Brief report

E-cigarettes and Weight Loss—Product Design Innovation Insights From Industry Patents

Harkirat Singh MPH, Ryan David Kennedy PhD, Lisa P. Lagasse PhD, MHS, Lauren M. Czaplicki MPH, Joanna E. Cohen PhD, MHSc

Institute for Global Tobacco Control, Department of Health, Behavior and Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

Corresponding Author: Ryan David Kennedy, PhD, Institute for Global Tobacco Control, Department of Health, Behavior and Society, Johns Hopkins Bloomberg School of Public Health, 2213 McElderry Street, 4th Floor, Baltimore, MD 21205, USA. Telephone: 410-614-5378; Fax: 410-614-1003; E-mail: rdkennedy@jhu.edu

Abstract

Objective: There is emerging evidence that e-cigarettes are being used by some to mitigate weight gain after quitting smoking, and being used to help control weight. This study sought to identify and describe patents related to innovations for e-cigarette devices associated and weight loss.

Methods: Relevant patents were identified using Google Patents with the core search terms: “electronic cigarette” OR “e-cigarette” OR “vaporizer” OR “vapourizer” AND “nicotine” AND “weight loss” OR “weight control” OR “obesity” OR “hunger”. Patents were reviewed to identify and classify the innovation related to weight loss or weight control.

Results: Our search identified 23 unique patents that were filed between 2004 and 2015. Patent applications were sponsored by individual inventors ($n = 7$), tobacco companies ($n = 5$), e-cigarette companies ($n = 8$), pharmaceutical companies ($n = 2$) and a cannabis company ($n = 1$). More than half the patents ($n = 12$) were filed in the United States; other countries included China, Germany, South Korea, and South Africa. Strategies included using e-cigarette devices to deliver constituents to users that support weight loss through altered metabolism, reduced nutrient absorption, suppressed appetite, or supported healthy behavior change. In most cases ($n = 18$), the innovations detailed in the patents were intended to be used with an e-cigarette device that delivered nicotine to the user.

Conclusions: Companies from around the world, and from a range of industries are developing and patenting technologies related to e-cigarettes and weight loss. E-cigarettes may be presented to cigarette users as a possible solution to support smoking cessation and address the fear of weight gain.

Implications: This article presents evidence that a range of industries are innovating to design e-cigarettes or constituents to be used with e-cigarettes to deliver a variety of drugs beyond nicotine including weight loss drugs, laxatives, and nutritional supplements. This study may inform surveillance studies to systematically include weight loss as a possible motivation to use e-cigarettes. Further, market surveillance of e-cigarette products needs to monitor ingredients in e-liquids including constituents that have been historically used for weight loss or weight control. Regulations around e-cigarette marketing, promotion, product design including e-liquid constituents need to consider weight loss claims.

Introduction

One of the reasons that individuals, particularly youth and women, report that they smoke cigarettes, is the belief that smoking can help control body weight.^{1,2} For established smokers, the fear of weight gain is a reported barrier to smoking cessation,³ and a common reason reported why people relapse after a quit attempt.⁴ Most smokers who quit smoking cigarettes experience weight gain within 1 year.⁵

The behavioral and metabolic mechanisms through which smoking cigarettes may affect body weight are complex. It is proposed that most metabolic effects, including altered glucose metabolism and increased energy expenditure, are mediated by nicotine.^{6,7} Nicotine further influences body weight by effects on the brain that support increased satiety and decreased appetite.^{6,8} The act of smoking a cigarette may influence behavior by providing an alternative activity to eating, which could result in fewer consumed calories and consequently support weight control.⁶

E-cigarettes are devices that generate an aerosol by heating a liquid, often called e-liquid, typically comprised of propylene glycol and/or glycerin. The aerosol is inhaled by the user, and can deliver nicotine into the lungs. It has been suggested by some researchers that e-cigarettes with nicotine may be an important defense against weight gain associated with smoking cessation.⁹ E-cigarette aerosol may also contain flavor agents that could fulfill certain sensory experiences including taste and smell, and like cigarettes, provide an alternative activity to eating.

There is emerging evidence that some adult e-cigarette users report using e-cigarettes for weight loss and weight control^{10,11}; however, it is unclear how many e-cigarette users are primarily or secondarily using these devices for these purposes. E-cigarette users share experiences on social media how using e-cigarettes is associated with weight loss,¹² or how using flavored e-liquids like desserts or fruits or chocolate can satisfy cravings for sweet food.¹³

One study reviewed the chemical content of e-liquids and reported that some products include drugs in addition to nicotine including Rimobant, which was at one time approved for weight loss in Europe.¹⁴

The present study sought to understand what innovations were being patented related to e-cigarettes and weight loss or weight control. Patents have been an important source of data for tobacco control researchers and product regulators to understand industry strategies regarding product design,^{15,16} including e-cigarette design.¹⁷ Patents can provide insight into the direction of product marketing and design innovations made by the industry, and can provide insight into what an industry is capable of doing.

Methods

Sample

Relevant patents, (issued and applications), were identified using Boolean searches in Google Patents. Google Patents searches a comprehensive database of all patents and published applications from 17 patent offices around the world including Canada, China, Europe, Japan, South Korea, and the United States.¹⁸ Iterative searches were conducted between December 2015 and December 2016. Core search terms included “electronic cigarettes” OR “e-cigarettes” OR “vaporizer” OR “vapourizer” OR “A61M15/06” OR “A24F47/008” (International Patent Classification [IPC] terms generally applied to e-cigarettes—IPC codes are used for patent classification by more than 100 countries in the world) ($n = 175\ 043$). Searching within

this set of international patents, additional search terms were added including: “weight loss” OR “weight control” OR “obesity,” AND “nicotine” ($n = 90$). Finally, iterative search terms were added, including “hunger,” “appetite,” “satiety,” “slimming,” “meal replacement,” “diet,” and “appetite suppressants” to further refine the sample. Patents were included in the final sample if the inventor(s) claimed that their innovation supported weight loss or would satiate hunger.

Analysis

First, descriptive characteristics of the patents were quantified including the country of origin, type of sponsor (eg, tobacco company, e-cigarette company, individual inventor), date of filing, publication date, and date the patent was granted (if applicable). In many instances, the same patent was filed in multiple countries; the country of origin was determined to be the country that had the earliest filing based on date. Second, the patents were reviewed to identify if the innovation described in the patent was to be used with a product that included nicotine or tobacco. Third, the innovation described in the patent was reviewed and classified by the general strategy used to achieve the weight loss or weight control claim.

Results

The team identified 23 unique patents related to weight loss or weight control using e-cigarette devices.

Descriptive Findings

The patents included in the study were filed between 2004 and 2015. Of these, four were granted patents and 19 were applications. More than half of the patents were filed in the United States ($n = 12$); other countries included China ($n = 6$), Germany ($n = 2$), South Korea ($n = 2$), and South Africa ($n = 1$). Patents were sponsored by individual inventors ($n = 7$), tobacco companies ($n = 5$), e-cigarette companies ($n = 8$), pharmaceutical companies ($n = 2$), and a cannabis company ($n = 1$).

Of the patents identified, most described the innovation(s) to be used with a product that included nicotine or tobacco ($n = 18$).

Innovation Strategies

Details about each patent (labeled P1–P23) including its unique patent number and innovation strategy are provided in Table 1. The innovations being patented were classified into 3 weight loss or weight control strategies. Some patents reported innovations that addressed multiple strategies. The strategies are described here:

- (1) Adding weight loss drugs or other constituents to the e-liquid to alter body metabolism or nutrient absorption

Most patents identified ($n = 20$) detailed strategies that involved adding drugs or other constituents to the e-liquid delivered to the user within the aerosol generated by the e-cigarette. Proposed metabolic altering constituents include: capsaicin, bupropion, linolenic acid, oolong green tea, human growth hormones, ephedrine, and fenfluramine. Potential additives that alter metabolic activity, or prevent fat absorption and deposition, include rosemary acid, and green tea (Table 1). A majority of patents ($n = 17$) using this strategy for weight loss or weight control also described the innovation to be used in combination with nicotine or tobacco as a constituent of the e-liquid.

- (2) Adding appetite suppressants to the e-liquid

The study identified patents ($n = 7$) that described the addition of appetite suppressing constituents to the e-liquid, including terpenes isolated from cannabis, liquid eggplant, vitamins, herbs, and homeopathic additives (Table 1). In addition to these constituents, the inclusion of nicotine in the e-liquid was also described in most ($n = 5$) of these patents.

(3) Supporting behavior change through biomarker and behavior monitoring

One patent included innovations to support behavior change by integrating e-cigarette user data with a smartphone and other associated hardware such as a pedometer. This permits the user to set a variety of goals related to multiple health behaviors including weight loss. The e-cigarette, described in the patent, keeps track of the volume of nicotine and time that it is consumed. These data can sync to a smartphone where other relevant health data are kept such as the user's blood sugar levels and calorie intake. These data could then be used to inform a schedule of e-cigarette use that may regulate access or use of the device, and/or to manage the composition and concentration of e-liquid for weight control. The device could also support nicotine cessation through similar mechanisms (Table 1).

Discussion

Tobacco, e-cigarette, pharmaceutical, and cannabis companies, located in multiple countries, have been working to develop

e-cigarette products to support weight loss or weight control. Strategies largely rely on adding constituents to the e-liquids. Some of the constituents that are identified as possible additives to e-liquids include licensed drugs that are traditionally ingested and not inhaled. Some identified additives include laxatives, which are a potentially dangerous means to achieve weight loss or weight control. Further, some patents (eg, P18* filed in the United States) identified e-liquid additives such as the drug fenfluramine that have not been available in the US market for decades due to concerns about cardiovascular and pulmonary complications.

Several patents described the addition of micronutrients (vitamins and minerals) and other supplements in the e-liquid. Supplements cannot be marketed in the United States as a form of treatment or prevention, but there is evidence that these products are used for weight loss.¹⁹ It is possible that e-liquid containing micronutrients could be advertised in terms of weight control claims, emphasizing the importance of patents research in highlighting future innovations that may warrant regulation.

The findings from this study should be considered within the context of its limitations. First, our search was limited to patents that explicitly used IPC codes commonly applied to e-cigarettes, and/or patents that included the terms “e-cigarettes” or variants, and included the word “nicotine”. This search strategy may have missed relevant innovations such as aerosols without nicotine. Secondly, not all patent applications are granted; further, not all patents translate into commercial products and not all innovations are patented.

Table 1. Strategies Detailed in Filed or Awarded Patents Related to E-cigarettes and Weight Loss or Weight Control

Adding weight loss drugs or other constituents to the e-liquid to alter body metabolism or nutrient absorption ($n = 20$)		
STRATEGY:		
Patent filed by	Patent number-filing date—country of origin	Description of innovation in patent
Individual inventor ($n = 7$)	P1 (DE102011111999B4)—08/31/2011—Germany	<p>“As pharmacologically active substances, ...selected from the following ...human growth hormones, ...minerals additives, laxatives, vitamins, such as vitamin D3, ..., appetite suppressants, ...mineral and nutritional supplements, anti-weight loss/appetite /anti-obesity agents, ...lipid lowering agents”—P1</p> <p>“The drug warehouse filled with... Rosemary 4.5%-5.5% ...cloves and lemon flavor ...Rosemary leaves with tea, ...have antioxidant...mainly carnosol, Rosmanol, bearberry component acid, rosemary acid. Its Function: elimination of bloating, enhance memory..., obesity...As containing the slimming agent, the slimming functional electronic cigarette liquid of the invention has the function of weight-losing. Therefore, the user can lose weight while enjoying smoking”—P4*</p> <p>“The pharmacological agent in the absorption conditioning unit (ACU) can be any of the following: ...botanical bioactive agents such as PMI-006 (botanical bioactive, derived from a spice, ...possesses range of novel bioactivities related to both lipid and glucose metabolism”—P10</p> <p>“Oolong tea, also known as green tea, semi-fermented tea ...can promote the metabolism and burn fat, and improve the absorption of dietary fat. It contains catechin, polyphenols burn calories, combined with exercise and a balanced diet, can well promote weight loss...Oolong tea contains large amounts of polyphenols, can enhance the role of enzymes break down fat, lower blood cholesterol levels.”—P6</p>
	P2 (WO2013030202A1)—08/29/2012—Germany	
	P4* (CN102266125A)—07/28/2011—China	
	P8 (WO2015076515A1)—11/07/2014—South Korea	
	P9* (CN102551218B)—01/20/2012—China	
	P10 (US20140166027A1)—12/14/2012—U.S.	
Tobacco companies ($n = 5$)	P20 (KR101208473B1)—07/25/2011—South Korea	
	P5 (CN104026731A)—07/01/2014—China	<p>“Oolong tea, also known as green tea, semi-fermented tea ...can promote the metabolism and burn fat, and improve the absorption of dietary fat. It contains catechin, polyphenols burn calories, combined with exercise and a balanced diet, can well promote weight loss...Oolong tea contains large amounts of polyphenols, can enhance the role of enzymes break down fat, lower blood cholesterol levels.”—P6</p>
	P6 (CN104382227A)—11/26/2014—China	
	P12 (US20080241255A1)—03/25/2008—U.S.	
	P13 (CN102355914B)—09/03/2010—U.S.	
	P14 (CA2755580C)—09/03/2010—U.S.	

Table 1. Continued

Adding weight loss drugs or other constituents to the e-liquid to alter body metabolism or nutrient absorption (<i>n</i> = 20)		
STRATEGY:		
Patent filed by	Patent number-filing date—country of origin	Description of innovation in patent
E-cigarette companies (<i>n</i> = 8)	P3* (CN101919584A)—08/16/2010—China P7 (US20140150785A1)—12/05/2013—U.S. P11 (US20150196060A1)—09/19/2014—U.S. P15 (US20150013695A1)—09/07/2014—U.S. P17 (CN104983065A)—08/13/2015—China P21 (US20130199528A1)—04/23/2012—U.S. P22 (US20140190496A1)—11/27/2013—U.S. P23 (US20150216237A1)—01/22/2015—U.S.	“ natural slimming agents containing capsaicin can reduce intestinal pair glucose uptake , inhibit the increase in plasma glucose, and open Ca ²⁺ , Na ⁺ channel on the cell membrane, preventing the intestinal absorption of fat , inhibit fat deposition , burn fat , fat break down into CO ₂ and H ₂ O excreted ...it contains linolenic acid , oleic acid and other unsaturated fatty acids and a variety of alkaloids, which has a lipid-lowering effect , so as to achieve the effect of weight loss .”—P3* “Some of the possible additives with their function listed below: vitamins—reduce vitamin deficiency, ginseng—energy, bitter orange (<i>Citrus aurantium</i> L.)— weight loss function ”—P15
Adding appetite suppressants to the e-liquid (<i>n</i> = 7)		
Strategy:		
Individual inventor (<i>n</i> = 3)	P1 (DE102011111999B4)—08/31/2011—Germany P2 (WO2013030202A1)—08/29/2012—Germany P10 (US20140166027A1)—12/14/2012—U.S.	“The pharmacological agent in the absorption conditioning unit (ACU) can be any of the following ... botanical bioactive agents such as ...PMI-007 (a powerful, centrally acting, botanical appetite suppressor which acts ...by increasing ATP content/production, possesses potent anorectic activity ... suppresses both appetite and reduces weight “-P10
E-cigarette company (<i>n</i> = 1)	P7 (US20140150785A1)—12/05/2013—U.S.	“additives can be added to the electronic atomization inhaler, both with or without liquid nicotine, liquid eggplant extract , or liquid eggplant... a vitamin, an herb, a homeopathic additive, or a dietary supplement , human growth hormone (diet suppressant).”—P7
Pharmaceutical companies (<i>n</i> = 2)	P16 (WO2013150406A2)—03/20/2013—South Africa P18* (US7008616B2)—04/01/2004—U.S.	“ Ephedrine and fenfluramine are given at strengths of 10 mg and 20 mg respectively for appetite suppression , ...for increasing one’s energy level, or for a positive inotropic effect”—P18*
Cannabis company (<i>n</i> = 1)	P19* (WO2016004121A1)—06/30/2015—U.S.	“Some of the medical benefits attributable to one or more of the terpenes isolated from cannabis include treatment of sleep disorders, ...act on cannabinoid receptors and other neuronal receptors, stimulate the immune system, and/or suppress appetite ”—P19*
Supporting behavior change through biomarker and behavior monitoring (<i>n</i> = 1)		
Strategy:		
Individual inventor (<i>n</i> = 1)	P8 (WO2015076515A1)—11/07/2014—South Korea	Obesity control sensor can measure the input and information necessary for management of obesity calorie measurement with the user’s food intake ... Smartphone connection device characterized in that the inhaler is configured to obtain the user information of the medical examination ...and measurement device for checking the effect of the user’s health ... camera’s healthcare capability ... Bluetooth Combination Obesity Management detectors ...characterized by having a blood glucose and serum concentrations meter”—P8

P3*, P4*, P9*, P18*, P19* patents that did not state the innovation used or included nicotine or tobacco.

Finally, our search identified patents that make specific claims related to altering metabolism, nutrient absorption, appetite suppression, and behavior change. The efficacy of these claims is unknown. Some innovations included delivering licensed weight loss drugs; however, trials for these drugs may not have included delivery via inhalation.

Our searches did not identify any innovations that claimed their product would deliver an aerosol or vapor that would satisfy cravings for foods. There are electronic products on the market which

resemble e-cigarettes, such as Slissie, which are advertised as a device that delivers “appetite suppressing flavors,” used to support healthy snacking by providing users with an alternative to sweets.²⁰

It is important to note that worldwide obesity has more than doubled since 1980; obesity contributes to chronic diseases including heart disease, stroke, diabetes, and some cancers.²¹ Obesity, like tobacco use, is a complex public health challenge.⁹ If e-cigarettes support smoking cessation and are not associated with weight gain (or are associated

with weight loss), these devices may help address an important barrier to successful quit attempts and sustained quitting. Such outcomes may result in non-tobacco users initiating e-cigarette use to support weight loss or weight control, and consequently, introduce naïve tobacco users to a potentially addictive product. The uptake of e-cigarettes for weight loss or weight control warrants attention by the public health community and highlights the importance of collecting relevant information through population-level surveillance methods.

Funding

This work was supported by the Johns Hopkins Center of Excellence in Regulatory Science and Innovation (5U01FD004977-02). LMC receives support for her doctoral training from a National Cancer Institute grant (T32 CA009314).

Declaration of Interests

Authors have no competing interests to declare. All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. The text of this article was not reviewed by the sponsor. The article is not under review by another journal.

References

1. Sutter ME, Nasim A, Veldheer S, Cobb CO. Associations between unhealthy dieting behaviors and tobacco use among adolescents. *J Eat Disord.* 2016;4:39.
2. Wee CC, Rigotti NA, Davis RB, Phillips RS. Relationship between smoking and weight control efforts among adults in the United States. *Arch Intern Med.* 2001;161(4):546–550.
3. Shang C, Chaloupka FJ, Fong GT, Thompson M, Siahpush M, Ridgeway W. Weight control belief and its impact on the effectiveness of tobacco control policies on quit attempts: findings from the ITC 4 Country Project. *Tob Control.* 2015;0:1–7.
4. Mukhopadhyay S, Wendel J. Is post-smoking-cessation weight-gain a significant trigger for relapse? *Appl Econ.* 2011;43(24):3449–3457.
5. Pistelli F, Aquilini F, Carrozzi L. Weight gain after smoking cessation. *Monaldi Archives for Chest Disease.* 2016;71(2):81–87.
6. Audrain-McGovern J, Benowitz NL. Cigarette smoking, nicotine, and body weight. *Clin Pharmacol Ther.* 2011;90(1):164–168.
7. Harris KK, Zoepf M, Friedman TC. Metabolic effects of smoking cessation. *Nat Rev Endocrinol.* 2016;12:299–308.
8. Jessen A, Buemann B, Toubro S, Skovgaard IM, Astrup A. The appetite-suppressant effect of nicotine is enhanced by caffeine. *Diabetes Obes Metab.* 2005;7(4):327–333.
9. Glover M, Breier BH, Bauld L. Could vaping be a new weapon in the battle of the bulge? *Nicotine Tob Res.* 2016;33(2):1–5.
10. Morean ME, Wedel AV. Vaping to lose weight: predictors of adult e-cigarette use for weight loss or control. *Addict Behav.* 2017;66:55–59.
11. McQueen A, Tower S, Sumner W. Interviews with “vapers”: implications for future research with electronic cigarettes. *Nicotine Tob Res.* 2011;13(9):860–867.
12. E-cigarette Forum. Weight Gain/Loss/Steady since started vaping. *E-cigarette Forum.* 2013. www.webcitation.org/query?url=https%3A%2F%2Fwww.e-cigarette-forum.com%2Fforum%2Fthreads%2Fweight-gain-loss-steady-since-started-vaping.460484%2F&date=2016-07-04. Accessed January 18, 2017.
13. ECF Veteran. A different reason to pick up vaping. *E-cigarette Forum.* 2013. www.webcitation.org/query?url=https%253A%252F%252Fwww.e-cigarette-forum.com%252Fforum%252Fthreads%252Fa-different-reason-to-pick-up-vaping.423388%252F&date=2016-07-04. Accessed January 17, 2016.
14. Hadwiger ME, Trehy ML, Ye W, Moore T, Allgire J, Westenberger B. Identification of amino-tadalafil and rimonabant in electronic cigarette products using high pressure liquid chromatography with diode array and tandem mass spectrometric detection. *J Chromatogr A.* 2010;1217(48):7547–7555.
15. Carpenter CM, Wayne GF, Pauly JL, Koh HK, Connolly GN. New cigarette brands with flavors that appeal to youth: tobacco marketing strategies. *Health Aff (Millwood).* 2005;24(6):1601–1610.
16. Kennedy RD, Millstein RA, Rees VW, Connolly GN. Tobacco industry strategies to minimize or mask cigarette smoke: opportunities for tobacco product regulation. *Nicotine Tob Res.* 2013;15(2):596–602.
17. Brown CJ, Cheng JM. Electronic cigarettes: product characterisation and design considerations. *Tob control.* 2014;23(suppl 2):ii4–10.
18. Google Help. About Google Patents. 2017. <https://support.google.com/faqs/answer/7049585>. Accessed December 11, 2016.
19. Geller AI, Shehab N, Weidle NJ, et al. Emergency department visits for adverse events related to dietary supplements. *N Engl J Med.* 2015;373(16):1531–1540.
20. Slissie tasty electronic slimming aid and habit trainer—starter pack. 2017. <https://slissie.co.uk/products/slissie-starter-kit>. Accessed April 24, 2017. (Archived by WebCite® at <http://www.webcitation.org/6py8GfhOL>)
21. World Health Organisation. Obesity and Overweight, Fact Sheet N°311 [Updated June 2016]. 2014. www.who.int/mediacentre/factsheets/fs311/en/. Accessed December 11, 2016.