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Authors

Park, Eun Young
Park, Eunjung
Jeong, Bo Yoon
et al.

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Comparison of smoking cessation rates of Quitline users in Korea between smokers of ultra-low nicotine yield cigarettes and other types of cigarette: a prospective study

Eun Young Park[1], Eunjung Park[1], Bo Yoon Jeong[2] (ID), Jinju Park[5] (ID), Do-Hoon Lee[3] (ID), Neal L. Benowitz[4] (ID) & Min Kyung Lim[1,5] (ID)

Division of Cancer Prevention and Early Detection, National Cancer Control Institute, National Cancer Center, Gyeonggi-do, Korea,[1] Division of Cancer Control and Policy, National Cancer Control Institute, National Cancer Center, Gyeonggi-do, Korea,[2] Department of Laboratory Medicine, National Cancer Center, Gyeonggi-do, Korea,[3] Departments of Medicine and Bioengineering and Therapeutic Sciences, Zuckerberg San Francisco General Hospital, University of California San Francisco, USA[4] and Department of Cancer Control and Population Health, Graduate School of Cancer Science and Policy, National Cancer Center, Gyeonggi-do, Korea[5]

ABSTRACT

Aims It is not known whether the machine-smoked nicotine yield of usual brand of cigarette smoked is associated with the chances of success of quit attempts. This study aimed to assess this association. **Design** Prospective study. **Setting** Republic of Korea. **Participants** A total of 16 808 male smokers registered for the Quitline between 7 April 2006 and 31 December 2013. Of these, 13 176 participants who were > 19 years of age and provided data on their demographic characteristics, smoking-related behaviors, nicotine dependence, tobacco brands used and self-efficacy were included in this study. **Measurements** Machine-smoked nicotine yield was based on information provided by tobacco companies on cigarette packages that smokers reported as their usual brand. Ultra-low nicotine yield was defined as ≤ 0.1 mg machine-smoked nicotine yield per cigarette, whereas higher nicotine yield was defined as > 0.1 mg machine-smoked nicotine yield. Participant personal information and self-reported continuous abstinence at 1-month, 6-month and 1-year follow-up were recorded in electronic databases. **Findings** Continuous abstinence rates in the ultra-low nicotine yield versus higher nicotine yield groups were, respectively, 40.7 versus 34.6% at 1 month [odds ratio (OR) = 1.22, 95% confidence interval (CI) = 1.12–1.33], 22.7 versus 18.8% at 6 months (OR = 1.20, 95% CI = 1.08–1.32) and 19.5 versus 16.6% (OR = 1.19, 95% CI = 1.10–1.29) at 1 year. The association between ultra-low nicotine yield cigarette smoking and successful quitting was stronger among the smokers with higher cigarette dependence. **Conclusions** Male smokers who use the Korean Quitline are more likely to quit successfully if they smoke ultra-low nicotine yield cigarettes than if they smoke higher nicotine yield cigarettes.

Keywords Cessation, cigarette, nicotine, prospective study, smokers, ultra-low nicotine yield.

INTRODUCTION

Machine-smoked tar and nicotine yields of cigarettes have declined substantially since the mid-1950s, which is when the link between smoking and lung cancer was established. At one time, US public health authorities encouraged smokers who could not quit to switch to machine-smoked lower yield cigarettes with the hope of reducing disease risk. However, it was later determined that lower yield cigarettes do not reduce disease risk.

Machine-smoked yield does not predict actual nicotine yield to the smoker. Smokers take deeper and more puffs and block filter ventilation holes, allowing them to inhale the desired amounts of nicotine (accompanied by increased exposure to tar and other toxins). An analysis of the health effects of machine-smoked low yield cigarettes found no evidence that they reduce harm from smoking. They can increase harm due to smokers' perceptions of lower harm, leading them to switch to machine-smoked lower yield cigarettes instead of quitting [1].

Cross-sectional studies of the biomarkers of nicotine exposure in smokers of different machine-smoked yield cigarettes found that smokers of ultra-low nicotine (ULN) yield cigarettes ($\leq$ 0.1 mg) have a 30% lower nicotine intake, compared with that of smokers of all other nicotine yield cigarettes [2]. This difference is because these cigarettes are so highly ventilated that complete compensation is difficult. In most countries, small percentages of the population smoke ULN cigarettes, presumably because smokers cannot obtain desired levels of nicotine. Therefore, little information is available on the smoking behaviors and disease risks in the smokers of ULN cigarettes. However, there is a high prevalence of smoking in Korea. For example, as of 2013, 42.2% of men and 6.2% of women aged > 19 years smoked cigarettes [3], and a substantial proportion of the population smokes ULN cigarettes. This higher prevalence makes research on the smokers of ULN cigarettes feasible.

Nicotine is highly addictive and is primarily responsible for the development and maintenance of tobacco use [4]. The severity of nicotine dependence appears to be related to daily nicotine intake [5,6]. In this context, quitting has been examined in smokers switching from conventional to reduced nicotine content (RNC) cigarettes. Unlike commercial machine-smoked low yield cigarettes, RNC cigarettes contain less nicotine. A very low nicotine content in the tobacco makes it more difficult for smokers to compensate. Thus, smokers of RNC cigarettes take in less nicotine compared with smokers of normal nicotine-content cigarettes [7,8]. In a randomized clinical trial, Hatsukami *et al.* found significantly higher quit rates among smokers who used very low nicotine-content cigarettes (VLNC, 0.05 mg nicotine) compared with higher nicotine-content cigarettes (0.3 mg) for 6 weeks (36 versus 14%) [9]. The quit rate with the VLNC cigarette was similar to that with use of nicotine lozenge (20%). Further analysis of data from this and another VLNC quit study found that the greater reduction in nicotine intake by the smoker, the higher the quit rate [10].

The combined effect of VLNC cigarette use and usual Quitline care was reported by Walker *et al.* They found a higher 7-day point prevalence of cessation after 6 months in the intervention group (33%, VLNC cigarettes and usual Quitline care) compared with the control group (28%, usual Quitline care) [11]. A pilot study found a reduction in nicotine dependence with gradual nicotine reduction over 6 weeks, and 25% of the participants had successfully quit by 4 weeks after tapering [12]. Large studies have reported that decreased levels of nicotine dependence and increased numbers of days without smoking were associated with gradual or rapid nicotine reductions [8,13]. However, these experimental studies were not designed to examine the effects of RNC cigarette use on quitting in real-world settings. Many of the participants in these trials were not interested in quitting, and in many cases participants smoked a combination of RNC and their usual-brand cigarettes.

While ULN commercial cigarettes are not reduced nicotine-content cigarettes they are associated, as mentioned above, with an average 30% lower nicotine intake compared with higher yield cigarettes. To our knowledge, the association between ULN cigarette use and smoking cessation has not been reported for any population-level studies. Therefore, it is not known whether the machine-smoked nicotine yield of usual brand of cigarette smoked is associated with the chances of success of quit attempts.

The World Health Organization (WHO) Framework Convention on Tobacco Control (FCTC, articles 9–11) recommends that government agencies that regulate tobacco products test contents and emissions and mandate the disclosure of results and monitoring information through package inserts and labeling. In contrast, for the reasons described above, a WHO TobReg advisory report suggested that producers of commercial cigarettes that are nominally low-nicotine yield according to smoking machine assessment would not be expected to make changes that reduce actual nicotine intake or decrease addictiveness [14].

In this context, we hypothesized that reduced nicotine exposure associated with the use of machine-smoked ULN cigarettes might affect smoking cessation. Our study investigated this hypothesis using data on successful quitting and continuous abstinence from longitudinal follow-up of smokers who used the nation-wide toll-free Quitline in Korea.

METHODS

Quitline in Korea

As described previously [15], under the direction of the Korean Ministry of Health and Welfare, the nation-wide toll-free Quitline based on the transtheoretical theory began operation in 2006. Smokers voluntarily contact the Quitline by telephone to register for the smoking cessation program. The entire program lasts for 1 year and is free of charge. It consists of comprehensive telephone-based behavioral counseling for the first 6 months and includes seven telephone calls during the first 30 days and 14 additional calls during the next 11 months for smoking cessation and maintenance counseling. Booklets and short message service (SMS) messages are delivered throughout the cessation process.

Smokers who wish to enroll in Quitline are first assessed using a structured questionnaire to collect information on demographic characteristics, smoking habits (e.g. brand of tobacco smoked, level of nicotine dependence) and related health risk factors. Nicotine dependence is evaluated using the Fagerström Test for Cigarette Dependence [16].

Personal information and interview details are recorded in electronic databases. During the first counseling session, nicotine replacement therapy options are introduced and explained by the Quitline coaches. The Quitline does not supply any pharmacotherapeutic products.

Study sample

In Korea, Quitline offers smoking cessation programs aimed at different populations (e.g. adolescents, women and men) for more effective intervention outcomes. Differences in these programs are based on factors such as smoking prevalence, smoking behaviors, smoking-trigger factors and motivational factors for quitting [3,17,18]. In the current analysis, only male Quitline users were included in the study because they constitute the majority of the smoking population in Korea. They were all coached using an identical cessation program.

A total of 16 808 male smokers registered for Quitline between 7 April 2006 and 31 December 2013, and were all followed-up. Among these participants, 13 908 smokers who provided data on their demographic characteristics, smoking-related behavior, nicotine dependence, brand of tobacco smoked and self-efficacy were included in this study. After excluding adolescents, the final analysis included 13 176 male smokers.

The requirement for verbal consent via telephone from each participant was waived by the Institutional Review Board of the National Cancer Center of Korea, which approved the study protocol.

The analysis in this study was not pre-registered and the results should be considered exploratory.

Measurements

The baseline data collected at Quitline enrollment included sex, age (20–29, 30–39, 40–49, 50–59 or ≥ 60 years), education level (middle school or less, high school, college or more), body mass index [defined as the body mass divided by the square of the body height (m), classified as <23, 23–25 or ≥ 25 kg/m^2] [19], per month alcohol consumption frequency (non-drinker, ≤ 5 times per month, 6–10 times per month or ≥ 11 times per month), nicotine dependence [Fagerström Test for Cigarette Dependence score: < 3 (mild), 4–6 (moderate) or 7–10 (severe)] [16], age at smoking initiation (< 20 or ≥ 20 years), duration of smoking (≤ 5, 6–10 or ≥ 11 years), cessation support (not supported, friends or other peers, or parents or other family members), motivation to contact (voluntary versus recommended), reason for smoking cessation, level of self-efficacy for smoking cessation, experiences of past quit attempts and reasons for relapse (e.g. withdrawal, stress, temptations in the social environment).

The smokers were also asked about the brand of cigarette smoked at the time of Quitline enrollment (i.e. 'What brand of cigarette do you smoke most often, currently?'). The nominal nicotine yield of the cigarette brand smoked was assessed using the information provided by tobacco companies and on the packages of the cigarette products smokers reported they used. The nominal nicotine yields ranged from 0.01 to 1.2 mg. Yields were classified into quartiles (25th: 0.1 mg, median: 0.5 mg, 75th: 0.65 mg). We defined ULN as ≤ 0.1 mg machine-smoked nicotine yield per cigarette, which corresponded to the lower 25th percentile [2]. Higher nicotine yield was > 0.1 mg machine-smoked nicotine yield per cigarette.

This study used a modified version of the instrument for measurement of self-efficacy proposed by Shin [20] (Cronbach's alpha = 0.71). The instrument consisted of eight statements, to which each participant could respond 'yes' or 'no'. One point was added for each statement with a 'yes' response. The sum of these points was divided into three categories (0–2, 4–6 or 7–8 points); higher scores indicated higher smoking cessation self-efficacy [20].

Data analyses

χ^2 tests were performed to estimate associations between characteristics of the male smokers at baseline and the use of machine-smoked nicotine yield cigarettes. Simple and multiple logistic regression analyses were performed to measure associations between use of machine-smoked nicotine yield cigarettes and self-reported smoking abstinence at 1 month, 6 month and 1 year after the quit date. A stratification analysis by nicotine dependence was performed after examination on the potential interaction between nicotine dependence and nicotine yield of cigarettes with the χ^2 test [5,6]. We used the Breslow–Day statistic to test the homogeneity of odds ratios (ORs; i.e. whether measures of association were significantly different by the strata). A statistically significant Breslow–Day statistic indicated the presence of a moderation effect. In these cases, we reported separate ORs for each stratum of nicotine dependence. If a test for homogeneity was not significant, we performed a multiple logistic regression analysis with adjustment for nicotine dependence and then compared the adjusted OR with the crude OR results. Thus, the logistic regression analysis models were: model 1: unadjusted; model 2: age, education level, drinking frequency per month, duration of smoking, average number of cigarettes smoked, self-efficacy and past quit attempts; model 3: age, education level, drinking frequency per month, duration of smoking, average number of cigarettes smoked, nicotine dependence, self-efficacy and past quit attempts. A longitudinal analysis was also performed using a generalized estimating equation (GEE) model to assess the association between machine-smoked nicotine yield and chances

of success of quit attempts. The SAS version 9.3 software (SAS Institute Inc, Cary, NC, USA) was used for all analyses. A result with a *P*-value < 0.05 indicated a statistically significant result.

RESULTS

At the 1-month, 6-month and 1-year follow-up times after smoking cessation, 1.9, 5.3 and 10.5%, respectively, of the study subjects were lost to follow-up. The proportion of subjects lost to follow-up at 1 year was greater in the ULN group of cigarette smokers. Those lost to follow-up were younger, had shorter smoking durations and less self-efficacy than subjects who were followed-up at 1 year (Supporting information, Table S1).

Compared with the higher nicotine yield cigarette smokers, the ULN cigarette smokers were older, more highly educated, drank more alcohol, had longer smoking durations, milder nicotine dependence and higher self-efficacy (Table 1).

Whether or not subjects smoked different nicotine yield cigarettes, age, education level, self-efficacy and nicotine dependence all showed statistically significant associations with continuous abstinence at the 1-month, 6-month and 1-year follow-ups (Supporting information, Tables S2–S4).

Table 2 presents the results for successful quit rates and ORs for the rates by the machine-smoked nicotine yield of cigarettes smoked. The continuous abstinence rates in the ULN cigarette smokers (i.e. 40.7, 22.7 and 19.5% at 1 month, 6 months and 1 year, respectively) were higher than those of the higher nicotine yield cigarette smokers.

Table 1 Baseline characteristics of participants by nominal cigarette nicotine yield.

Characteristics	Total N = 13 176	Nominal nicotine yield of cigarette		χ^2	P-value
		≤ 0.1 n = 4433 (33.6)	> 0.1 n = 8743 (66.4)		
Age (years)					
20–29	2213	377 (8.5)	1836 (21.0)	365.68	< 0.0001
30–39	5100	1830 (41.3)	3270 (37.4)		
40–49	3686	1469 (33.1)	2217 (25.4)		
50–59	1621	602 (13.6)	1019 (11.7)		
≥ 60	556	155 (3.5)	401 (4.6)		
Education level					
Middle school or less	733	198 (4.5)	535 (6.2)	226.33	< 0.0001
High school	4777	1259 (28.6)	3518 (40.7)		
College or more	7540	2944 (66.9)	4596 (53.1)		
Drinking frequency per month					
Non-drinker	1292	260 (6.4)	1032 (12.8)	137.97	< 0.0001
≤ 5	4408	1529 (37.6)	2879 (35.7)		
6–10	2984	1143 (28.1)	1841 (22.8)		
≥ 11	3443	1133 (27.9)	2310 (28.7)		
Duration of smoking (years)					
≤ 10	863	174 (3.9)	689 (7.9)	94.94	< 0.0001
11–20	4105	1312 (29.7)	2793 (32.1)		
≥ 21	8149	2930 (66.4)	5219 (60.0)		
Average number of cigarettes smoked per day					
≤ 10	2525	924 (20.9)	1601 (18.4)	19.38	< 0.0001
11–20	6977	2364 (53.4)	4613 (52.9)		
≥ 21	3642	1138 (25.7)	2504 (28.7)		
Nicotine dependence					
0–3 (mild)	5119	1999 (45.6)	3120 (36.1)	115.31	< 0.0001
4–6 (moderate)	5283	1649 (37.6)	3634 (42.1)		
7–10 (severe)	2618	739 (16.9)	1879 (21.8)		
Self-efficacy					
0–2	1523	445 (10.4)	1078 (12.8)	16.38	0.0003
3–6	7613	2621 (61.0)	4992 (59.3)		
7–8	3575	1233 (28.7)	2342 (27.8)		
Past quit attempt					
No	1521	497 (11.3)	1024 (11.8)	0.81	0.3674
Yes	11 561	3912 (88.7)	7649 (88.2)		

Table 2 Point prevalence and odds ratios for self-reported smoking cessation success at the end of 1-month, 6-month and 1-year follow-up.

	Total N	Successful quitting			OR[b] (95% CI)	OR[c] (95% CI)	OR[d] (95% CI)
		n	Nominal nicotine yield				
			≤ 0.10	> 0.10			
Point prevalence of quitting							
1-month follow-up	12 923	4732	1768 (40.7)	2964 (34.6)	1.297 (1.203–1.398)[a]	1.250 (1.149–1.361)[a]	1.219 (1.119–1.328)[a]
6-month follow-up	12 476	2508	948 (22.7)	1560 (18.8)	1.264 (1.154–1.385)[a]	1.221 (1.103–1.351)[a]	1.195 (1.079–1.323)[a]
1-year follow-up	11 796	2069	758 (19.5)	1311 (16.6)	1.220 (1.105–1.347)[a]	1.185 (1.062–1.323)[a]	1.161 (1.040–1.296)[a]
Longitudinal analysis (GEE)							
Overall follow-up	11 796	2069	2069	–	1.259 (1.169–1.357)[a]	1.217 (1.120–1.322)[a]	1.191 (1.095–1.294)[a]

95% CI = 95% confidence interval around the odds ratio (OR). [a]Bold type = ORs that are significant at $P < 0.05$. [b]Unadjusted OR; [c]OR adjusted for age, education level, drinking frequency per month, duration of smoking, average number of cigarettes smoked, self-efficacy and past quit attempt; [d]OR adjusted for age, education level, drinking frequency per month, duration of smoking, average number of cigarettes smoked, nicotine dependence, self-efficacy and past quit attempt. GEE = generalized estimating equation.

The ORs for quitting in smokers of ULN cigarettes were significantly greater at all follow-up times compared with smokers of higher nicotine yield cigarettes [OR = 1.22, 95% confidence interval (CI) = 1.12–1.33 at 1 month, OR = 1.20, 95% CI = 1.08–1.32 at 6 months, OR = 1.19, 95% CI = 1.10–1.29 at 1 year]. The longitudinal analysis using GEE also revealed that there was a statistically significant association between ULN cigarette smoking and continuous abstinence over the follow-up times.

Regarding the significant interaction between nicotine yield and nicotine dependence (*P*-value 0.0211 at 1 month, 0.0354 at 6 months and 0.0841 at 1 year), the subgroup analysis by the level of nicotine dependence was performed. The analysis found that the association between ULN cigarettes and chances of success of quit attempts was increased in the group of smokers with severe nicotine dependence (OR = 1.51, 95% CI = 1.23–1.86) at 1 month, OR = 1.65, 95% CI = 1.27–2.13 at 6 months, OR = 1.52, 95% CI = 1.15–2.02 at 1 year and OR = 1.51, 95% CI = 1.23–1.86) for overall follow-up]. However, the ORs in each strata of nicotine dependence were statistically different only at the 6-month follow-up time (Tables 2 and 3).

DISCUSSION

Our findings indicate that, even considering the known compensatory smoking behaviors of low nicotine yield cigarette smokers, ULN cigarette smokers are more successful at quitting smoking than higher nicotine yield cigarette smokers. We also found that the association between ULN cigarette smoking and successful quitting was greater in smokers with more severe nicotine dependence. Taken together, these results suggest that the cigarette nicotine delivery is primarily responsible for the severity of addiction of smokers and that use of ULN or very low nicotine content cigarettes could increase the odds of successful quitting.

To our knowledge, this study is the first community-based examination of the effects of smoking machine-smoked nicotine yield cigarettes on long-term (i.e. 6-month and 1-year follow-up times) smoking cessation. The strengths of this study include its large sample size and prospective nature (i.e. long-term follow-up period after smoking cessation). Additionally, the Korean population differs from the US population in that a much larger percentage of Korean smokers smoke ULN cigarettes. This type of smoker is less common in the United States, and we are unaware of any study that has assessed population quit rates in US ULN cigarette smokers.

Assuming that Korean smokers smoke ULN cigarettes similarly to US smokers of similar cigarettes, these smokers take in an average of 30% less nicotine per day, compared with that of smokers of higher yield cigarettes [2]. Thus,

Table 3 Odds ratios for self-reported continuous abstinence at 1-month, 6-month and 1-year follow-ups stratified by the level of nicotine dependence.

	Level of nicotine dependence									Moderation effect[c]
	Mild (0–3)			*Moderate (4–6)*			*Severe (7–10)*			
	Success	OR[c] (95% CI)	OR[d] (95% CI)	Success	OR[c] (95% CI)	OR[d] (95% CI)	Success	OR[c] (95% CI)	OR[d] (95% CI)	P-value
1-month follow-up	n = 2236 (44.3)			n = 1664 (32.2)			n = 775 (30.3)			0.0969
Nominal nicotine yield										
≤ 0.10	915 (46.5)	**1.153** (1.029–1.292)[a]	1.078 (0.949–1.224)	570 (35.3)	**1.232** (1.088–1.395)[a]	**1.287** (1.120–1.480)[a]	262 (36.2)	**1.461** (1.217–1.754)[a]	**1.510** (1.225–1.861)[a]	
> 0.10	1321 (43.0)	Ref	Ref	1094 (30.7)	Ref	Ref	513 (28.0)	Ref	Ref	
6-month follow-up	Success n = 1213 (24.8)	OR[c] (95% CI)	OR[d] (95% CI)	Success n = 874 (17.6)	OR[c] (95% CI)	OR[d] (95% CI)	Success n = 398 (16.1)	OR[c] (95% CI)	OR[d] (95% CI)	P-value
Nominal nicotine yield										0.0249
≤ 0.10	503 (26.4)	**1.149** (1.007–1.312)[a]	**1.096** (0.947–1.268)[a]	293 (19.1)	1.152 (0.987–1.346)	1.176 (0.990–1.396)	147 (21.1)	**1.620** (1.292–2.030)[a]	**1.647** (1.272–2.133)[a]	
> 0.10	710 (23.8)	Ref	Ref	581 (17.0)	Ref	Ref	251 (14.2)	Ref	Ref	
1-year follow-up	Success n = 1003 (21.6)	OR[c] (95% CI)	OR[d] (95% CI)	Success n = 710 (15.2)	OR[c] (95% CI)	OR[d] (95% CI)	Success n = 337 (14.4)	OR[c] (95% CI)	OR[d] (95% CI)	P-value
Nominal nicotine yield										0.1718
≤ 0.10	403 (22.6)	1.096 (0.950–1.264)	1.035 (0.884–1.210)	237 (16.7)	1.180 (0.995–1.399)	1.214 (1.008–1.463)	115 (17.8)	**1.438** (1.125–1.840)[a]	**1.524** (1.151–2.019)[a]	
> 0.10	600 (21.1)	Ref	Ref	473 (14.5)	Ref	Ref	222 (13.1)	Ref	Ref	
Longitudinal analysis (GEE)										
Overall effect	–	**1.131** (1.014–1.260)[a]	1.067 (0.946–1.203)	–	**1.205** (1.061–1.368)[a]	**1.239** (1.077–1.424)[a]	–	**1.448** (1.203–1.744)[a]	**1.512** (1.230–1.859)[a]	–

[a]Bold type = odds ratios (ORs) that are significant at *P* < 0.05. [b]Testing for the homogeneity of the ORs via the Breslow–Day statistic; [c]Unadjusted OR; [d]OR adjusted for the OR. [d]OR adjusted for age, education level, drinking frequency per month, duration of smoking, average number of cigarettes smoked, self-efficacy and past quit attempt. 95% CI = 95% confidence interval around the OR. GEE = generalized estimating equation.

our results suggested that a 30% reduction in nicotine intake significantly affected the odds of quitting. Although the overall quit rates in smokers were low, even for ULN cigarette smokers, the findings suggested that reduced nicotine consumption could significantly increase successful quitting and continuous abstinence (i.e. ULN cigarette smokers versus higher nicotine yield cigarette smokers, 40.7 versus 34.6% at 1 month, 22.7 versus 18.8% at 6 months and 19.5 versus 16.6% at 1 year). Absolute quit rates were little different between smokers who used ULN cigarettes compared with those who used higher nicotine yield cigarettes. One explanation for this result is that commercial cigarettes are designed to deliver an adequate level of nicotine to sustain addiction, and an adequate level of nicotine is available even in ULN cigarettes. Of note, however, excess successful quitting associated with reduced nicotine exposure of ULN cigarette could be significant on a population basis, because 942 million men and 175 million women ≥ 15 years of age are current smokers globally [21]. Furthermore, the associations found in this study remained consistent after adjusting for confounding variables (including nicotine dependence) although, paradoxically, the stratification analysis found that these associations were stronger in smokers with severe nicotine dependence. Tobacco use remains affordable in Korea, and tobacco companies use terms and images on cigarette packs to promote their products as being relatively less addictive and less harmful. Therefore, these results are not easily explained by any factors other than lower nicotine delivery through ULN cigarette use.

These study findings highlight once more that nicotine is primarily responsible for smoking. The findings suggest that the use of VLNC cigarettes, not the currently marketed low nicotine yield cigarettes, could positively affect public health. The WHO FCTC has encouraged the use of tobacco products with reduced nicotine content, and national agencies such as the United States and Korean Food and Drug Administrations (FDAs) have the authority to regulate nicotine content in cigarettes [4]. However, to our knowledge, no countries currently have standards for tobacco nicotine content. The United States recently promulgated a proposed rule to reduce the nicotine content of cigarettes to minimally addictive levels and is currently evaluating public comments on the proposed rule [22].

This study revealed novel findings on the associations between VLNC cigarette use and the chances of success of quit attempts. However, there were some limitations. First, as with most observational studies, selection bias probably occurred. To overcome this problem, we adjusted the analysis for confounders such as age, education level, alcohol drinking frequency, self-efficacy and past attempts to quit, and found that the results remained consistent after these adjustments. In addition, the smoking cessation coaching was executed using the same protocol and the same standardized manual and content. However, quit success may have been affected by unmeasured or unconsidered confounding variables (e.g. job or social stress).

Secondly, the brands of ULN cigarettes used differed among smokers, and some subjects may have selected ULN cigarettes because they were more interested in healthy behaviors and were more willing to quit. The statistical significance of the small difference in quit rates may be due to the use of a large sample size (i.e. $n = 13\,000$). However, as noted above, we adjusted for confounders associated with brand preference of ULN cigarettes as well as quitting smoking in general, and our results did not change.

Thirdly, because we collected data from the Quitline based on proactive calls from smokers, the additional limitations included self-reported cessation rather than biochemically verified cessation. This self-report may have resulted in overestimation of the smoking cessation success rate. Self-reporting may also have resulted in under-reporting of the amount and duration of smoking, nicotine dependence and unhealthy behaviors such as drinking frequency. However, self-reporting is used extensively as an outcome measure in studies on smoking exposure and cessation. In addition, under the traditional social and cultural norms of Korea, male smoking has been socially acceptable while female smoking has not; there are no social and emotional barriers to male smokers discussing their smoking or quitting [23]. The social environment supports smokers and their quit attempts. Comprehensive cessation services are offered at the national level with governmental support. The Korean government has encouraged smokers to get help to quit smoking since 2004 [24]. Therefore, in Korea, male smokers are less likely to misreport their smoking and quitting behaviors. Quitline users tend to be more honest when providing their smoking information because, unlike face-to-face counseling, the telephone-based service is anonymous and confidential.

Fourthly, regarding the interaction between ULN cigarette use and nicotine dependence, stratification analyses by nicotine dependence were also performed and consistent findings with narrow OR confidence intervals were identified. The temporality between ULN cigarette use and level of nicotine dependence could not be identified due to the type of information collected during Quitline registry. However, the fact that lower nicotine exposure might have greater effects on smokers with relatively higher levels of nicotine addiction corresponds with existing knowledge and supports the statistical significance of the association between ULN cigarette use and chances of success of quit attempts. Finally, the current findings cannot be generalized to all smokers, because the results are based on a population of smokers who voluntarily called Quitline for assistance with cessation. Therefore,

their readiness to quit and the effects of low nicotine yield cigarettes may differ from those of smokers who did not attempt to quit. Furthermore, the findings of this study cannot be applied to women and adolescents, because compared with male smokers, they have different smoking prevalence, smoking patterns, smoking-trigger factors and motivations for quitting smoking [3,17,18].

In conclusion, male smokers who used the Korean Quitline were more likely to successfully quit if they were smokers of ULN cigarettes. The association between ULN cigarette smoking and chances of success of quit attempts was increased among smokers who had severe nicotine dependence. However, studies that consider potential confounders missing from this study should be performed to confirm the effects of ULN cigarette smoking on successful quit attempts and continuous abstinence. Cessation interventions should be continuously provided to all smokers because among all smokers, no matter what cigarette is smoked relapse rates are high.

Declaration of interests

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 Comparison of baseline characteristics between those who followed and those who did not follow at one-year.

Table S2 Odds ratios of self-reported smoking cessation at the one-month follow-up

Table S3 Odds ratios of self-reported smoking cessation at the six-month follow-up

Table S4 Odds ratios of self-reported non-smoking at the one-year follow-up.