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E-cigarette use in young Swiss men: is vaping an effective way of reducing or quitting smoking?

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Summary

QUESTION UNDER STUDY: To test longitudinally differences in conventional cigarette use (cigarettes smoked, cessation, quit attempts) between vapers and nonvapers.

METHODS: Fifteen months follow-up of a sample of 5 128 20-year-old Swiss men. The onset of conventional cigarette (CC) use among nonsmokers, and smoking cessation, quit attempts, changes in the number of CCs smoked among smokers at baseline were compared between vapers and nonvapers at follow-up, adjusted for nicotine dependence.

RESULTS: Among baseline nonsmokers, vapers were more likely to start smoking at follow-up than nonvapers (odds ratio [OR] 6.02, 95% confidence interval [CI] 2.81, 12.88 for becoming occasional smokers, and OR = 12.69, 95% CI 4.00, 40.28 for becoming daily smokers). Vapers reported lower smoking cessation rates among occasional smokers at baseline (OR = 0.43 (0.19, 0.96); daily smokers: OR = 0.42 [0.15, 1.18]). Vapers compared with nonvapers were heavier CC users (62.53 vs 18.10 cigarettes per week, p <0.001) and had higher nicotine dependence levels (2.16 vs 0.75, p <0.001) at baseline. The number of CCs smoked increased between baseline and follow-up among occasional smokers (b = 6.06, 95% CI 4.44, 7.68) and decreased among daily smokers (b = –5.03, 95% CI –8.69, –1.38), but there were no differential changes between vapers and nonvapers. Vapers showed more quit attempts at follow-up compared with nonvapers for baseline occasional smokers (incidence rate ratio [IRR] 1.81, 95% CI 1.24, 2.64; daily smokers IRR 1.28, 95% CI 0.95, 1.73).

CONCLUSIONS: We found no beneficial effects of vaping at follow-up for either smoking cessation or smoking reduction.

Key words: *E-cigarette; smoking cessation; quit attempts; Switzerland*

Introduction

As pointed out by Grana, et al. [1], the USA patent describes e-cigarettes (ECs) as a substitution for cigarettes to help smokers quit smoking. In the past few years, ECs have quickly penetrated the market in established market economies [1, 2]. Such an increasing prevalence opened a heated debate on the pros and cons of EC use [3–5]. Four major concerns were raised and discussed [3, 4]:

a) the safety of EC use and its potential effects on health;
b) there may be limited evidence that EC use actually helps smokers quit smoking;
c) the widespread use of ECs may "renormalise" smoking, which may increase the smoking prevalence, or slow down its decrease;
d) EC use may act as a gateway to conventional cigarette (CC) use.

The claim that longitudinal studies are lacking is common in debates on EC use. In a recent review [1], only four population-based longitudinal studies on smoking cessation and EC use were found [6–9]. These studies have been criticised, among other things, for not accounting for the level of nicotine dependence or not including subjects who may have quit smoking as a result of EC use [4, 5]. The present study looks at longitudinal changes in smoking status, quit attempts, and the number of cigarettes smoked by young male vapers ("EC users" and "vapers" are used interchangeably, "smokers" referring to users of CCs) adjusted for nicotine dependence.

There is now consensus that, although EC use is not safe, it is less harmful than CC use [4, 10–12]. Therefore, the question whether the use of ECs reduces the use of CCs, including smoking cessation, is fundamental. This argument faces the counter-argument that EC use in many studies was most prevalent among CC users, otherwise known as "dual users" [1]. However, this does not mean *per se* that EC use has a negative impact on health, provided that dual users reduce their CC use in favour of EC use [4, 5]. A review confirmed that EC use is likely to reduce the

number of CCs smoked, but that vapers are less likely to quit smoking than nonvapers [1]. However, only reducing the number of smoked cigarettes may have little beneficial value for reducing toxicant exposure, because of compensatory smoking, e.g. by taking longer puffs or inhaling more deeply [13]. The studies included in this review have been criticised for design issues [5] and for not adjusting for nicotine dependence [4]. A recent real-world experiment [2] showed – adjusting for nicotine dependence – that EC use results in more quit attempts and continued abstinence than with nicotine replacement therapy products bought over the counter or without any aid. Another recent longitudinal study adjusting for nicotine dependence found a significant increase in the number of CCs smoked and a lower likelihood of quitting smoking among vapers compared with nonvapers [14]. However, studies have also shown that EC use may be positively associated with attempts to quit smoking CCs [15]. Hence, findings are still heterogeneous and more longitudinal studies are needed.

Another concern is that, because there is a growing awareness and an increase in the first use of ECs among young people [11], EC use may lead to a renormalisation of CC use or act as a gateway into CC use. This view has been criticised for mainly three reasons: (a) EC use is still rare nowadays among young people, (b) smoking prevalence rates continue to decrease despite the increasing use of ECs in some countries, and (c) ECs are mainly used by current, mostly heavy CC users [5]. This critique has been supported, amongst others, by a study in 10–16-year-olds in Wales [16], which showed that CC use became increasingly common, but that regular EC use was uncommon and mainly associated with current cigarette smoking as well as cannabis use. Nevertheless, other studies found that EC use increased, even among young nonsmokers, e.g. in the USA [17]. Moreover, strong increases in EC and CC use have been found among 15–19-year-olds in Poland [18], not reflecting the substitution of CCs for ECs.

The present study followed-up men aged 20 years at baseline over a period of around 15 months. It examined the following research questions:

a) Is vaping compared with nonvaping associated with higher follow-up smoking rates among baseline nonsmokers?
b) Is vaping compared with nonvaping associated with higher follow-up cessation rates among baseline smokers?
c) Is vaping compared with nonvaping associated with fewer cigarettes used at follow-up among smokers?
d) Is vaping compared with nonvaping among smokers associated with more attempts to quit smoking?

Methods

Study design and participants

The data used in the present study are part of the Cohort Study on Substance Use Risk Factors (C-SURF). The research protocol (15/07) has been approved by the ethics committee for clinical research of Lausanne University Medical School. In Switzerland, the army recruitment procedure is mandatory for young males: all 20-year-old males must report to one of the six Swiss army recruitment centres to determine their eligibility for military or civil service. Enrolment took place in three of six army recruitment centres, covering twenty-one of the twenty-six Swiss cantons. Although the tasks of informing and enrolling participants to the study took place in the army recruitment centres, the study was kept independent of the army. Because questionnaires were completed at home, participants were not influenced by army procedures when filling out questionnaires.

A total of 7556 participants gave written consent to participate and, among them, 5987 (79.2%) completed the baseline questionnaire between September 2010 and March 2012, and 6020 (79.7%) completed the follow-up questionnaire between March 2012 and April 2013. A total of 5,479 (91.5% of baseline respondents) completed both the baseline and follow-up questionnaires. As the standard method of assessment, online questionnaires were used, participants were provided via email with an individualised link to an online questionnaire, but participants could receive a paper and pencil version upon request. Missing values were listwise deleted. The final analytical sample comprised 5128 respondents (93.6% of respondents to baseline and follow-up). More information on the enrolment procedure as well as on nonparticipation has been described in previous studies [19, 20]. In short, differences between nonconsenters, nonrespondents and respondents were commonly small and sometimes in different directions. For example, respondents more often consumed alcohol (93.7%) compared with the total population including nonrespondents and nonconsenters (92.6%). However, respondents were less often smokers (37.8%) and cannabis users (32.5%) compared with the total population (46.2% vs 34.3%).

Measures

E-cigarette use

At follow-up, participants were asked whether they had used ECs in the previous 12 months. The use of ECs differentiated between 12-month vapers and nonvapers.

Conventional cigarette use

At baseline and follow-up, participants were asked whether they had smoked cigarettes in the previous twelve months. Questions on the frequency of smoking and the number of cigarettes smoked on a typical smoking day were used to differentiate between 12-month cigarette nonsmokers, occasional (less than daily) smokers, daily smokers, and the weekly number of cigarettes smoked.

Number of attempts to stop smoking

At follow-up, CC smokers were asked whether and how many times they had attempted to stop smoking. Possible responses were zero, one, two, three and four or more attempts. Quit attempts were defined as seriously trying to stop smoking and not smoking during several consecutive days.

Nicotine dependence

At baseline and follow-up, nicotine dependence was assessed with the Fagerström Test for Nicotine Dependence

[21]. The continuous score ranging from 0 –"no symptom of dependence" – to 10 – "high number of symptoms of nicotine dependence" – was used.

Covariates

Sociodemographic variables, including age and the highest completed level of education, were assessed at baseline and follow-up. The highest completed level of education consisted of three categories of schooling: primary schooling (9 years); vocational training (>9–12); post-secondary schooling (13 years or more, including high school, which can be only twelve years in some cantons). The linguistic region differentiated between French- and German-speaking participants.

Statistical analyses

Crude statistics to characterise vapers and nonvapers used χ^2- and t-tests. Multinomial logistic regressions models, stratified by baseline cigarette smoking status (non-smokers, occasional smokers, daily smokers) were conducted to test the associations between EC use and cigarette smoking status (non-smokers, occasional smokers, daily smokers) at follow-up. Three models were run: the unadjusted model 1 tested the bivariate associations of EC use, model 2 adjusted for baseline covariates, and model 3 examined the associations of EC use adjusting for baseline covariates and baseline nicotine dependence. A series of linear mixed models, stratified by baseline cigarette smoking status (non-smokers, occasional smokers, daily smokers), were conducted to test whether changes between baseline and follow-up in the weekly number of cigarettes smoked and whether nicotine dependence differed between vapers and nonvapers. Model 1 tested EC use (vapers vs nonvapers) as the between-subject factor, time of assessment (follow-up vs baseline) as the within-subject factor, and the interaction between EC use and time of assessment. Time of assessment tested changes among nonvapers and the interaction tested the difference in changes between nonvapers and vapers. Model 2 additionally adjusted for covariates, and model 3 additionally adjusted for nicotine dependence. The association between EC use and the number of quit attempts was tested using negative binomial regression models. The same three models as those specified for multinomial logistic regressions were used.

C-SURF was not designed to test particular hypotheses on EC use, but to enrol as many participants as possible over the course of a year to test a multitude of hypothesese about addictive behaviours [22]. Nevertheless, with regard to the sample size, we estimated that for a type 1 error of 5% and a power of 80%, 4221 participants would be needed to detect an odds ratio (OR) of 1.5. This OR corresponds to a small effect size [23, 24] under the assumption that the response probability (e.g. for rare prevalence rates such as illicit drug use) is around 5%, and the independent variables of interest (e.g. EC use) is correlated with control variables (here age, highest achieved education, linguistic region) with an $R^2 = 0.20$. Thus, the sample size was more than sufficient to test small effect sizes given that the prevalence rates of the corresponding dependent variables (e.g., smoking status) were much higher. Pass 11 (NCSS, Kaysville, Utah, USA. http://www.ncss.com), using the algorithm described by Hsieh et al. [24], was used to calculate sample sizes.

Results

Descriptive characteristics of the total sample, vapers and nonvapers

Descriptive characteristics of the total sample, vapers and nonvapers, are reported in table 1. The mean age of participants was 19.98 years at baseline and 21.31 years at follow-up. Vapers were significantly older than nonvapers by about 2–3 months.

The 12-month vaping prevalence at follow-up was 5.0% (254 vapers and 4874 nonvapers). Out of the 2825 baseline nonsmokers, only 32 were vapers at follow-up (1.1%). Vapers were most often daily smokers, whereas nonvapers were more often nonsmokers. CC use rates were significantly higher (by more than three times) among vapers than among nonvapers.

Association between e-cigarrette use and cigarette smoking status at follow-up

Among baseline nonsmokers, those who were vapers at follow-up were more likely to initiate smoking (50.0%) and to become daily smokers (12.5%) by follow-up (table 2) than were baseline nonsmokers who were not vapers (13.1%; 367/2793 initiated smoking and 1.7% became daily smokers)). Among occasional baseline smokers, nonvapers became more often nonsmokers and less often daily smokers than vapers. Differences were smaller among daily baseline smokers. Nevertheless, 6.5% of nonvapers no longer smoked at follow-up, compared with 2.9% of vapers.

Multinomial regression models (table 3) revealed that among nonsmokers at baseline, vapers were 6 times more likely to be occasional smokers and over 12 times more likely to be daily smokers at follow-up (vs nonsmokers) than nonvapers. Among occasional baseline smokers, vapers (vs nonvapers) were less likely to be nonsmokers (OR 0.43; 95% confidence interval [CI] 0.19, 0.96) and about 2.3 times more likely to be daily smokers (vs occasional smoker) at follow-up. Among daily smokers at baseline, EC use was negatively associated with nonsmoking at follow-up, but the association did not reach significance. Findings from all three models (unadjusted, adjusted for covariates, adjusted for covariates and nicotine dependance) were substantially equivalent.

Change in weekly number of cigarettes smoked and nicotine dependence

For the weekly number of cigarettes smoked and levels of nicotine dependence (table 4), mixed models were used only for occasional and daily smokers at baseline, since baseline nonsmokers by definition did not smoke and were not nicotine dependent. However, vapers among nonsmokers at baseline (table 2) smoked 10 times as many cigarettes at follow-up (mean 21.97 cigarettes per week) as nonvapers (mean 1.98 cigarettes per week, see table 2),

$t(2823) = 7.10$, $p<0.001$). Similarly, among nonsmokers at baseline, nicotine dependence scores at follow-up were higher for vapers than nonvapers, $t(2823) = 9.15$, $p<0.001$. Among baseline occasional smokers, the mixed model for EC use indicated that vapers smoked on average an estimated 9.88 more cigarettes (adjusted for control variables) at baseline than nonvapers (model 3: b = 9.88, 95% CI 6.37, 13.40); the coefficient "b" is the difference between those coded 1 (vapers) and those coded 0 (nonvapers), when time of assessment and the interaction are 0, which is the case for the baseline measurement. A significant effect of time of assessment indicated that nonvapers (coded

Table 1: Descriptive characteristics at baseline and follow-up of the total sample and of vapers and nonvapers (measured at follow-up only), Switzerland 2010–2013.

			Baseline measures of smoking and demographics							Follow-up measures of smoking and demographics				
	Total		Vapers at follow-up (n = 254)		Nonvapers at follow-up (n = 4 874)			Total		Vapers at follow-up (n = 254)		Nonvapers at follow-up (n = 4 874)		
	n	%	n	%	n	%	p-value	n	%	n	%	n	%	p-value
Smoking status							<0.001							<0.001
Nonsmoker	2825	55.1	32	12.6	2793	57.3		2 783	54.3	27	10.6	2756	56.5	
Occasional smoker	1348	26.3	82	32.3	1266	26.0		1 273	24.8	72	28.3	1201	24.6	
Daily smoker	955	18.6	140	55.1	815	16.7		1 072	20.9	155	61.0	917	18.8	
Cigarette use														
Weekly number of cigarettes (M, SD)	20.31	43.01	62.53	57.26	18.10	40.97	<0.001	22.29	44.03	65.68	58.43	20.02	41.94	<0.001
Nicotine dependence (M, SD)	0.82	1.63	2.16	2.21	0.75	1.57	<0.001	0.87	1.64	2.39	2.20	0.79	1.57	<0.001
Number of quit attempts (M, SD)	–	–	–	–	–	–		0.19	0.59	0.54	0.89	0.18	0.56	<0.001
Sociodemographics														
Age (M, SD)	19.98	1.22	20.15	1.47	19.97	1.21	0.026	21.31	1.27	21.55	1.59	21.30	1.25	0.002
Education							0.068							<0.001
Primary	2495	48.7	128	50.4	2367	48.6		379	7.4	23	9.1	356	7.3	
Secondary	1475	28.8	83	32.7	1392	28.6		2 342	45.7	148	58.3	2 194	45.0	
Tertiary	1158	22.6	43	16.9	1115	22.9		2 407	46.9	83	32.7	2 324	47.7	
Linguistic region														
French-speaking	2857	55.7	127	50.0	2730	56.0	0.060			–	–	–		

M = mean; SD = standard deviation

Table 2: Smoking characteristics at baseline and follow-up of vapers and nonvapers (measured at follow-up only) as a function of cigarette smoking status at baseline, Switzerland 2010–2013.

	Vapers at follow-up				Nonvapers at follow-up			
	Smoking baseline measures		Smoking follow-up measures		Smoking baseline measures		Smoking follow-up measures	
Smoking status at baseline	**M/n**	**SD/%**	**M/n**	**SD/%**	**M/n**	**SD/%**	**M/n**	**SD/%**
Nonsmoker at baseline	n = 32				n = 2 793			
Smoking status at follow-up								
Nonsmoker (n, %)	–	–	16	50.0	–	–	2 426	86.9
Occasional smoker (n, %)	–	–	12	37.5	–	–	320	11.5
Daily smoker (n, %)	–	–	4	12.5	–	–	47	1.7
Weekly number of cigarettes (M, SD)	–	–	21.97	65.89	–	–	1.98	14.34
Nicotine dependence (M, SD)	–	–	1.44	2.26	–	–	0.21	0.72
Number of quit attempts (M, SD)	–	–	0.09	0.39	–	–	0.03	0.22
Occasional smoker at baseline	n = 82				n = 1 266			
Smoking status at follow-up								
Nonsmoker (n, %)	–	–	7	8.5	–	–	277	21.9
Occasional smoker (n, %)	–	–	47	57.3	–	–	804	63.5
Daily smoker (n, %)	–	–	28	34.1	–	–	185	14.6
Weekly number of cigarettes (M, SD)	21.89	28.73	28.96	34.29	8.82	16.94	16.23	29.52
Nicotine dependence (M, SD)	0.77	1.34	0.82	1.26	0.51	0.98	0.61	1.17
Number of quit attempts (M, SD)	–	–	0.59	0.94	–	–	0.30	0.75
Daily smoker at baseline	n = 140				n = 815			
Smoking status at follow-up								
Nonsmoker (n, %)	–	–	4	2.9	–	–	53	6.5
Occasional smoker (n, %)	–	–	13	9.3	–	–	77	9.4
Daily smoker (n, %)	–	–	123	87.9	–	–	685	84.0
Weekly number of cigarettes (M, SD)	100.70	46.29	97.24	48.12	94.61	49.85	87.83	52.24
Nicotine dependence (M, SD)	3.46	1.98	3.53	1.95	3.31	2.03	3.07	2.10
Number of quit attempts (M, SD)	–	–	0.61	0.92	–	–	0.48	0.81

M = mean;SD =standard deviation

0) smoked an estimated 6.06 more cigarettes at follow-up than at baseline (model 3: b = 6.06, 95% CI 4.44, 7.68); "b" indicates the change from baseline (coded 0) to follow-up (coded 1), when EC use and the interaction are 0 which is the case for nonvapers. The time of assessment by EC use interaction did not reach significance, indicating that the changes between follow-up and baseline assessments did not statistically differ between vapers and nonvapers.

Among baseline daily smokers, the effect of EC use was not significant. Nonvapers smoked fewer cigarettes at follow-up than at baseline (model 3: b= –5.03, 95% CI –8.69, –1.38). The time of assessment by EC use interaction did not reach significance, indicating, together with the nonsignificant effect of EC use, no evidence for a difference between vapers and nonvapers in the number of cigarettes smoked at baseline and changes in the number of cigarettes smoked to follow-up.

With regard to nicotine dependence (model 2) among baseline occasional smokers, vapers reported higher levels (on average a difference of 0.24 points on the Fagerström Test for Nicotine Dependence, adjusted for covariates) of nicotine dependence than nonvapers (b = 0.24, 95% CI 0.02, 0.46), nicotine dependence increased significantly among nonvapers (b = 0.12, 95% CI 0.02, 0.21) and there was no difference between nonvapers and vapers (nonsignificant interaction EC use by time of assessment).

No significant difference in nicotine dependence was found between vapers and nonvapers among baseline daily smokers (effect of EC use). Nicotine dependence changed in unadjusted analysis (model 1) between baseline and follow-up among baseline daily smokers (time of assessment), but the change did not survive after adjusting for covariates. Moreover, even in the unadjusted analysis, no significant difference in change was found between vapers and nonvapers (interaction).

Association between e-cigarette use and number of attempts to stop smoking

Negative binomial regression models of the number of attempts to stop smoking on the use of EC (table 5) showed that vapers reported significantly more attempts than nonvapers among baseline occasional smokers (model 3, incidence rate ratio [IRR] 1.81, 95% CI 1.24, 2.64). Among baseline daily smokers, the association was not significant (IRR 1.28, 95% CI 0.95, 1.73). Unadjusted models and models adjusting for demographics only produced substantially equivalent results.

Discussion

To our knowledge, the present study is one of the rare longitudinal studies on smoking patterns among EC users in early adulthood. The 5.0% prevalence of past 12-month vaping was relatively low, compared with around 45% of CC use. Vapers were more likely to be smokers and particularly heavy smokers, as has been shown in many studies (see [1] for review). EC users in the present study showed higher nicotine dependence scores and smoked more cigarettes, so they did have other smoking patterns than nonvapers, a dimension often neglected in other studies. The finding of the present study that vapers have more smoking quit attempts than nonvapers supported the finding of other studies that ECs are used as an aid to quit smoking [6, 25]. However, even adjusting for nicotine dependence, vapers were less likely to quit smoking than nonvapers.

Before further discussing the findings of the present study, one main caveat has to be mentioned. We measured EC use at follow-up only, a design that is common in the literature, but that has been criticised [5]. Thus, we do not know whether vapers actually became vapers between baseline and follow-up or were vapers already at baseline. Theoretically, it may also be that some former smokers at baseline have stopped smoking already at baseline by using ECs. Unfortunately, there are no data currently available about the increase of vaping in Switzerland. Anecdotal evidence from the market leader in EC sales or from incidental poisoning of little children with EC liquids in Switzerland suggests that, whereas EC use was almost nonexistent in 2010, it increased strongly thereafter. This suggests that the large majority of vapers in the present study started to use ECs after baseline assessment. Nevertheless, we cannot claim, for example, that EC use initiated CC use or led to an in-

Table 3: Results of multinomial regression models of cigarette smoking status at follow up on e-cigarette use (measured at follow-up only), stratified by cigarette smoking at baseline, Switzerland 2010–2013.

	Smoking status at follow-up								
	Model 1			**Model 2**			**Model 3**		
	Nonsmoker	**Occasional smoker**	**Daily smoker**	**Nonsmoker**	**Occasional smoker**	**Daily smoker**	**Nonsmoker**	**Occasional smoker**	**Daily smoker**
	Odds ratio (95% CI)	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**
Nonsmoker at baseline									
E-cigarette use	ref.	5.69 (2.67, 12.13)	12.90 (4.16, 40.07)	ref.	5.92 (2.76, 12.66)	11.38 (3.61, 35.89)	ref.	6.02 (2.81, 12.88)	12.69 (4.00, 40.28)
Occasional smoker at baseline									
E-cigarette use	0.43 (0.19, 0.97)	ref.	2.59 (1.58, 4.24)	0.43 (0.19, 0.97)	ref.	2.47 (1.50, 4.07)	0.43 (0.19, 0.96)	ref.	2.31 (1.38, 3.86)
Daily smoker at baseline									
E-cigarette use	0.42 (0.15, 1.18)	0.94 (0.51, 1.74)	ref.	0.42 (0.15, 1.17)	0.92 (0.52, 1.71)	ref.	0.42 (0.15, 1.18)	0.99 (0.52, 1.86)	ref.

CI = confidence interval
Model 1 = e-cigarette
Model 2 = model 1 adjusted for age, highest achieved education, linguistic region
Model 3 = model 2 adjusted for nicotine dependence.

Table 4: Results of mixed models for weekly number of cigarettes and nicotine dependence, Switzerland 2010–2013.

	Model 1		Model 2		Model 3	
	b	95% CI	b	95% CI	b	95% CI
Weekly number of cigarettes						
Occasional smoker at baseline						
E-cigarette use	13.00	9.02, 16.97	12.55	8.59, 16.50	9.88	6.37, 13.40
Time of assessment	7.41	5.97, 8.86	7.09	5.22, 8.97	6.06	4.44, 7.68
E-cigarette use by assessment	–0.30	–6.16, 5.56	–0.77	–6.63, 5.09	0.11	–4.87, 5.10
Daily smoker at baseline						
E-cigarette use	6.09	–2.76, 14.94	6.22	–2.58, 15.03	3.31	–2.94, 9.57
Time of assessment	–6.79	–10.20, –3.39	–8.02	–12.90, –3.13	–5.03	–8.69, –1.38
E-cigarette use by assessment	3.32	–5.58, 12.22	3.05	–5.89, 12.01	–1.84	–9.02, 5.34
Nicotine dependence						
Occasional smoker at baseline						
E-cigarette use	0.26	0.03, 0.48	0.24	0.02, 0.46	–	–
Time of assessment	0.11	0.04, 0.17	0.12	0.02, 0.21	–	–
E-cigarette use by assessment	–0.06	–0.34, 0.22	–0.08	–0.37, 0.20	–	–
Daily smoker at baseline						
E-cigarette use	0.16	–0.20, 0.52	0.17	–0.19, 0.53	–	–
Time of assessment	–0.23	–0.35, –0.11	–0.18	–0.37, 0.01	–	–
E-cigarette use by assessment	0.29	–0.03, 0.61	0.28	–0.04, 0.61	–	–

b = estimate; CI = confidence interval
Model 1 = time of assessment, e-cigarette, time of assessment by e-cigarette interaction
Model 2 = model 1 adjusted for age, highest achieved education, linguistic region
Model 3 = model 2 adjusted for nicotine dependence.
Estimate for e-cigarette use reflects the difference between vapers and nonvapers at baseline. Estimate for time of assessment reflects the difference between follow-up and baseline in nonvapers. Estimate for e-cigarette by time of assessment interaction reflects the difference between estimate of time of assessment in nonvapers and estimate of time of assessment in vapers.

crease in CC use. However, we stratified the analysis by smoking status at baseline, assuming that nonsmokers at baseline used ECs at baseline less often – if at all – than occasional smokers, and that occasional users did so less often than daily smokers. We did have longitudinal data on smoking changes, and compared these between vapers and nonvapers which,in our opinion, is indicative of whether vapers – independent of whether they became vapers after baseline or had already been vapers at baseline – reduced their smoking or stopped smoking. Nevertheless, conclusions have to be drawn with this limitation in mind.

Clearly, as has been shown in general population studies on emerging adulthood [1], among young men in Switzerland, vapers were commonly dual users [26]. At follow-up, only 10.6% of vapers were nonsmokers, 28.3% were occasional smokers and 61.0% were daily smokers. This is not a surprise, as ECs are often used for harm reduction compared with CC use, in situations where smoking CCs is prohibited, or as an aid to quit smoking [6, 25, 27].

Among nonsmokers at baseline, only 1.1% were vapers at follow-up, of which 50% became also CC users, but 13% (n = 367) became CC users without vaping. There are increasingly alarming claims about increasing rates of "ever-EC-users", particularly among young nonsmokers. Here are a few recent examples among adolescents: the percentage of "never smokers" who reported ever having used ECs reached 8.0% in Wales [16], and 15.8% of e-cigarette users were never-smokers in North West England [28]. EC use among young (grade 6 grade 12) never-smokers in the USA increased three-fold from 79 000 to over 263 000 between 2011 and 2013 [17]. However, these apparently alarming results meant that 3% of all students were never-smoking EC users in the Hughes et al. [28] study (15.5% of 19.2% ever EC users), or 0.9% in the USA study [17]. When regular EC use was assessed, in both the USA study and the Wales study [16], only 0.3% of regular EC users were never-smokers. In addition, as stated by West et al. [4] or McNeill et al. [5], increases in EC use were in some

Table 5: Negative binomial regression models of the number of attempts to stop smoking on e-cigarette use (measured at follow-up only), stratified by cigarette smoking at baseline, Switzerland 2010–2013.

	Model 1	Model 2	Model 3
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Occasional smoker at baseline			
E-cigarette use	1.92 (1.32, 2.80)	1.88 (1.29, 2.73)	1.81 (1.24, 2.64)
Daily smoker at baseline			
E-cigarette use	1.27 (0.94, 1.70)	1.28 (0.95, 1.72)	1.28 (0.95, 1.73)

CI = confidence interval; IRR = incidence risk ratio
Model 1 = e-cigarette
Model 2 = model 1 adjusted for age, highest achieved education, linguistic region
Model 3 = model 2 adjusted for nicotine dependence.

countries accompanied by decreases in smoking rates, although this has not always been the case [18]. Thus, among young men in Switzerland as among youths and young adults in most other countries, EC use was unlikely to instil the renormalisation of smoking among nonsmokers [4, 5].

Although vaping was not very prevalent in general and particularly in baseline nonsmokers, the latter were 6 times more likely to be occasional smokers and more than 12 times more likely to be daily smokers at follow-up when vaping than when not vaping. Similarly, occasional smokers at baseline were more than 50% less likely to be nonsmokers at follow-up and more than twice as likely to be daily smokers at follow-up when vaping than when not vaping. Again, there may be a "reversed" causation that higher dependence levels, related to lower quit rates, led to a more prevalent use of EC. Occasional smokers may have become more dependent (daily) smokers first, and then started using ECs. However, we think it is fair to say that even though EC use may not have been the cause for rather unfortunate findings, EC use at least seemed not to have had the beneficial effects of reducing smoking among occasional smokers or of reducing the progression in smoking among both former nonsmokers or occasional smokers.

Among daily smokers at baseline, no significant difference could be found between vapers and nonvapers in the reduction from daily CC use to occasional CC use. Despite the 0.42 odds ratio (in the adjusted model) for resuming smoking abstinence, vapers were not significantly less likely than nonvapers to stop smoking (95% CI 0.15–1.18). Again, even though some baseline daily smokers were vapers at baseline already, continued EC use would not have been successful in reducing daily smoking. Moreover, if daily smokers took up vaping between baseline and follow-up, it did not help reduce smoking either. Our results were in line with a review on smoking cessation by Grana et al. [1], as well as with more recent studies adjusting for nicotine dependence as our study did [7, 14]. Randomised trials, however, have shown that EC use is more efficacious than nicotine patches when it comes to quitting smoking [29] or nicotine-free e-cigarettes [30]. Similarly, a recent real-world experiment [2] showed that EC use is of more help with quitting than over-the-counter replacement therapy products or no aid. More specifically, Biener et al. [27] found that intensive EC users were six times more likely to quit smoking at follow-up for at least 1 month compared with EC nonusers or those who only tried out the EC, whereas intermittent EC users showed no effect. This may mean that the only persons who may benefit from EC use are the ones who use EC as a serious attempt to quit or reduce smoking (e.g. by using them daily). Other prospective real-word studies such as among callers of quitlines [8], or cancer patients [31] enrolled in a tobacco treatment programme found lower cessation rates for vapers compared with nonvapers. Unfortunately, despite the large sample size, prevalence rates in the present study were too small to distinguish between intensive and intermittent EC use. As a result, we can only speculate whether ECs were used by 20-year-old men primarily out of curiosity [32] or in places where they were not allowed to smoke conventional cigarettes, and not yet as a substitute for smoking. Vapers, however, showed more quit attempts than nonvapers in the present study, which was significant for occasional smokers only. Thus, ECs may be used by young people as an aid for quitting smoking. Indeed, although they quit smoking less often, they report more quit attempts. More quit attempts but less success in quitting have also been reported in other studies [14, 33], including in a USA study among 18–25-year-olds [15]. The lack of successful quit attempts may be related to the use of somewhat ineffective, first generation nicotine delivery devices. The present study could not differentiate between the type of ECs used, but will do so in subsequent waves.

Mixed models (table 4) showed that vapers smoked more CCs and had higher nicotine dependence levels already at baseline than nonvapers. Again, this demonstrated the need for smoking patterns to be accounted for in research on EC use. EC use may be beneficial provided that CC use is reduced or at least partly replaced with less harmful nicotine products. In the International Tobacco Control Study, vapers had significantly reduced the number of CCs smoked compared with nonvapers, although there was no significant difference in quitting smoking between vapers and nonvapers [6]. This finding was supported by studies in the review of Grana et al. [1]. However, other studies have shown increases in CC use among EC users in comparison with nonvapers [14]. Grana et al. [7], adjusting for nicotine dependence, found that EC use by smokers was not followed by greater rates of quitting or by reduction in cigarette consumption one year later. The present study lies somewhere between the latter results, showing no differential effect between vapers and nonvapers.

Beside the caveat mentioned above, another limitation of the present study is its restriction to men only. As Grana et al. [1] or Collaco et al. [11] pointed out, it may well be that trying out the EC is even more prevalent among women. Despite these limitations, and given our findings, we find it difficult to argue how EC use by young Swiss men could be considered to be predominantly beneficial. Even though EC use was a consequence of heavier smoking after baseline, the onset of EC use has not reduced the number of CCs smoked. Assuming that the onset of EC use occurred already at baseline (a detail which was not observed) in the present study, continued EC use does not seem to have influenced smoking cessation rates positively. Indeed, even though vaping at follow-up among baseline nonsmokers was rare, vapers were more often smokers at follow-up than nonvapers.

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