use is linked to perceptions of social norms. In addition, the responses of enjoying using the product itself was higher in HTPs than in e-cigarettes.

In South Korea, HTP occupies a particularly dominant share of the tobacco product market over e-cigarette. One of the fundamental reasons for this phenomenon is that smokers' satisfaction from using the product is higher with heated cigarettes than with e-cigarettes. Indeed, some studies reported that subjective satisfaction scores (e.g., psychological reward, enjoyment of respiratory tract sensations, and craving reduction) were higher in the order of conventional cigarette, HTPs, and e-cigarette [235, 236]. Pharmacologically, HTPs can reach the maximum nicotine concentration faster than (refillable) e-cigarettes [237] and provide a closer

feel to conventional cigarettes by using tobacco leaves [238]. Previous studies also found that the main reason for discontinuing e-cigarette use was that it is less satisfying than conventional smoking [176, 185, 239]. In these respects, the decision-making about regular use of new tobacco may depends on the balance of perceived benefits and barriers (e.g., lower satisfaction) compared to conventional cigarettes.

5.2.2. Implication for public health in South Korea

Regarding the effectiveness of e-cigarette smoking cessation, previous studies have mainly focused on the *individual perspective* to investigate whether e-cigarette product use is effective to achieve smoker's cigarette cessation [95]. However, this study attempted to closely understand the smoking cessation effectiveness of e-cigarettes from the *population perspective*, which indicates whether e-cigarette use is related to net cessation rates in the Korean adult population. The results of this study provide evidence for the various unintended consequences of concurrent use on public health that may appear at the population level. This implies that the effectiveness of e-cigarette use on smoking cessation at the individual level cannot be fully translated to population level effectiveness of e-cigarette use on smoking cessation [96].

Previous studies have actively studied the relationship between e-cigarettes and smoking cessation *behavioral outcomes* (e.g., quit attempts, abstinence) [63]. However, this study identified the *behavioral motivation and intention* to quit smoking as the central variables, which had not received much attention. Among the existing literature, RCTs targeting smokers who desire to quit smoking have reported significant results of positive efficacy of e-cigarette, whereas observation studies based on population have reported that e-cigarette use is not related to smoking cessation [95]. These differences may have been derived from the heterogeneity of interest or desire to quit smoking in the general population [83]. In particular, this study emphasizes the importance of these cognitive factors in determining the real-world efficacy, given the diversified purposes of e-cigarette use.

Existing studies had a dichotomous frame of motivation for e-cigarette use: *adult smokers* use e-cigarette for smoking cessation and health, while *adolescent non-smokers* for experimental/entertainment purposes [125, 160, 240, 241]. However, the findings from the current study are completely contrary to such existing evidence, suggesting even among adult smokers, recreational purposes outweighed smoking cessation motives across all age groups. In that respects, this is the first break from the subdivision of motivation for e-cigarette use by age and cigarette smoking status [241, 242]. Furthermore, it suggests a concern that smokers of conventional cigarettes may try e-cigarettes in addition to conventional smoking simply out of interest about new things. Concurrent use for smoking cessation has been somewhat controversial, but it is undisputed that concurrent use for purely recreational purposes is a public health concern.

Whereas the interest in e-cigarette of adolescents was concentrated among non-smokers [196], e-cigarette initiation of adults was intensively on existing cigarette user, leading to being concurrent user [185, 198]. The motives in smokers' using e-cigarettes may closely linked with their complex product use behavior, thereby may determine the health outcomes of a large proportion of concurrent users. Designing an effective strategy to directly promote smokers' cigarette cessation instead of concurrent use of e-cigarettes is the best for reducing the net harm to public health in response to the rapidly changing tobacco landscape.

South Korea is one of the countries that officially e-cigarette deemed as tobacco product [243]. Their regulations were applied to be equivalent to those of conventional cigarettes (e.g., prohibited use in indoor smoke-free areas; prohibited

sales to minors under 19; restrictions on advertisements on public media; imposition of excise taxes; bans on sales over the internet, by telephone or mail order; and contained health warning labels) [244]. Additionally, the government has been making national efforts to raise public awareness of the effects and harms of e-cigarettes to date. One of the examples includes anti-vaping advertisements under various slogans since 2018 in South Korea.

According to previous studies in Korea, the top reason for using e-cigarette among adult are 'smoking cessation', followed by less harmful than smoking [245, 246]. However, this study shows the decline in e-cigarette use for smoking cessation, health and social norms, which reflects national efforts to date. Instead, this study found that the most cited reasons for e-cigarette use in Korean adults was 'More acceptable' in 2016, and further suggested that changes to 'Curiosity' in 2020. Given that the prevalence of e-cigarette use has not declined in Korean adult smokers in recent years, these results indicate that the main drivers of concurrent use have changed dynamically: from *cessation/health* to *social influences* and eventually *mere interest*.

Curiosity may end up as a temporary trial of e-cigarette use, whereas it also has the potential to develop into other aspects of enhanced interest [188-190]. Particularly, curiosity is usually triggered by perceived benefits and novel stimuli not yet experienced [186, 187], this implies features of e-cigarette different from conventional ones (e.g., flavor, devices) may be a main interest of concurrent users. Indeed, one of the main reasons for using liquid e-cigarettes in 2020 was 'taste', which was inconsistent with the results from the HTPs. In order to effectively

intervene in smokers' concurrent use of a new tobacco products, it would be helpful to establish a strategy for how to respond to emerging motives for using it.

Despite the strict legal environment for e-cigarettes in Korea, its enforcement, promotion and awareness are not yet established. The third study suggested that about 15% of smokers report that e-cigarettes are permitted, while regular cigarettes are completely banned in public and workplaces. This is in line with the Korean study reporting that 83.5% of smokers have used e-cigarettes in the places where smoking banned [219]. Additionally, 23.0% of smokers thought e-cigarettes were less harmful than regular cigarettes, and 58.3% of concurrent users had a higher rate. This implies that the public's interest in harm reduction is still influence on e-cigarette use. The motivation of e-cigarette use responds to the dynamic external environment (i.e., regulation and marketing) and induced changes in perception. The government needs to make efforts to minimize loopholes in e-cigarette legislation and raise public awareness about it.

5.3. Limitation and Future Researches

This stud have some limitations:

First, the findings might not generalize to other settings, such as countries with different regulatory environments for e-cigarettes, particularly where e-cigarette was utilized as cessation aids. This is because the main outcome variables including motived and intention to quit smoking may be sensitive to national regulatory situations. Nevertheless, it also means that motivation itself can be used as an important indicator to compare and decide national policies.

Second, this study used cross-sectional data from nationwide survey. Due to the inherent characteristics of cross-sectional data, temporal precedence cannot be confirmed. Even though, the large-scale nationwide cross-sectional analysis provides population-level insight into the concurrent use behavior. For future research, it is necessary to use longitudinal data to elucidate the changes in motives of e-cigarette use and intentional changes within individuals, and the subsequent behavioral action via transition modelling.

Third, although the intention to quit smoking is one of the strongest predictors of future smoking cessation behavior, it does not guarantee the achievement of smoking cessation behavior. Also, there is a need to consider changes in motives of e-cigarette use and intentional changes within individuals. Indeed, some smokers who use e-cigarette with no intention to quit smoking also achieve reducing amount of existing cigarettes or stop using them— "Intention-behavior gap" [247]. In that respect, it is more important to closely explore the intention to quit smoking of e-cigarette users for the future study.

Forth, this study could not adjust for other e-cigarette-related factors, such as the detailed amount, dependence, or duration of e-cigarette use, or the nicotine levels in e-cigarette solutions, because the information was not available. To determine the health effects of e-cigarette use, further research is needed to estimate changes in total consumption of nicotine among concurrent users of e-cigarettes and conventional cigarettes, considering their initial reason for use.

Fifth, sensitivity analysis indicates that there may be a potential influence of unmeasured confounding variables on our findings. For example, smokers who have difficulty quitting smoking (e.g., smokers with high dependence on smoking, smokers with repeated failures to quit smoking, smokers with low self-efficacy for quitting smoking, etc.) are more likely to use e-cigarettes, but less likely to succeed in quitting smoking. Therefore, the negative relationship between e-cigarette use and smoking cessation behavior may be overestimated due to these hidden biases. Nevertheless, this study carefully adjusted for proven strong predictors of smoking cessation behavior such as smoking amount, smoking initiation age, and smoking duration [248-252] to minimize residual confounding effect. Additionally, the original study noted that small E-value does not mean that no association exists [151]. When the multivariate analyses were conducted with variable selection, the results remained consistent, supporting the robustness of the findings.

So far, ‘cessation’ has been dealt with as a concept centered on traditional smoking, but there is urgent need to redefine the concept of ‘cessation’ in response to the emergence of new types of cigarettes—cigarette cessation to tobacco/nicotine cessation. Additionally, complete switching from cigarettes to electronic cigarettes

can occur even by some smokers who do not intend or plan to quit cigarette; as they simply replace the satisfaction of conventional ones. Therefore, further research is required to distinguish the difference between unintentional and intentional cigarette cessation among new tobacco products users—unintended cigarette cessation versus intended cigarette cessation.

5.4. Conclusions

At the population-based level, e-cigarette users likely to remain concurrent users without an immediate plan to quit cigarette than never users. Concurrent users' motives for e-cigarette use have shifted from instrumental ones such as smoking cessation to intrinsic ones linked with frequent e-cigarette use and sustained concurrent use behavior. Furthermore, existing tobacco control policies and smoking interventions did not associate with the intention to quit smoking among concurrent users.

These findings support the unintended consequences of concurrent use on smoking cessation at the population level (Figure 5-1). This implies the possibility that many e-cigarette users in Korean adults will be stuck in a concurrent use phase. Additionally, motives for e-cigarette use diversified, and establishing the correct policy direction to promote tobacco quitting have more complexity. To minimalize the potential threat of concurrent use to public health and tobacco control, it will be essential to regulate strategies for achieving tobacco cessation considering diversified motives and targeted complex product users.

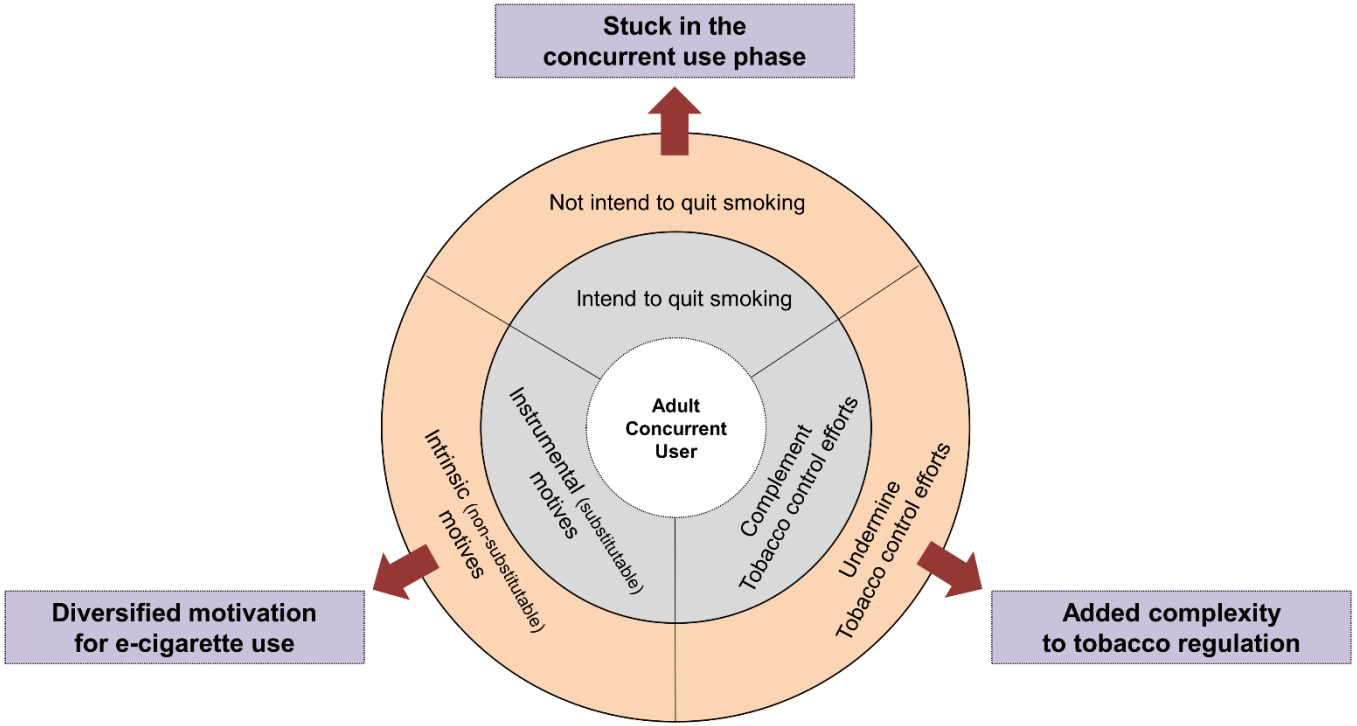

Figure 5-1. Unintended consequences of e-cigarette use on smoking cessation from the population perspective

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Abstract in Korean

액상형 전자담배 사용 동기 중심의 일반담배 금연의지 및 행동 이해

서울대학교 보건대학원

보건학과 보건학전공

윤 원 정

배경

흡연자의 전자담배 동시사용에 대한 공중보건학적 관점은 여전히 논란이 크다. 가령 동시사용이 궁극적으로 담배제품을 끊기 위한 일시적인 상태라면 담배로 인한 위해를 줄이는 데에 기여할 수 있을 것이라는 의견이 있다. 반면, 이러한 동시사용이 기존 흡연과 함께 지속되는 장기적인 행동이라면 오히려 새로운 중독 습관을 형성하고 잠재적으로 더 큰 건강위험이에 이를 수 있다는 우려가 있다. 이러한 동시사용 행동의 공중보건학적 영향을 고려했을 때, 성인 흡연자에서 전자담배 사용과 일반담배 금연의지 및 행동의 관계를 파악하고 사용동기 및 후속 행동을 포괄적으로 이해하는 것이 중요하다. 본 연구의 목적은 한국 성인 흡연자를 대상으로 액상형 전자담배 사용과 금연의지 및 행동 간 관계를 사용동기를 중심으로 파악하고, 궁극적으로는 동시사용자가 일반담배와 전자담배 모두를 중단할 수 있도록 돕는 전략에 기여하고자 한다.

방법

제7차 국민건강영양조사 (KNHANES, 2016~2018) 와 2016년 및 2020년에 수행된 ITC (International Tobacco Control) 한국 설문조사로부터 얻은 전국단위의 단면자료를 사용한다. 대상자는 19세 이상 성인 흡연자이다. 주요 변수는 전자담배 사용과 금연의지, 사용동기를 포함한다. 범주형 변수를 다루기 위해 다변량 로지스틱 회귀분석이 수행되었고, 모든 분석에는 표본 가중치와 층화 변수가 적용되었다.

결과

첫 번째 연구는 전자담배 사용은 전자담배 사용현황과 금연행동의 관계를 행동변화단계 모델에 기반하여 분석하였다. 전자담배 사용은 과거의 금연 시도와 관련이 있었으나, 현재 금연여부, 금연 계획 및 장기적 금연기간과는 관련이 없었다. 과반이 넘는 전자담배 사용자들은 금연시도를 하지 않았거나 금연의지가 없는 것으로 나타났다. 금연 단계에 따르면, 전자담배 사용은 전체 금연 과정에서 후기 단계와 양적 관련이 없었다. 가령, 현재 및 과거 전자담배 사용자는 비사용자에 비해 'Precontemplation' 과 'Contemplation'에 있을 가능성이 유의미하게 높았으나, 'Preparation' 과 'Action' 단계에 있을 가능성은 유의미한 차이가 없었다. 특히 현재 전자담배 사용자는 'Maintenance' 단계에 있을 가능성이 유의미하게 낮았다.

두 번째 연구는 전자담배를 사용하는 이유를 고려하여 전자담배 사용과 금연행동의 관계를 규명하였다. 금연, 건강, 사회적 영향 등 전자담배 사용의 도구적 동기는 금연의지 또는 흡연량 감소와 관련이 있었다. 반면, 호기심, 맛, 즐거움 등 전자담배 사용의 내재적 동기는 일반적으로 금연 의지와

흡연량 감소 둘 다와 관련이 없었다. 한편, 2016년과 2020년 ITC 한국 자료를 비교하였을 때, 도구적 동기로 전자담배를 사용하는 흡연자는 유의미하게 감소한 반면, 내재적 동기로 전자담배를 사용하는 흡연자는 유의미하게 늘어났다. 2020년에는 동시사용자의 60.3%가 기존 궐련담배의 금연 및 흡연량 감소 둘 다 목표하지 않는 것으로 나타나, 금연 및 흡연량 감소를 위해 사용한다고 보고한 비율을 넘어섰다.

세 번째 연구는 전자담배 사용, 궐련담배의 금연행동, 그리고 두 제품 간의 위험 및 규제에 대한 격차 인식 간의 복합적인 관계를 탐구하였다. 약 10%가 넘는 흡연자들은 궐련담배와 전자담배 간에 건강위험과 실내 전면금지 여부에 차이가 있다고 인식했다. 이러한 두 제품에 대해 흡연자가 인식하는 간극은 그들의 전자담배 사용 및 기존 담배 금연의지와 관련이 있었다. 가령, 전자담배가 일반담배보다 덜 해롭고, 중독성이 낮다고 인식한 흡연자들은 동시사용자일 가능성이 유의미하게 높았고 기존 담배에 대한 금연의지도 가질 가능성이 높았다. 사는 지역의 공공장소에서 궐련담배와 전자담배가 둘 다 전면 금지라고 보고한 흡연자들은 동시사용자일 가능성이 유의미하게 낮았고, 금연에 대한 의지를 가질 가능성은 높았다. 반면, 거주지역의 공공장소에서 궐련담배만 전면 금지라고 보고한 흡연자들은 금연의지를 가질 가능성이 유의미하게 관찰되지 않았다.

결론

전자담배 사용은 일부 흡연자들의 금연 시도와 단기 금연을 촉진할 수 있지만, 흡연자들이 즉각적인 금연 의도 없이 담배를 계속 피우도록 유도하는 역할이 인구 수준에서 지배적이다. 또한, 성인 흡연자에서의 동시사용의 주된 동기가

금연 및 건강과 같은 도구적 동기를 넘어 금연의지를 가지지 않는 내재적 동기로 변화하고 있다. 두 제품에 대한 위험과 규제에 인식된 격차가 동시사용과 연관된다는 점을 감안할 때, 이러한 격차를 줄이는 것은 기존 담배규제 노력이 침식 및 와해되는 것과 같이 전자담배 사용으로 인한 의도되지 않은 공중보건학적 결과를 예방하기 위해 중요할 것이다. 종합적으로, 전자담배 사용은 인구 수준에서 기존 궐련담배의 흡연을 대체함으로써 순공중보건 혜택을 줄 가능성은 회의적임을 시사한다.

주요어: 전자담배, 금연, 중단행동, 동시사용, 담배규제정책, 공중보건학적 영향

학 번: 2017-38911

Appendix

Appendix 1-1. Comparison of features between tobacco/nicotine products, cessation aids, and medications

Types	Nicotine	Phase	Source	Main contents	Brand	Note.
Conventional cigarette	Yes	Solid	Fire	Tobacco leaves	ex. Malboro, ESSE	담배 – 기획재정부, 보건복지부
Heat-not-burn	Yes	Solid	Electricity	Tobacco leaves	ex. IQOS (2017~)	담배 – 기획재정부, 보건복지부
E-cigarette (ENDS)	Yes	Liquid	Electricity	Tobacco based nicotine Salt nicotine	ex. 1st generation (2007~) ex. JUUL (2019~)	담배 – 기획재정부, 보건복지부
E-cigarette (ENNDS)	No	Liquid	Electricity	-	*판매허가된 제품 없음 *소비자 직접제조	의약외품 – 식약처 흡연습관개선보조제
Consumer products	No	Liquid	Electricity (disposable)	Synthetic nicotine 0.01% *Required permission	ex. Tabacare, vitasoo	공산품, 일회용흡입기 *약국판매 가능
Cessation aids						
Quasi-drugs	No	Solid	Fire	Other leaves	ex. NosmoQ herbal cigarettes	의약외품 – 식약처 흡연욕구저하제(궐련형, 점화식)
	No	Solid	No-fire	Aroma oil, essential oil	ex. Aroma pipe	의약외품 – 식약처 흡연욕구저하제(궐련형, 비점화식)
	No	Toothpastes	-	-		의약외품 – 식약처 흡연욕구저하제(치약형)
	No	Liquid	Electricity (cartridge)	Only flavor (Tabanone 0%)	*판매허가된 제품없음 ex. (Vita stick)	의약외품 – 식약처 흡연습관개선보조제
	No	Liquid	Electricity (cartridge)	Tobacco absolute oil (Tabanone 8~12%)	ex. Change stick	의약외품 – 식약처 흡연욕구저하제(전자식)
Medications						
Ethical-the-counter drugs	Yes	Nicotine Replacement Therapy (NRT)		Synthetic nicotine *Required permission	ex. patch, gum, lozenge, etc	일반의약품
Over-the-counter drugs	No	Pills		Varenicline Bupropion	ex. Champix, ex. Wellbutrin,nicopion	전문의약품, 의료인 처방