The Graduate School

Public Health Sciences

QUALITATIVE ANALYSIS OF AN ELECTRONIC CIGARETTE SURVEY

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by

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ABSTRACT

Background: Awareness and use of e-cigarettes (e-cigs) has increased significantly in the last five years, but little is known about the experiences, satisfaction, opinions and important e-cig characteristics for e-cigs users.

Methods: We used an Internet survey of 8814 ever-users of e-cigs during December 2012 to October 2013. A random sample (N=200) was selected from participants (N=1177) who completed all open-ended questions on use of, and opinions about e-cigs and their qualitative responses were analyzed.

Results: Most respondents were men (69%) from the United States (86%). They had used e-cigs for the 6 months (median) and daily use was around 15 times (median, around 15 puffs or last for 10 minutes). Approximately 79% were former smokers, while 21% were currently smoking traditional cigarettes occasionally or on a daily basis. Respondents used e-cigs for various reasons; most common were to quit smoking, as a safe alternative to use nicotine, feasibility in using at smoke-free places or around other people. Positive effects were health (improved breathing, less coughing, overall positive health) and psychological (feeling good, no craving) benefits. Respondents enjoyed the throat sensations with e-cigs and the availability of the various flavors. The most common side effects were dryness of mouth and throat irritation. Respondents raised some concerns about possible toxicity, about future regulation and legal status, and also recommended need for long-term study on safety profile of e-cigs.

Conclusions: E-cig users reported e-cigs helped them to quit smoking and to have positive effects on their health, but several other respondents also raised concern about addiction potential, toxicity and use by first time users. There is an urgent need for research on e-cigs specifically focusing on the efficacy, safety, and toxicity of electronic cigarettes.

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To my wife, my children, your love and support inspire me every day.

Introduction

Awareness and use of electronic-cigarettes (e-cigs) has increased significantly in the United States and many other countries, particularly among current smokers. One large survey (HealthStyles) carried out by King et al., found awareness of e-cigs among US adults has increased from 40.9–57.9% from 2010 to 2011, during the same time e-cig use rose from 3.3 to 6.2% (King et al. 2013). Although the number of e-cigs users has continued to increase in the last five years, little is known about their experiences and what e-cigs characteristics are important for e-cigs users.

The e-cig is a 21st century invention; its current form was invented by Chinese pharmacist Hon Lik in 2003. Typically e-cigs consist of a tube, electronic heating element, and liquid cartridge or container tank (Figure 1). The cartridge holds a liquid mixture typically containing nicotine, distilled water, flavorings agents and either propylene glycol and/or vegetable glycerin. Activation of the heating element leads to vaporization of the liquid and nicotine, and resulting vapor is expelled and inhaled. The vapor is a fine mist, which dissipates more quickly than smoke. E-cig users have the option to choose from several nicotine strengths, non-nicotine liquids, and various varieties of flavors including vanilla, chocolate, mint etc.

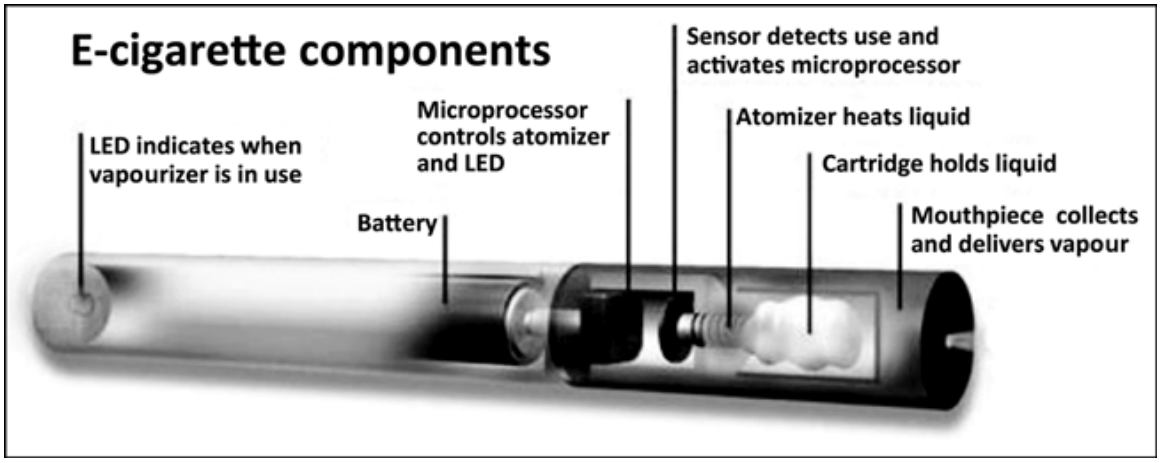

Figure 1. Typical components of an electronic cigarette (Foulds et al., 2011)

There has been constant innovation and development of more and more proficient and attractive products. Currently there are three broad categories of e-cigs available in the market (Dawkins, 2013) (Figure 2).

1. First-generation devices: These devices are generally the same size and appearance as regular cigarettes. They consist of small lithium batteries and cartomizers. Cartomizers contain cartridges, which are usually prefilled with a liquid (nicotine + flavoring agent) that bathes the atomizer. Batteries may be rechargeable or disposable. Many e-cigs are also designed so the tip becomes brightly colored (e.g. red or blue) during inhalation.
2. Second-generation devices: These devices consist of atomizers that can be refilled with liquid and have higher-capacity lithium batteries. Refillable liquids are sold in separate bottles. In some models, there is an option to change the atomizer head (resistance and wick) while keeping the body of the atomizer, thus helping to maintain low operating costs. These devices typically include a button enabling the electricity supply and heating of the coil to begin prior to inhalation, ensuring that it has reached an adequate temperature during the puff.
3. Third-generation devices: These devices are also referred to as 'Mods' (from modifications) and consist of large-capacity lithium batteries with integrated circuits which enable e-cig users to control the voltage or power (wattage) delivered to the atomizer. These devices can be combined with rebuildable atomizers, which provide the ability for e-cig users to customize the setup of resistance and wick. These devices can be also combined with second-generation atomizers.

Figure 2. Examples of electronic cigarette devices currently available on the market (Farsalinos and Polosa, 2014)

Research has shown that e-cig users choose e-cigs for various reasons, most frequently as a smoking cessation aid (Etter, 2010). Additionally, e-cigs are used to alleviate the craving to smoke after abstinence (Bullen et al., 2010), and may be used to reduce cigarette consumption in traditional cigarettes smokers (Caponnetto et al., 2011; Polosa et al., 2011; Siegel et al., 2011).

The increasing popularity of e-cigs may be due in part to their ability to satisfy nicotine dependence and provide the behavioral component associated with smoking; such as hand to mouth experience, sensory stimulation and visible smoke/vapor [Farsalinos et al. 2013b]. The behavioral and sensory similarity to smoking is largely absent in nicotine replacement therapies (NRTs) or oral medications. The ability to deal both with the physical and the behavioral components may explain why the e-cigs have become more popular than approved medications over a relatively short time (Farsalinos et al. 2013b).

E-cigs are widely used; however the impact e-cig use has on public health remains uncertain (Etter et al., 2011). Many public health professionals have raised concerns that e-cigs may perpetuate the use of nicotine and tobacco products among smokers who might otherwise quit, and have an adverse impact on the users' health, counter the effectiveness of smoke-free policies and encourage smoking initiation. Potentially harmful constituents including irritants, diethylene glycol, animal carcinogens and genotoxins have also been documented in some e-cigs cartridges, (Cobb et al., 2010; FDA, 2009). Despite the concerns raised by public health authorities about the safety of e-cigs and the appropriateness of using them as an alternative to smoking, the number of e-cig users continues to increase (National Association of Attorneys General, 2013; Food and Drug Administration, 2009a; Mayers, 2009).

Most of the research on e-cigs has been quantitative in nature and based on what public health researchers already know about e-cigs. This provides the opportunity to understand e-cig use from a behavioral and quantitative perspective. There may be other important e-cigs characteristics, or experiences of users of which public health researchers are totally unaware. Qualitative research provides an opportunity to understand how people feel about e-cigs use and why they make the choice to use e-cigs.

To date only two qualitative studies has been reported that focused on e-cig users (Etters, 2011, Mcqueen et al., 2011). Etters used a French-language Internet survey, which was posted in 2009 in Europe. In this survey participants (N=81) answered open-ended questions about their

usage pattern, reason for use, and opinion about e-cigs. Participants reported the major motivation to use e-cigs was to quit smoking, but several respondents were also concerned about the potential toxicity of e-cigs. Mcqueen et al. interviewed e-cig users (N= 15) individually, or in small groups, who attended a convention or club meeting. Despite the concern of toxicity the number of e-cig users continues to increase, a recent report by www.smokinginengland.info indicates a significant increase number of e-cigs use among smokers from 2% in May of 2011 to 17% in February 2014 (West et al, 2014). With this increase, and changes in e-cig devices overtime, there is need for new descriptive study to understand the views and experience of e-cig users.

This research aims to improve the understanding of experienced e-cig users concerning their patterns of use of e-cigs, what side effects they have experienced, important e-cig characteristics and what they identify as important factors from a public health prospective.

Methods

Researchers Jonathan Foulds and Stephen Wilson from Penn State University posted a link to a survey in REDCap (Research Electronic Data Capture) on various websites (commercial as well as social groups or forums) with the initial aim of recruiting e-cig users for a laboratory study of the psychological and biological effects of the electronic cigarette. The purpose of this online survey was to improve the understanding of the use of electronic cigarettes (https://redcap.ctsi.psu.edu/redcap/surveys/?s=v94cbA), including the types of e-cigs being used, how frequently they are used and whether or not they are replacing other types of tobacco among e-cig users aged ≥18 years old. This survey was first posted on the Internet in December 2012. It was posted on one of the largest e-cig user websites "ecigaretteforum.com", and members of this site then cross-posted it on other websites. The announcement and link to the survey was also posted on webMD.com, NJoy.com and other websites related to e-cigs. This study was approved by the Penn State University Institutional Review Board. Data collection for this study is still ongoing. The participants for this study were those who entered the survey from December 2012 to October 2013.

Participation in this study was completely voluntary. Responses to this survey were anonymous, although individuals who wished to volunteer for the laboratory component of the study entered their contact details at the end of the survey. Responses were stored on REDCap, a secure, web-based application designed exclusively to support data captured for research studies. This survey is very comprehensive; it contains 158-items including socio demographics profile, e-cig use history, tobacco use history and various free text responses.

Eligible participants were current adult e-cig users who completed the survey up to the last question, which takes approximately 15 minutes to complete. On the survey form, participants indicated the total number of days that they had been using e-cigs, the number of puffs per day, the cost of e-cigs, whether they had ever used traditional cigarettes, or were currently using them, and what other kinds of tobacco they have used. In addition, subjects indicated whether e-cigs had helped them to quit smoking. Participants were asked to report about their age, sex, occupation, location and highest level of education. Medians rather than means were used for continuous variables because medians are less sensitive to outliers.

For the purpose of this study only those participants who entered responses for all five open-ended questions were included. A computerized SPSS program was then employed to randomly select a sample of 200 participants. The qualitative responses from the selected random sample (N=200) were then analyzed. Analysis of free text responses was completed by two independent evaluators (RB and KC). Differences in interpretation of text responses were resolved by discussion among independent evaluators on a weekly basis to reach consensus. The qualitative questions that were analyzed focused on e-cig characteristics that are important to users, side effects they have experienced, differences between the use of e-cigs as compared to traditional cigarette, where they heard about this survey, and an opportunity to provide additional information, which they believed a public health researcher, should know about e-cigs.

Data was analyzed using SPSS v. 9.2.

Results

Sample

This survey was posted online in December 2012 and 8814 participants entered the survey between December 2012 and October 2013, of whom 5000 (56.7%) were eligible participants who completed the survey to the end. Only 1177 (13.35%) participants completed all the open-ended questions and were included in this quantitative analysis. Comparison between the eligible participants who completed (N =1177) and those who did not complete (N = 3823) all open-ended questions revealed no significant difference in sex, location, race, education or employment status. However, those who completed all the open-ended questions were significantly older than who did not complete the survey (40.74 vs. 38.89, $p < 0.001$).

Most respondents were men (69%) from the United States (86%). Approximately 79% were former smokers, while 21% reported continued use of smoking traditional cigarettes either occasionally or on a daily basis. Participants had an average of five previous attempts to quit smoking. Almost all former smokers (93%) were able to quit smoking after starting using e-cigs. Approximately one-fourth (20-35%) of the smokers also used other forms of tobacco including pipe, cigar, chewing tobacco and hookah (Table 1).

Table 1: Characteristics of e-cigarette users

Characteristic	
Number of respondents	1177
Age, median (range), years (N=1177)	40 (18-76)
Gender (N=1177) (%) • Male • Female	 812 (69%) 365 (31%)
Location (N=1176) (%) • USA • Others	 1016 (86.3%) 160 (13.6%)
Race/Ethnicity (N=1177) (%) • White • African American • Asian • Others	 1067 (90.7%) 14 (1.2%) 29 (2.5%) 67 (5.6%)
Hispanic/Latino (N=1177) (%)	43 (3.7%)

Education (N=1177) (%)	
• Less than High School Diploma	18(1.5%)
• High School Diploma or GED	160 (13.6%)
• Some College/Technical School	525 (44.6%)
• College Degree/Graduate Degree	474 (40.3%)
Employment status (N=1177) (%)	
• Full-time/ part-time employment	810(68.9%)
• A full-time homemaker/stay at home caregiver	52 (4.4%)
• A full-time/part-time student	83 (7%)
• Retired	88 (7.5%)
• Unemployed/laid off	62 (5.3%)
• Unable to work due to long term disability/sickness	82 (7%)
Cigarette smoking status (N=1177) (%)	
• Past user	935 (79.4%)
• Current occasional user	106 (9%)
• Current daily user	136 (11.6%)
Past cigarette user – quit smoking (N=935) (%)	
• Years ago	276 (29.5%)
• Months ago	570 (61%)
• Days ago	89 (9.5%)
Quit smoking (N=935) (%)	
• Long before started using e-cigs	64 (6.8%)
• After started using e-cigs	871 (93.2%)
Other types of tobacco usage	
• Pipe smoker (N=1177) (%)	233 (19.8%)
• Cigar smoker (N=1177) (%)	414 (35.2%)
• Smokeless/chewing tobacco (N=1177) (%)	333 (28.3%)
• Hookah user (N=1160) (%)	283 (24.4%)
Previous attempts to quit cigarettes median (25^{th} and 75^{th} percentiles) (N=1147)	5 (3,10)

Use of the electronic cigarette

Most e-cig users reported using e-cigs for approximate 6 months and were using approximately 15 times/day; the survey defined one "TIME" as consisting of around 15 puffs, or e-cigs use for around 10 minutes. Most e-cig users had tried at least 3 different models prior to the one they were using currently. Approximately half of the e-cig users spent more than 50 U.S. dollars on their current e-cig with a weekly maintenance cost of approximately 10 U.S. dollars. The most frequently used e-cig contained a button to press prior to inhalation/puffing (84%), had a tank to hold the liquid (57%), and used both propylene glycol (PG) and vegetable glycerine (VG) (51%). The single most important reason cited for use of e-cigs was the perception that it was less harmful to health (35%); other frequent reasons for the use was the desire to quit smoking or

prevent relapse (29%). The most reported important e-cigs characteristic was ability to provide good vapor quality (94%), followed by long battery life (82%) and variety of liquid flavor (65%). The most reported negative side effects were dry mouth (25%), throat irritation and dry cough (5%). Approximately 72% respondents started using e-cigs to quit tobacco soon. The majority of e-cig users (93%) reported that e-cigs helped them to quit smoking (Table 2).

Table 2: E-cigarette usage patterns

Use of electronic cigarettes	
Days of use of the e-cigarette, median (25^{th} and 75^{th} percentiles) (N=1170)	180 (60,480)
Use of e-cigs times per day (one "TIME" consists of around 15 puffs, or lasts around 10 minutes), median (25^{th} and 75^{th} percentiles) (N= 1146)	15 (10,25)
Number of models of e-cigs have been used prior to the current one, median (25^{th} and 75^{th} percentiles) (N=1158)	3 (2,5)
Price per package, median (U.S. dollars) (25^{th} and 75^{th} percentiles) (N=1157)	50 (26,100)
E-cig cost more than 50 U.S. dollars (N=1172) (%)	575 (49.1%)
Maintenance cost of vaping per week, median (U.S. dollars) (25^{th} and 75^{th} percentiles) (N=1104)	10 (6,20)
E-cig contains button to press just prior to inhalation/puffing (N=1177) (%)	952(80.9%)
Length and width of e-cigs as compare to cigarette (N=1177) (%)	
• E-cig same	165(14%)
• E-cig smaller	22(1.9%)
• E-cig larger	990(84.1%)
Liquid for e-cig (N=1177) (%)	
• Prefilled cartridges	133 (11.3%)
• Drip-feed from bottle	224 (19%)
• Tank feed	669 (56.8%)
Type of liquid in e-cig (N= 841) (%)	
• Propylene glycol (PG)	64 (5.4%)
• Vegetable glycerine (VG)	77 (6.5%)
• Both PG and VG	601 (51.1%)
Single most important reason to use e-cig (N=1177) (>5%)	
• Less harmful to my health	406 (34.5%)
• Quit smoking or avoid relapsing	339 (28.8%)
• Less toxic than tobacco	79 (6.7%)
• To reduce tobacco consumption in preparation of a quit attempt	64 (5.4%)
• Prefer the taste of an e-cigs	61 (5.2%)
Very important E-cig characteristics	
• Provides good vapor quality (N=1164) (%)	1098 (94.3%)
• Long battery life (N=1175) (%)	958 (81.5%)

• Variety of liquid flavor (N=1170) (%) • Fast battery charge (N=1172) (%) • Shaped like a cigarette (N=1175) (%)	762 (65.1%) 272 (23.2%) 149 (12%)
Experienced effects as a result of e-cigs (quite often/once a week) (>1%) • Dry mouth (N=1173) (%) • Throat irritation (N=1172) (%) • Dry cough (N=1174) (%) • Mouth irritation (N=1172) (%) • Sore throat (N=1169) (%) • Headache (N=1170) (%) • Dizziness (N=1171) (%)	 294 (25%) 45 (4.6%) 42 (4.4%) 18 (1.5%) 18 (1.5%) 17 (1.5%) 16 (1.3%)
When you started using e-cigs, was it your intention to quit tobacco soon (N=1176) (Yes, %)	848 (72.1%)
Does (did) the e-cigarette help you quit smoking? (N=1177) (Yes,%)	1096 (93.1%)

Qualitative Analysis

A random sample of 200 participants was selected using SPSS from the 1177 participants who completed all the open-ended questions. Comparisons of the random sample (N = 200) and the remaining of eligible participants (N =977) revealed no significant difference in age, sex, location, race, education and employment status. On several open ended questions many participants commented on multiple themes in their response (for example - open ended question: Please describe any other e-cig characteristics that are important to you; response sample: *Ease of maintenance, reliability, consistent performance, good battery life, economical*). All themes were identified in particular response.

When we asked about where participants heard about this survey, the most frequent response was the e-cigs forum (71 comments), followed by the commercial e-cig website Njoy and social groups related to e-cigs (Table3).

Table 3: How participants learned about survey: open-ended comments* from e-cig users

(N=200) **(Total themes = 9)**	**Number of comments** **(Total = 202)**
E-cig forum	71
E-cigs website - NJOY	38
Social groups/websites (Facebook, Twitter, Vapers Network, Vepetv, Vapernews, Chat room, Pburados tasteyourjuice)	38
Reddit	25
Internet search (including Google search)	9
Other online forums (Aussie vapers, Ecig advanced, Nu-Vapor,	8

stevevape)	
Referral (Friends, family members, email)	7
Other e-cigs websites (Nic Fit nation, Bedford Slims, Blu, Smoker's Angel, Smokecignals)	4
The Consumer Advocates for Smoke-free Alternatives Association (CASSA)	2

- Free text question: How did you learn about this survey? (on which website etc?)

When asked, as compared to how they smoke/smoked their traditional cigarettes, to describe any ways that they use the e-cig differently (one open-ended field, 9 common themes, 276 comments) the most frequent answers were: fewer puffs but more frequently; shallow or less deeply inhalation; less frequently; more frequently; about the same in both frequency and inhalation; more deeply inhalation; about the same in inhalation; longer puffs, and about the same in frequency (Table 4).

Table 4: Description of e-cig use as compared to how e-cigs users smoke/smoked cigarette: open-ended comments* from e-cig users

(N=200) **(Most common themes =9)**	**Number of comments (Total = 276)**	**Examples**
Fewer puffs more frequently	53	• *..use my Ecig more frequently but for less time! 2 or 3 puffs a time instead of smoking full cigarettes when ever I could.* • *..puff on it more frequently but only do so once or twice in a row multiple times a day.*
Frequency - less than cigarette	50	• *..use my electronic cigarette less than I smoked regular cigarettes.* • *..use the ecig much less frequently*
Frequency - more than cigarette	39	• *use my electronic cigarette much more frequently.* • *..use the e-cig much more frequently than traditional cigs because I can smoke the e-cig in my house, in my cubicle, etc.*
Inhalation - less deeply/shallow	51	• *inhale less deeply* • *seems more nasal than deep inhalation of tobbacco*
Inhalation - more deeply	23	• *..inhale more deeply* • *..more deeply*
Longer duration of puffs	11	• *Also, I take much longer puffs on an e-cig because they don't work exactly the same way.* • *I generally vape for a longer period of time*

		than a single cigarette.
About the same - in both frequency and inhalation	28	• *I smoke my ecig the same way as the regular cig.* • *I can't say there is really much different*
About the same - in inhalation	15	• *Inhale about the same I think.* • *I inhale neither more or less deeply with my ecig.*
About the same - in frequency	6	• *Frequency is about the same.*

- Free text question: Compared to how you smoke/smoked your traditional cigarettes please describe any ways that you use your e-cig. differently. For example, do you use it more or less frequently (per day), and do you inhale more or less deeply than you did with a regular cigarette?

The most important e-cig characteristics identified were: design; ability to control voltage; simple to operate and maintain; durability; consistent performance of e-cig device and experience; taste and variety of flavors; throat hit; compatibilities of variety of e-cig components; machine quality; cost of e-cig device including maintenance cost; battery life; tank size; safety features; easy availability of e-cigs device components and flavors, and the ability to customize liquids and coils (Table 5).

Table 5: E-cig characteristics that are important to e-cig users: open-ended comments* from e-cig users

(N=200) (Most common themes =15)	**Number of comments (Total = 272)**	***Examples***
Design	40	• *looks nice and feels good in my hands.* • *I like lights on it. I want it to look like a weapon*
Voltage control/variable voltage	35	• *Variable voltage, variable watt, ability to adjust these on the fly depending on the 'juice' being used.* • *Variable voltage for better vapor production*
Simplicity/convenient	34	• *.. Ease of service and maintenance* • *..ease of operation and cleaning,* • *..easy to refill*
Durability	26	• *Durability of the battery case* • *Durability*
Reliability/consistent performance	20	• *Consistency is also very important. I want it to work consistently all the time.* • *Consistency of hits.(if I hit it it should be the same flavor, throat hit, and nicotine every time wether I hit it for 1 second every hour or continuously for an hour)*

Variety/taste of flavor	18	• *…it tastes like a natural cigarette* • *Good flavor of the vapor*
Throat hit	16	• *A good throat hit* • *Good throat hit.*
Compatibilities	14	• *having a connection that is compatible with a wide variety of clearomizers and cartomizers,* • *flexible options for modifications or interchangeability of parts and accessories*
High quality	14	• *overall quality of machining* • *….fair to good build quality*
Economical	14	• *Total cost of ownership* • *Not expensive…. Cheaper then smoking real cigs.*
Battery life	11	• *……long battery life are the most important.* • *..good battery life..*
Tank Size	10	• *..ability to hold a lot of liquid,* • *Big tanks so I don't have to load them very often*
Safety features	10	• *avoidance of spilling/leaking e-cigs* • *safe battery protection, safety features*
Better availability	9	• *Easy access to and a variety of choices of cartomizers, clearomizers and atomizers*
Ability to customize liquids and coils	6	• *Possibility to make own coils/wicks*

*Free text question: Please describe any other e-cig characteristics that are important to you.

The most frequently cited positive aspects of e-cig use were: assisted in smoking cessation, reduced cigarette consumption; beneficial effect on health; improved breathing, decreased cough, fewer sore throats; safe way to use nicotine; pleasure of inhaling and smoking-related actions; comparatively less toxic than smoking tobacco; improvement in sense of smell and taste; less expensive than cigarettes; feasibility to use e-cigs; similar gestures or action of smoking cigarette; not associated with unpleasant odors and ash or dirt; taste and variety of flavors; safe for others or bystander with no second hand smoke; helped relieve the craving for tobacco, and improvement in dental health (Table 6).

Table 6: The most positive aspect of e-cigs: open-ended comments* from e-cig users

(N=200) (Most common themes =15)	**Number of comments (Total = 492)**	**Examples**
To quit smoking/ to reduce cigarette consumption/	81	• *As far as Nicotine Replacement Devices go, ecigs are fantastic. Both my wife and I quit smoking after 15 years using them.*

facilitates smoking cessation		• *as a smoker for 7 years I failed every attempt at quitting until I started vaping.* • *electronic cigarette was the only successful way I have ever quite smoking tobacco, my health has improved greatly . I was a 25 year 2 pack a day smoker that tried many times to quite with the patch and never was able to be successful with that.*
Beneficial effects on health	71	• *…My blood pressure has stabilized and have, under doctors orders, quit taking some of my medications for it. My alergies are much less severe.* • *…The improvements to my health and lifestyle in the last two years has been amazing.* • *Blood pressure is 22% lower, actually*
Improves breathing and respiration, less cough, less expectoration, fewer sore throats	70	• *Breathing is easier. No hacking cough at any time of the day* • *…Within a week my constant chest wheeze went away. My morning coughing/hacking went away.*
Safe and controlled way to use nicotine	42	• *I know I'm still using Nicotine but I'd use it anyway, why not use a more healthy option.* • *I'm still on nicotine, but much less. I'm avoiding close to 4000 chemicals in a traditional cigarette.*
Pleasure of smoking/ pleasure of inhaling	34	• *…pleasure of slowly blowing smoke out of your mouth* • *E-cigs are fun, tasty, and cool.*
Less toxic than tobacco smoke	33	• *It doesn't have any of the toxic chemicals found in traditional cigarettes. It has been said that there are around 4000 toxic chemicals in tobacco* • *Very easy to switch from burning tobacco (combustion with tar/toxic chemicals) to an ecig (where user can control nicotine levels in eliquids). The elimination of 4000 cancer causing toxins being inhaled is paramount to an ecig user.*
Improves sense of smell and taste	32	• *Senses of taste and smell are increased.* • *A few short weeks later my sense of smell and taste improved.*
Less expensive than cigarettes	28	• *Despite buying some very high end battery holders/mods I have more disposable income, due to not buying traditional cigarettes, and fewer doctor visits.* • *It's cheaper than tobacco*
Feasibility to use	23	• *AVP refers to Advanced Personal Vaporizer, which I believe is more accurate than electronic*

		cigarette. I use my AVP more frequently per day because of the convenience. For example, I vape in the car because it won't leave a foul odor and in the house because it won't set off smoke alarms • *It helps with work productivity since I can vape while I work when I get tired of sitting and doing work.*
The gestures or actions (similar to smoking)	21	• *..Vaping give's me the hand to mouth like an analog* • *vaping/smoking is much more about habit and oral fixations then it is about nicotine.*
No unpleasant odors or bad breath, no ash, dirt, or burned clothes	21	• *My home, car, clothes, person smell fresh and clean. My skin looks and feels better. But most importantly... my children do not shy away from hugging me anymore.* • *myself and my house/car/clothes no longer stink of smoke odor*
Taste and variety of flavors	12	• *…various fruity and candy flavors that I enjoy so much* • *Enjoyable taste*
No second hand smoke/safe to others or bystander	10	• *I am convinced that 'second hand vape' is a non-issue* • *if I had not found e-cigs I am sure I'd still be killing myself and those around me with smoking.. if you ask me e-cigs saved my life as well as those around me..*
Relieves craving for tobacco	10	• *With E-Cigs I was able to stop a 2 pack a day habit cold turkey. …. I still have an unused pack of cigarettes sitting on my desk. I have absolutely no urge to smoke them.* • *I don't feel any desire at all to use a traditional cigarette.*
Improvement in dental health	4	• *freedom from the tooth staining effects.* • *My teeth are brighter.*

*Free text questions: 1. Please describe any other e-cig characteristics that are important to you. 2. Please describe any other effects that you have experienced as a result of using e-cigs 3. Please provide any additional information you believe a public health researcher should know, in order to understand the electronic cigarette.

When asked to describe any other effects that they have experienced as a result of using e-cigs approximately one fourth (26 comments) reported there were no undesirable effects. The most common negative effects (85 comments) were: symptoms related to dehydration including dry mouth, chapped lips and bad breath; worsening respiratory symptoms (cough, allergy, exacerbation of asthma symptoms and excessive phlegm); side effects specifically to nicotine

overdose; throat and nasal irritations; transient headache (during first few days); increased heart rate; nauseating sensation; dizziness, allergic reactions to liquids; acid reflux etc. Of the participants who reported undesirable effects, 13 reported the transient nature of the undesirable effects (Table 7).

Table 7: Undesirable effects of e-cigarettes: open-ended comments* from e-cig us

(N=200) **(Most common themes =14)**	**Number of comments (Total = 124)**	**Examples**
Dry mouth/bad breath/chapped lips/dehydration	25	• *Dry mouth occurred more when I first started using the e-cig and was every time I used it. That has since subsided to an occasional thing but I always drink water while using it.* • *Bad breath probably due to dry mouth, usually remedied by a larger water intake.*
Cough/worsening allergy/ exacerbation of asthma symptoms/excessive phlegm	10	• *Exacerbation of asthma symptoms* • *Lung Air Way Resistance (not too much) when I use it for prolong periods of time*
Nicotine overdose/side effects	8	• *I experienced once a slight nicotine overdose, but it was 'researched' (I know it's not really careful), I experienced the limits of dual coil cartomizers at around 15W with 18mg/mL liquid. I felt e little dizzy with very very light headache. It never happened with regular use.* • *headaches are from high nicotine laves (24mg+)*
Throat irritation/nasal irritation	8	• *I only experienced throat irritation one time with a very tangy flavored liquid. I have not experienced it since*
Headache	6	• *The first and only headache I have ever had was once when I was trying a bunch of new flavors with a Drip Tip Atomizer. I have never had a headache since* • *headache for first few days...none since*
Rapid heart rate	5	• *tachycardia if using for a long period of time – 'chain vaping'* • *When I first got my large battery I used it continuously with 24 mg/mL liquid for a period of about 4 hours. My heart rate was highly elevated for about 10 minutes and then settled back down.*

Nausea	4	• *Nausea can occur if you over do it* • *nausea once (maybe twice) near the beginning of my experience as I learned to titrate my specific preferences along with what my body would accept (I had 1 bottle of 36mg/ml liquid then that got me – everything else was 24mg/ml, and I stuck with that at the beginning).*
Dizziness	4	• *a few times the dizziness,* • *makes me dizzy*
Allergy to liquid	3	• *I always use vegetable glycerin because of allergies to propylene glycol. But if I have to use PG I have a hard time breathing,* • *I only have throat issues with Pg based liquids.*
Acid reflex	2	• *Heartburn*
Muscle soreness	2	• *Muscle soreness in upper legs for first 2-3 weeks of switching*
Others	8 (1 each)	• *Shakes, loss of taste, hiccups, disturbed sleep with vivid dreams, mouth ulcer, increased bowel movements, cluster Headache, tinnitus*
No undesirable effects	26	• *No negative effects, they have all been positive.* • *No other effects I am yet aware are caused by my use of e-cigs*
Transient effects	13	• *In the first few months when I was trying all those new kinds I did have dry mouth & other symptoms but not with what I use now* • *The first and only headache I have ever had was once when I was trying a bunch of new flavors with a Drip Tip Atomizer. I have never had a headache since.* • *Rapid heart rate a couple of time when I first quit smoking.*

*Free text questions: Please describe any other effects that you have experienced as a result of using e-cigs.

When asked to provide additional information that participants thought would be important to for a public health researcher should know, the most common comments were: it helps to quit smoking (66 comments), health benefits (44 comments) and improvement in respiratory status (34 comments), and a safer way to use nicotine (33 comments). Many of e-cig users (24 comments) also felt that there was need for more research on e-cigs safety and long-term effects.

Fifteen people were concerned about the harmful effects of e-cigs and their addiction potential. Twelve commented that e-cigs are better than available nicotine replacement therapy (NRT) and Food and Drug Administration (FDA) approved medications. Interestingly, few (5 comments) complained about available NRT and medications. There were also suggestions regarding how to improve the survey (11 comments) and the need for increased awareness of e-cigs availability and efficacy. A need for price control was also cited (7 comments). Regarding the regulations, nine were against regulation by the FDA, while four were in favor of government regulation. Seven e-cig users commented about the difference in vaping e-cigs and cigarette smoking. Respondents (5 comments) were concerned about the use of e-cigs by adolescents and first time users (Table 8).

Table 8: Additional information shared by e-cig users, which they believe public health researchers, should know in order to understand the e-cig: open-ended comments* from e-cig users

(N=200) (Most common themes =15)	**Number of comments (Total = 277)**	**Examples**
Quit smoking	65	• *Without the ecig, I am extremely skeptical my quitting would have been as easy, or as successful.* • *This device has saved my life! I was smoking 2+ packs a day. I tried all the NRTs and none worked. I was able to switch to e cigs literally overnight. I have not smoked a cigarette in 12 months.*
Health benefits	44	• *A year ago I saw a cardiologist for the first time. When he was listening to my heart/lungs he replied 'A non-smoker I see'……A man who has seen and heard everything declared I had clean lungs, even after using an e-cig for over (then) two and a half years!!* • *…my health is better in every regard. Increased ability in respiration and can now exercise effectively, more energy, better mental outlook…*
Improves breathing and respiration	34	• *I can breath better . No longer have the smokers cough* • *. … I no longer cough/hack every morning and I never feel a tightness in my chest….*
Safe and controlled way to use nicotine	33	• *Very easy to switch from burning tobacco (combustion with tar/toxic chemicals) to an ecig (where user can control nicotine levels in eliquids).* • *It should be marketed as an alternate nicotine*

		deliver system as it allows smokers to enjoy the same recreation as smoking a normal cigarette with all the benefits of inhaling water vapor instead of tar and other toxins.
Need for more research (safety of ingredients, long term effects etc.)	24	• *… like to know more about the long term health effects…* • *….. like to see some double-blind studies* • *… like to see an unbiased … research into the contents and safety of the vapor produced by e-cigs* • *…are not safe until studies are done by independent researchers*
Harmful effect (health concern/addiction potential)	15	• *…still addicted to nicotine* • *…quitting an e-cig would be as hard as quitting cigarettes cold turkey.*
Better than available Nicotine Replacement Therapy/ medications	12	• *…..after repeated attempts to quit using NRT which did not work for me for longer than 2 months, I quit Tobacco in 2 days with an E-Cig* • *…the e-cig was the reason I was able to stop smoking traditional cigs. I take wellbutrin daily (generic) but it had nothing to do with the smoking*
How to improve survey or question framing	11	• *..Some of these questions were kinda tricky to answer. Like, the reason I wanted to switch.….* • *Rather than ask how many times a day I use my e-cig, I think a more accurate measurement would be to ask how much e-juice I consume a day*
Against FDA regulation	9	• *Please do not let our govt ban these, they are the most effective method to get off tobacco and that is the main goal.* • *I fear future regulation will make these harder to purchase and/or get rid of the various fruity and candy flavors that I enjoy so much (most of the tobacco replicating ones taste terrible) and cause me to wind up back on tobacco.*
Differences in vaping e-cigs and cigarette smoking	7	• *Vaping is not smoking* • *Please understand that vaping is not like smoking at all*
Need for more awareness of availability /efficacy/ need for price reduction of e-cigs	7	• *If more people knew what ecigs could do they would be more willing to try.* • *If electronic cigarettes or supplies become difficult to acquire, I will return to smoking cigarettes.* • *I would very quickly go back to using regular cigarettes if denied the use of an electronic cigarette.*
Complain about	5	• *Any researcher worthy of the name should press*

available NRT/medications		*the FDA to disallow Chantix.* • *Chantix was the worst thing I ever took*
Concern about use by adolescent/first time users	5	• *…stop selling to minors* • *I would not encourage a non-smoker to do it, unless they use 0-nic juice.*
In favor of FDA regulation	4	• *I think electronic cigarettes need to be regulated equal to tradition tobacco products. Addictive additives must be prohibited or they will be just as bad as smoking.* • *I believe these things should be regulated by the FDA*
Difference in first and third generation in e-cigs	2	• *I know a LOT of people who have briefly tried the models sold at gas stations with no long term success, because those things are terrible. I have seen much more success among those who buy a higher quality model of e-cig and a higher quality e-liquid.*

- Free text question - Please provide any additional information you believe a public health researcher should know, in order to understand the electronic cigarette.

Discussion

During the last five years, studies indicate the number of e-cig users has risen around the world. Awareness and availability of e-cigs has been increasing at the same time; e-cigs which were sold exclusively online around 5 years ago, are currently available at many gas stations, local food stores, departmental and warehouse stores in the United States. E-cig users are still very active on the Internet on various websites related to e-cigs. E-cigs are mainly marketed for enjoyment or feasibility to use in smoke-free places in United States and not marketed as a nicotine replacement therapy due to concerns related to regulation by FDA. This study helped us to understand about what are the most important e-cig characteristics for e-cigs users and their experiences with e-cigs from their own perspective.

Our survey was one of the most comprehensive survey (158 Items) that has been used in survey research on e-cig users. Our survey found that most e-cig users were former smokers who quit smoking shortly after starting to use e-cigs, but a few (<7%) among them quit smoking long before they started using e-cigs. Many respondents in this survey were motivated to quit smoking and had numerous failed attempts in the past. E-cig users in this survey were experienced e-cig users; they used e-cigs for an average 6 months and were using e-cigs for 15 times per day. Respondents in this survey appeared to be using all generations of e-cig devices; approximately half of the e-cig users were using third generation device (cost more than $50). E-cig users used e-cigs in this study for various reasons; most common were to quit smoking, health and respiratory benefits, as a safe alternative to use nicotine, feasibility in using at smoke-free places or around other people etc. Participants heard about this survey from e-cigs forum website, commercial e-cig websites and social groups related to e-cigs. E-cig users used e-cigs differently than traditional cigarettes, some used fewer puffs more frequently throughout the day, while others used less deeply or less frequently. For e-cig users design of e-cigs, ability to control voltage, simplicity in operation and easy maintenance were important factors. Positive effects were health (improved breathing, less coughing, overall positive health) and psychological (feeling good, no craving) benefits. Respondents enjoyed throat sensations with e-cigs and availability of various flavors. The most common side effects were dryness of mouth and worsening respiratory status. Respondents also raised some concerns about possible toxicity, about future regulation and legal status, and recommended for the long-term study on safety

profile of e-cigs.

Our results suggest that most e-cig users are either former or current smokers who use e-cigs to quit or reduce smoking. These findings are similar to those from small study in Europe, which also used open-ended questions in its survey (Etters, 2010). Studies show inconsistent results about role of e-cigs in helping smokers to quit smoking. A pragmatic randomized-controlled superiority trial comparing nicotine e-cigs, nicotine patches and placebo e-cigs showed both e-cigarettes (with and without nicotine) were modestly effective in helping smokers to quit smoking and achieved similar abstinence as with nicotine patches (Bullen C et. al. 2013). A longitudinal study, which assessed behavior change in e-cig users over 12 months, concluded that e-cigs may contribute to smoking cessation in current smokers and relapse prevention in former smokers (Etters & Bullens, 2013). In a pilot study on small convenience sample of unmotivated cigarette smokers, e-cigs experimentation and 1 week of ad libitum use increased readiness and confidence during the experimentation period and continued to increase during ad libitum use. Cigarette smokers also reduced regular cigarette smoking during ad libitum use (Wegner et al, 2014).

Other recent studies have raised concerns about the increasing use of e-cigs among adolescents. The Centers for Disease Control and Prevention (CDC) reported that the percentage of high school students who reported having ever used an e-cig rose from 4.7 percent in 2011 to 10.0 percent in 2012 and use of e-cigs within the past 30 days rose from 1.5 percent to 2.8 percent in same time period (CDC, 2013). In a recent study of US adolescents, authors reported e-cigs use was associated with higher odds of ever or current cigarette smoking; higher odds of established smoking, planning to quit smoking among current smokers, and lower odds of abstinence from conventional cigarettes among e-cigs experimenters in the US adolescents (Dutra LM & Glantz SA, 2014). The association between cigarette smoking and e-cig use in this cross sectional study might be related to the curiosity of adolescents who got another option of smoking (e-cigs) in the last 5 years which was easily available and had options to choose various taste and flavors of liquids. Also this study did not specify whether these adolescents were using liquid with nicotine or flavored liquid without nicotine.

The long-term effects of e-cigs, either deleterious or beneficial, are largely unknown. E-cig users reported health and respiratory benefits as well as side effects with e-cigs; users also feel that there is need for sound research on e-cigs focusing on long-term effects, efficacy and

safety of liquids etc. E-cig users also commented about how to improve questionnaire or survey, which is very important to understand for future study. One of the important suggestions was to measure the quantity of e-cig liquids as compared to asking how many puffs of e-cigs. This is relevant to those who refill their own e-cig manually, but may not be easy for those purchasing pre-filled cartridges. E-cig users do not perceive smoking e-cig as smoking traditional cigarette; they preferred using word 'Vaping' for smoking e-cigs.

There is no consensus about regulation of e-cig devices; suggestions vary from no regulations to complete banning of these devices. Because of its possible relationship with tobacco laws or medical drug policy, it is not entirely clear which category will be more appropriate for these devices. Some e-cig users in this survey were against regulation and were concerned that if in future there will be in difficulties in getting e-cig devices or its supplies, they may return to smoking traditional cigarettes; which are more dangerous than e-cigs because cigarette smoke contains at least 7000+ chemicals, including over 60 carcinogens. On the other hand, few e-cig users are in favor of the regulation of these devices because nicotine, the main content of liquid, has similar addictive potential.

There is also public health concern related to the feasibility of e-cig use, which enables users to continue to smoke nicotine in smoke-free environments, thus it may be preventing cessation in smokers who might otherwise quit. E-cigs users also perceive e-cigs as a safer way to use nicotine around other people. However, emerging evidence confirmed that e-cigs are not emission-free and their pollutants can be of health concern for e-cigs users and people around them. Specifically, ultrafine particles from supersaturated propylene glycol vapor can deposited in the lung, and aerosolized nicotine appeared capable of increasing the release of the inflammatory signaling molecule (Schober et al, 2013).

E-cigs users were concerned about use of e-cigs by adolescent and first time users. The availability of different kind of flavors (fruits, chocolate or mint) may attract adolescents or young adults, may facilitate initiation of nicotine and may work as gateway to traditional cigarettes. In a study on college students found 12% of ever e-cig users had never smoked a conventional cigarette and among current cigarette smokers, e-cigarette use was not associated with intentions to quit (Suftin et all, 2013). In another study on US adolescents, authors concluded that e-cigs do not discourage conventional cigarette use, and may encourage the use of conventional cigarettes (Dutra LM & Glantz SA, 2014).

E-cig users also believed that there was difference between first (small cigarette-like) and third generation (high-capacity batteries with electronic circuits that provide high energy) e-cig devices. A published study on first generation e-cigs, which measured plasma nicotine levels, reported remarkably low levels of nicotine absorption, while e-cigs were labeled as 'high nicotine' (Bullen et al, 2010). In a study by Farsalinos et al, newer e-cigs were compared with first generation e-cigs, newer devices were more efficient in nicotine delivery, but still delivery of nicotine was much slower compared to tobacco cigarettes (Farsalinos et al, 2014a).

Regarding the limitations about our study, this study was conducted on a self-motivated self-selected sample of Internet users. Participants who voluntarily answered all the open-ended questions may be different in important ways from those who did not respond to those questions. Participants who completed open-ended questions were significantly older than who did not. They may be more motivated in writing responses. Although our results provide very useful and convincing information on e-cig users, our findings might not be generalizable as this study only included motivated Internet users and should be interpreted with caution.

Conclusions

E-cigs users reported that e-cigs helped them to quit smoking and have positive effects on their health, but several other respondents also raised concerns about the addiction potential, toxicity and use by first time users. There is urgent need for more research on e-cigs, specifically focusing on the efficacy, safety, and toxicity of e-cigs and also comparing the different types of e-cig devices.

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