HHS Public Access

Author manuscript

Tob Control. Author manuscript; available in PMC 2017 June 21.

Published in final edited form as:

Tob Control. 2016 November ; 25(Suppl 2): ii67–ii72. doi:10.1136/tobaccocontrol-2016-053223.

Cigarette smoking and electronic cigarette vaping patterns as a function of e-cigarette flavourings

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Abstract

Introduction—The present study examined the influence of flavouring on the smoking and vaping behaviour of cigarette smokers asked to adopt e-cigarettes for a period of 6 weeks.

Methods—Participants were 88 current male and female smokers with no intention to stop smoking, but who agreed to substitute e-cigarettes for their current cigarettes. On intake, participants were administered tests of taste and smell for e-cigarettes flavoured with tobacco, menthol, cherry and chocolate, and were given a refillable e-cigarette of their preferred flavour or a control flavour. Participants completed daily logs of cigarette and e-cigarette use and were followed each week.

Results—Analyses over days indicated that, during the 6-week e-cigarette period, cigarette smoking rates dropped from an average of about 16 to about 7 cigarettes/day. e-Cigarette flavour had a significant effect such that the largest drop in cigarette smoking occurred among those assigned menthol e-cigarettes, and the smallest drop in smoking occurred among those assigned chocolate and cherry flavours. e-Cigarette vaping rates also differed significantly by flavour assigned, with the highest vaping rates for tobacco- and cherry-flavoured e-cigarettes, and the lowest rates for those assigned to chocolate.

Conclusions—The findings suggest that adoption of e-cigarettes in smokers may influence smoking rates and that e-cigarette flavourings can moderate this effect. e-Cigarette vaping rates are also influenced by flavourings. These findings may have implications for the utility of e-cigarettes as a nicotine replacement device and for the regulation of flavourings in e-cigarettes for harm reduction.

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Contributors MDL and CO conceptualized the study and selected the measures. MDL wrote the grant application that outlined its design, with assistance from VD. MDL and VD wrote the procedure manuals. MDL supervised the overall project, and VD supervised those aspects related to taste and smell testing. MDL designed and implemented the data analysis, including statistical analysis, wrote the primary draft and edited all subsequent drafts. VD and CO provided critical interpretation of the results and edited the manuscript. All authors approved the final manuscript.

Competing interests None declared.

Ethics approval University Institutional Review Board approved this study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data available at this time. A complete data set will be made available after all aspects of the parent study have been completed.

INTRODUCTION

Mounting criticism of combustible tobacco products, concerns about health and the high price of cigarettes have opened up the market for smokers to adopt alternative nicotine delivery products such as smokeless tobacco, hookah and electronic cigarettes (e-cigarettes), all of which have been perceived as healthier than cigarettes.[12] These efforts have dramatically increased the awareness of and use of e-cigarettes, especially among current smokers.[3] In addition, efforts to capture market share and to create new product users have induced makers of tobacco-based products to offer flavour additives to enhance the palatability and attractiveness of their products, especially to the young.

Nowhere is the use of flavourings more prevalent than in the production and marketing of e-cigarettes. Capitalising on the 2009 US Food and Drug Administration (FDA) ban on flavourings in cigarettes (with the exception of menthol), the inclusion of a variety of flavourings in e-cigarettes is considered a significant selling point that tends to draw cigarette smokers towards these products,[4] especially those who are contemplating quitting smoking.[5] The number and variety of flavourings available for e-cigarettes are overwhelming. One brand of e-cigarette offers over 100 flavours, a statistic that does not encompass flavoured e-juices provided by the burgeoning number of third-party manufacturers. Flavourings come in many varieties, including tobacco, menthol, fruit, dessert/candy, alcoholic drinks, snacks/meals and others.[6]

Electronic cigarettes have several attractions for cigarette smokers. e-Cigarettes are promoted as an alternative to cessation, as a means to smoke where smoking is not allowed,[7] as a safer alternative or adjunct to traditional cigarettes,[89] and for use in social settings where smoking might be objectionable.[10] e-Cigarettes are perceived to be less harmful to health, less addictive and more socially acceptable than most other types of tobacco products.[11] The result is that the trend towards adoption of e-cigarettes by smokers has been increasing in recent years.[3] 11 The most significant factor drawing smokers to e-cigarettes is their potential as a harm reduction or smoking cessation device.[8]

The routes that cigarette smokers take to using e-cigarettes are informal, however. A number of characteristics of e-cigarettes may be involved in smokers trying and adopting e-cigarettes. Among these characteristics are flavours. Farsalinos *et al*[4] conducted an online survey of over 4000 e-cigarette users. Their results indicated that flavours, and particularly the variety of flavours, were an important factor in the use and maintenance of e-cigarettes by current and former smokers. Interestingly, their results indicated that smokers tended to start with tobacco-flavoured e-cigarettes, and then would switch to multiple flavours as they transitioned from dual use to complete (or almost complete) substitution of e-cigarettes for their usual cigarettes.

Despite the increasing popularity of e-cigarettes among existing cigarette smokers, little is known about how adoption of e-cigarettes affects cigarette smoking, or how flavours influence adoption of e-cigarettes. A number of reports suggest that sweet or fruity flavours are particularly attractive, especially to young people.[1213] Menthol may also play a role in smokers' initiating and maintaining e-cigarette use. In one study, Rosbrook and Green[14]

exposed adult cigarette smokers to aerosolised e-liquids containing different concentrations of nicotine and menthol, and measured liking and harshness. Among the findings were that nicotine tended to enhance rather than suppress sensations of coolness from menthol, and menthol tended to slightly increase liking independently of nicotine concentration. These authors concluded that menthol potentially improves the appeal of e-cigarettes through its cooling properties and minty flavour, as well as by reducing the harshness of high concentrations of nicotine.

Smokers report an affinity to the variety of flavours offered for e-cigarettes. Berg[15] recruited 1567 adults, aged 18–34 years, through Facebook ads targeting tobacco users and non-users. Among smokers and non-smokers, fruity e-cigarette flavours were the most preferred. Relative to non-smokers, current cigarette smokers also were more likely to report interest in caramel, vanilla, chocolate or cream flavours, menthol and tobacco flavours. This study did not address how adoption of e-cigarettes affected actual smoking rates, or how flavours influenced the use of e-cigarettes.

The literature cited, including other reports, indicates that flavoured e-cigarette juices may influence adoption of e-cigarettes by current smokers. This phenomenon may be good and bad. A growing body of the literature indicates that e-cigarettes may be an effective harm reduction tool for smokers, providing nicotine replacement with significantly lower levels of toxins than seen in combustible tobacco products.[16] 17 The downside of using e-cigarettes as a harm reduction approach, however, is that it could undermine the public health message that all tobacco-related products are unhealthy and should be avoided, and instead influence non-smokers as well as current smokers to initiate e-cigarette use.[18] Finally, there may be adverse health effects of e-cigarettes that are as yet unknown.[19]

The present study examined the influence of e-cigarette flavouring per se, irrespective of nicotine content, on the vaping and smoking behaviours of cigarette smokers asked to adopt preferred flavoured or control flavoured e-cigarettes for a period of 6 weeks. It was expected that certain flavours would be preferred and that those flavours would prompt greater use of e-cigarettes and less use of cigarettes. Based on previous research, it was expected that the most preferred flavours would be fruity or sweet, or menthol. The findings could have implications for the regulation of flavours in e-cigarettes and the use of e-cigarettes in harm reduction efforts.

METHOD

Design

This was a two-phase study employing a laboratory study in Phase I and a field study in Phase II. In Phase I, male and female smokers were exposed to e-cigarettes of different flavours and recorded their flavour preferences. Phase II was intended to determine smokers' behavioural responses in their home environments to differing flavourings and levels of nicotine in e-cigarettes. The study was approved by the institutional review board at the University of Connecticut Health Center.

Based on preference findings from Phase I, Phase II was conducted as a 2 (nicotine level: high vs none)×2 (flavours: tobacco vs preferred)×2 (sex) factorial design. Male and female smokers were assigned to nicotine and flavour combination conditions. They were then asked to monitor their cigarette use daily for 1 week and then to substitute e-cigarettes in place of their regular cigarettes for a period of 6 weeks, during which they would make daily recordings of their experiences.

Participants

Participants (88 men and women current cigarette smokers, aged 18–55 years) were recruited from the greater Hartford, CT, area via advertisements in newspapers and on the radio from May 2015 through March of 2016, for a study on nicotine and flavourings in e-cigarettes. Interested persons were directed to call our offices and were administered a telephone screening to determine initial eligibility. Inclusion criteria included: (1) current use of at least 10 cigarettes daily, (2) willing to abstain from cigarette smoking and to substitute e-cigarettes for ~6 weeks, (3) not currently planning to stop smoking (score < −2 on an Intentions to Quit scale) and (4) able to read and sign a consent form in English. Exclusion criteria were (1) unstable medical or psychiatric disorders, including uncontrolled hypertension (BP>160/100) as determined by a medical doctor; (2) pregnancy; (3) known hypersensitivity to nicotine or to propylene glycol; (4) previous heart attack or stroke; (5) insulin-dependent diabetes; and (7) known chronic obstructive pulmonary disease (COPD) or asthma. Those with prior experience with e-cigarettes (ie, used on more than two occasions) were also excluded. We specifically chose persons who did not want to quit smoking in order to minimise the confound presented by those who might reduce the use of all tobacco products in an attempt to stop smoking.

Of over 300 persons who contacted our offices at the time of this writing, 88 were eligible and provided 7-week data. Of those excluded, most had chronic pulmonary disease (COPD, asthma) or cardiovascular disease, or wanted to use e-cigarettes to quit or cut down on their smoking. The remainder were excluded because of age exceeding 55 years, or for transportation or scheduling issues. Participants were 50% men, with a mean age of 36.3 years (SD=10.3), and were 70% white, 19% black, 8% Hispanic and 3% other. Their mean year of schooling was 13.2 (SD=2.4), 63% were employed at least part-time outside the home, 51% had incomes at or below $4000 per year and 66% were single or divorced. Participants had smoked for an average of 19.1 years (SD=11.4) and were smoking an average of 17.3 cigarettes per day (SD=7.0) during the 3 months prior to intake. The mean Fagerstrom Nicotine Dependence score[20] was 5.9 (SD=2.0). None had had experience with e-cigarettes.

Measures and instruments

Screening—Individuals seeking to participate were administered a 20-min Quick Screen interview over the telephone to identify those who were likely to meet criteria for inclusion. Information about preferred cigarettes was also obtained, particularly with regard to preference for menthol. Intention to quit smoking in the succeeding 3 months was assessed using two questions adapted from Strasser *et al*[21] tapping the likelihood that the person ‘will

try to quit; and ‘definitely will quit,’ and scored from −2 (definitely will not) to 2 (definitely will).

Dependent Measures Phase I—The Phase I laboratory study was used to determine e-cigarette flavour preferences. Liking ratings, palatability and sensation intensity (sweetness, bitter-sour, irritation) of various e-cigarettes were measured using a Generalised Labelled Magnitude Scale (gLMS) with end points of ‘barely’ and ‘strongest’, and intermediate anchors placed at approximately log-scaled intervals to appropriately capture the psychophysical distance between descriptors.[22]

Dependent Measures Phase II—The primary dependent measures in Phase II were cigarettes/day and e-cigarette episodes/day. An e-cigarette episode was defined as consisting of about 15 puffs or a period lasting about 10 min.[23] A timeline follow-back method (TLFB)[24] was used to assess daily smoking (or e-cigarette use) for the 90 days prior to intake, as a baseline measure, for the 1 week of regular smoking and for the 6 weeks of e-cigarette monitoring. TLFBs have good test–retest reliability and validity for verifiable events.[25] The TLFB method was buttressed by daily interactive voice response (IVR) recordings, described below. Breath carbon monoxide (CO) readings were also taken weekly to verify smoking rates.

Process Measures and Moderators—A number of variables were examined as moderators of smoking and e-cig behaviour. Among these were smoking history variables, especially use of menthol cigarettes. The Smoking History Questionnaire (SHQ)[26] is a self-report questionnaire used to assess smoking history and pattern. Another moderator was nicotine dependence, measured using the Fagerstrom Test of Nicotine Dependence (FTND).[20]

Procedures

Phase I

e-Cigarette Test 1: Eligible persons completed the informed consent process and the intake assessments prior to testing. All participants were first introduced to the e-cigarette that would be used in this study: the Joyetech eGo-C (Shenzhen Joyetech). This model was chosen because of its durability, and the flexibility afforded in the choice of base vehicle and size of atomiser reservoirs offered. The ‘juice’ used was purchased from AmericaneliquidStore (Americaneliquidstore.com), which offers a variety of flavours and nicotine levels (0–36 mg/mL). In these studies, we used a base of 50% vegetable glycerine —50% propylene glycol. The flavours tested were base only (no flavour, just propylene glycol and glycerin), tobacco, menthol, cherry and chocolate. These flavours were chosen based on their prevalence in all smoking products (ie, tobacco), popularity in smoking products (menthol) and their representativeness of major tobacco flavouring families (chocolate and fruit). Nicotine levels tested were 0 or 18mg/ml. This level was chosen on the basis of findings by Etter[7] and Foulds *et al*,[27] as well as our own pilot work suggesting that this concentration of nicotine is perceived by smokers as moderate to high.

The base-only flavour with no nicotine was used to evaluate the sensations associated with the e-cigarette 'vaping' process and the e-cigarette introduction procedure. Participants were shown the e-cigarette, taught how to assemble it for vaping, how to fill the atomiser reservoir and how to set it up for overnight charging. They were then instructed to vape for a period of 3 min at their own pace to get accustomed to the procedure. Following the vaping of the base only with no nicotine, participants were asked to rate their sensations using the gLMS described above (ie, level of liking/disliking, sweet intensity, bitter-sour intensity, irritation). Participants were then asked to vape for 1 min at their own pace with each of the 5 flavours being tested (base only, tobacco, menthol, chocolate and cherry) presented in a randomised order, with 5 min between each trial. After each 1 min trial, participants were presented with the series of gLMS scales.

Phase I

e-Cigarette Test 2: Test 2 proceeded after a 15 min break following Test 1 and involved the vaping for 1 min with each of the 5 flavours (base only, tobacco, menthol, chocolate and cherry), presented in a randomised order, with nicotine (18 mg/mL) added. After each 1-min trial, the participants rated the flavour–nicotine combination for likability, palatability and intensity of sensations on the gLMS. Additionally, they were asked to rank order each of the flavours in order of preference. These preference rankings determined the flavouring of the e-cigarette in Phase II.

Phase II

Home Monitoring of Cigarettes and e-Cigarettes: Following Phase I, men and women were separately randomly assigned to one of the four e-cigarette conditions (no nicotine—tobacco flavouring, high nicotine—tobacco flavouring, no nicotine—preferred flavouring, high nicotine—preferred flavouring) using an urn randomisation procedure[28] that balanced the four conditions on FTND level, baseline cigarette use in cigarettes/day and regular use of menthol versus non-menthol cigarettes. (For those participants whose preferred flavour was tobacco, the second-ranked flavour was used as the preferred flavour instead. This occurred in five cases.) The 'high' nicotine concentration was 18 mg/mL, as in Phase I. Participants were then instructed to return home, where they would record their usual daily smoking experiences for a period of 1 week and then return to our laboratory. CO levels were taken as a baseline.

e-Cigarette Monitoring (6 weeks): In this part of Phase II, participants were asked to try to refrain from smoking their regular cigarettes and, instead, to use only the e-cigarette with the appropriate juice provided (preferred flavour or not; nicotinised or not). Participants were instructed to record their daily use of e-cigarettes using the IVR call system. If a participant failed to call on a given day, the system called the participant. The overall response rate was over 78% of days recorded. Daily recording using these methods have proved extremely accurate in recording the use of substances.[29] Participants were further reminded that regular cigarettes were to be avoided, but that, if they were used, they should be recorded. This recording period of e-cigarette use lasted 6 weeks. At the end of each week of e-cigarette monitoring, participants were asked to return to the laboratory, where they had breath CO testing performed to verify cigarette smoking that had taken place. At the end of the 6 weeks

of e-cigarette use (7 weeks post-intake), participants returned to the laboratory for recording of CO levels and review of their last week of e-cigarette use. Participants were allowed to keep their e-cigarettes but were not supplied with additional e-cigarette liquid.

RESULTS

e-Cigarette flavour preferences

Results from the laboratory taste testing of e-cigarettes revealed the following e-cigarette flavour preferences: tobacco 24%, menthol 32%, cherry 30%, chocolate 10% and no flavour 4%.

Cigarette use, e-cigarette use and CO readings

Multilevel modelling (MLM; Proc MIXED, SAS Institute) with maximum likelihood estimation was used to evaluate the effects of assigned e-cigarette flavour on the use of usual cigarettes and e-cigarettes over the 6 weeks of e-cigarette monitoring and on the CO levels recorded over this period. MLM was used here because it takes advantage of all available data by using maximum likelihood estimation procedures to estimate the parameters of the multivariate model.[30] In these analyses, the dependent variable was analysed as a function of cigarettes per day measured at intake (to control for intake levels of smoking), week number, day number, week×day (to detect whether there were changes in daily patterns during weeks), flavour assigned and flavour×week. Additionally, terms were entered for menthol vs non-menthol cigarette smokers, and the nicotine levels of the e-liquid used, as well as terms representing their interactions with flavour. Flavours, menthol cigarette smoking and e-cigarette nicotine levels were all treated as fixed effects (ie, limiting our interpretations to the flavours and nicotine levels tested here). Participants (intercept) were treated as a random effect. (Treating participants as a random factor allows the intercept to be different for each participant, increasing generalisation of the results to all cigarettes smokers). Analyses included week 1 of monitoring as a baseline, in that participants were instructed to maintain their usual smoking habits during this time and had not yet been issued e-cigarettes. Post hoc contrasts were also run to parse main effects of flavours.

Alternative effects were also tested, including whether the flavour assigned matched the flavour preferred. In these analyses, the flavour preference matching factor did not emerge as significant in analyses of cigarette use, e-cigarette use or CO levels.

Results of the MLM analyses are shown in table 1. Plots of the predicted values over time for each of the dependent variables from the MLM analyses are shown in figure 1. The results indicated that, as expected, cigarette smoking rates dropped significantly during the 6-week e-cigarette period, from an average of 16.15 to about 7.4 cigarettes/day. Cigarette smoking did not stop, however. Only one of the 88 participants stopped smoking cigarettes entirely. e-Cigarette use increased from week 1 to week 2, at which point it levelled off to a mean of 12.0 e-cigarette episodes per day (SD=10.9).

As seen in table 1, cigarettes per day, e-cigarette episodes per day and CO levels varied significantly from week to week, as indicated by the significant F-value for the Week# effect for each of these dependent variables. The significant *F*-value for the baseline cigarettes/day

effect indicated that baseline smoking also influenced levels of the dependent variables over time such that higher baseline smoking was predictive of higher levels of smoking, e-cigarette use and CO levels over time. Finally, the levels of the dependent variables over time were significantly influenced by the e-cigarette flavour assigned to participants, even when the effects of e-liquid containing nicotine and being a menthol cigarette smoker were taken into account. Figure 1 shows the predicted smoking and vaping rates, and CO levels, by e-cigarette flavour condition over time. Analyses over days indicated that the largest drop in cigarette smoking occurred among those assigned menthol e-cigarettes (smoking 4.0 per day by week 7), and the smallest drop in smoking occurred among those assigned cherry and chocolate flavours (smoking 9.8 per day by week 7) (contrast: menthol vs all others: $F_{(1, 3143)}$=2.48; p<0.05).

e-Cigarette vaping rates also differed significantly by flavour assigned, with the highest vaping rates (about 12.3 vaping episodes per day) for tobacco e-cigarettes and the lowest rates for those assigned to chocolate (8.6 episodes per day) (contrast: tobacco vs chocolate: $F_{(1, 3143)}$=3.86; p<0.001). CO levels measured weekly tended to track reported cigarette use. CO levels dropped at the beginning of the e-cigarette period from a mean of 17.15 ppm (SD=9.2) to a 6-week mean of 12.3 ppm (SD=8.3). CO levels remained significantly higher for those assigned to the chocolate e-cigarette flavour (contrast: chocolate vs all others: $F_{(1, 2874)}$=9.16; p<0.001).

DISCUSSION

Despite the significance of flavourings in e-cigarettes, their influence on actual smoking and vaping rates has not been explored. This present study is the first to actually determine the effect of flavourings by assigning e-cigarette flavours to current smokers. The results offer some interesting insights.

Although participants were directed to substitute e-cigarettes for their usual cigarettes, only one participant totally gave up cigarettes for the 6-week e-cigarette period. This finding contrasts with that by Berg *et al*,[31] who, in their prospective study of smokers adopting e-cigarettes, found that 23% reported no cigarette use 8 weeks after initiating e-cigarette use. Our low rate of cigarette abstinence is almost certainly attributable to the fact that we specifically recruited people who did not want to quit smoking. It is also possible, however, that the e-cigarette used here was not sufficiently efficient as a nicotine delivery device to be totally satisfying. Despite this, e-cigarette flavours assigned did help determine the degree to which smokers adopted e-cigarettes.

The effects of specific flavours on cigarette use and e-cigarette use were intriguing. Regardless of preferred flavour, flavours had systematic effects on use. Menthol-flavoured e-cigarettes were the most successful at suppressing cigarette use, even though they did not yield the most e-cigarette use. e-Cigarette use did not appear to completely offset reduction in cigarettes smoked in this condition. That is, smokers assigned the menthol e-cigarette tended to reduce their use of *both* tobacco products. It is possible that this overall suppression effect is tied to recent findings by Hans *et al*[32] and Ashoor *et al*[33] who reported that menthol directly attenuates the activation of the nicotinic-acetylcholine system by

nicotine. Thus, the menthol in e-cigarettes may make them slightly less reinforcing, and thus prompt less use. This is also consistent with the finding by Benowitz *et al*[34] that menthol tends to inhibit metabolism of nicotine and may help explain why those who smoke menthol cigarettes tend to smoke fewer cigarettes per day.[35]

Chocolate flavour, on the other hand, tended to be the least popular e-cigarette assigned and yielded the lowest drop in cigarette use. Unlike the results seen for menthol, participants assigned to the chocolate-flavoured e-cigarette appeared to offset reduced e-cigarette use with continued smoking. This finding was substantiated by the high weekly CO measurements for those in the chocolate-flavoured condition. After 6 weeks of e-cigarette use, the predicted CO for the chocolate condition participants was above 18 ppm and rising, while e-cigarette use was slightly falling. This finding indicates that, despite the palatability of chocolate for some, this flavour in e-cigarettes may have decreased appeal over time and may make it a poor choice to start for harm reduction purposes.

This study has certain limitations, some of them intentionally built into the design of the study. The random assignment of flavourings to participants is not a situation encountered in the marketplace, so the actual behaviour of smokers choosing to adopt e-cigarettes on their own is not addressed here. Likewise, the stipulation that only a certain e-cigarette be used, with a single specific flavouring, is also not representative. Additionally, our assessments of cigarette and e-cigarette use are self-reports and thus subject to error, though the weekly CO measurements offer reassurance as to validity of the reports.

An additional limitation is also a function of the design of the study and may represent a partial confound in our findings. In this study, the non-tobacco flavours tested were preferred flavours. That is, the effect of the assigned flavours on e-cigarette use and cigarette use may in part be a function of preference, rather than entirely a function of the flavour per se. This is particularly important in interpreting the effects of menthol, in that it might be the case that menthol smokers could be the most likely to substitute menthol e-cigarettes for their menthol cigarettes. Three findings tend to militate against this explanation, however. The first is that, of the 51 menthol cigarette smokers in the study, only 28 indicated an e-cigarette flavour preference for menthol. The rest were assigned e-cigarettes of other flavours. The second finding is that the match of flavour preference with flavour received was not a significant predictor of cigarette use, e-cigarette use or CO levels over time (as noted in our results above). Thus, flavour preference did not, ultimately, appear to play a role in vaping rates and cigarette smoking offsets. And third, those who used menthol-flavoured e-cigarettes reported decreased use of cigarettes and e-cigarettes relative to those using other flavours. This finding may be due to the effects of menthol on nicotine absorption or metabolism, as suggested above. Unfortunately, we were not able to determine nicotine absorption in this study.

Finally, we provided just one flavour of e-cigarette to participants. It is possible that participants developed a tolerance to the single flavour, thus explaining the gradual decline in e-cigarette use over time. It should be noted, however, that e-cigarette flavours are actually odours, perceived retronasally. Adaptation does occur, but this effect would be uniform over all flavours.[3637]

This is the first study to examine the role of flavours per se on smoking and vaping patterns of smokers adopting e-cigarettes. These results may have implications for the regulation and use of e-cigarettes, especially for harm reduction and smoking cessation. Whereas menthol may be an attractive flavour for cigarettes, it also appears to be the most effective suppressor of cigarette smoking when used in e-cigarettes. The results also indicate that some flavours (chocolate in the present study) may be less effective suppressors of cigarette smoking. The present study suggests that flavourings per se will make a difference in the adoption patterns of e-cigarettes by current smokers. These considerations may need to be taken into account when considering the regulation of e-cigarettes and their utility as harm reduction agents.

Acknowledgments

The authors acknowledge Diane Wilson, Eileen Leonard, Abigail Young and Sarah Grace Glennon for their work on this project.

Funding Support for this project was provided by Grant 1 R01 DA036492 from the National Institute on Drug Abuse, and in part by General Clinical Research Center Grant M01-RR06192 from the National Institutes of Health.

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What this paper adds

Growth in the use electronic cigarettes (e-cigarettes) is increasing dramatically, particularly among current smokers. e-Cigarette makers are using a wide array of flavourings to market their brands. The effects of these flavourings on the adoption of e-cigarettes have not been studied. As a result of this study, we know that different flavourings can have different effects on e-cigarette use and on concurrent smoking rates in current smokers asked to adopt specific flavoured e-cigarettes. Menthol e-cigarettes elicited the biggest drop in smoking, and tobacco and cherry flavours elicited the highest vaping rates. The results may have implications for the regulation of e-cigarettes.

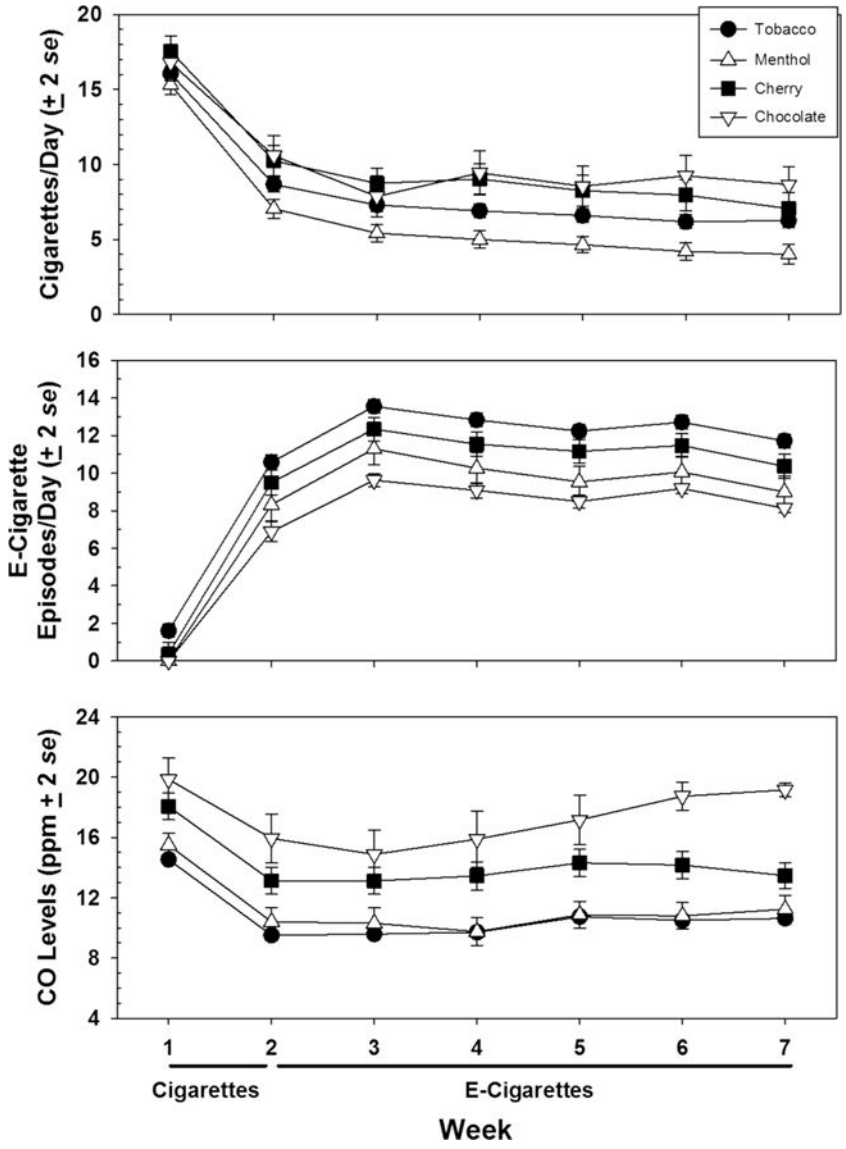

Figure 1.

Predicted values over study weeks of each of the three dependent variables by e-cigarette flavour assigned. Values shown are predicted based on the results of multilevel modelling analysis.

Table 1

Summary of multilevel model analyses of study-dependent variables as a function of e-cigarette flavour assigned, over weeks

	Effect tested									
Dependent variable	**Cigs/day baseline (df=1, 3143)**	**Week# (df=6, 3143)**	**Day# (df=6, 3143)**	**Week# × Day# (df=36, 3143)**	**Flavour assigned (df=3, 3143)**	**Menthol smoker (df=1, 3143)**	**Nicotine e-cigarette (df=1, 3143)**	**Flavour × Week# (df=18, 3143)**	**Flavour × menthol (df=3, 3143)**	**Flavour × nicotine (df=33 143)**
Cigarettes/day	672.98***	109.59***	0.52	0.84	2.23	34.48***	95.44***	1.73*	22.81***	1.75
e-Cigarettes/day	31.41***	52.78***	0.46	0.33	13.70***	6.97**	25.84***	1.13	7.03***	54.71***
CO levels[a]	323.74***	18.82***	–	–	36.72***	125.54***	77.30***	4.68***	41.09***	20.53***

Values shown are F-values

* p<0.05,

** p<0.01,

*** p<0.001.–, Effect not measured on this dependent variable; df, degrees of freedom.

[a] Denominator df for this dependent variable=2874

Tob Control. Author manuscript; available in PMC 2017 June 21.