

Health Effects and Demographics of Electronic Cigarette Users. A Comparison of Health Events in Previous Smokers With Three or more years of Electronic Cigarette Experience.

Robert L. Cranfield MD

November 24, 2015

ABSTRACT

Objectives: The purpose of this study was to assess not only the demographics of e-cig users, but to assess health effects on users with 3 or more years of experience of use.

Methods: Anonymous online surveys as well as some local paper surveys were distributed to electronic cigarette social media sites and local electronic cigarette stores in the Southeastern United States. There were 573 respondents in a 6 month period from March to August 2015. Subgroups analyzed were those with 3 or more years use, previous never users of tobacco products ,and those who had no health issues while smoking .

Results: E-cigarette users with 3 or more years of use were found to have a 96% reduction in reported adverse health events after initiation use, and a resolution of 61.8% of the measured existing health problems that developed while smoking. All groups of users reported feeling an improvement in health after starting use, including those who were previous never smokers. Never smokers who started use of electronic cigarettes developed no health problems. Demographics showed that vapers were more likely male and Caucasian. Those with 3 or more years of e-cig use were older, better educated and higher wage earners than the group of vapers as a whole.

Conclusion: Electronic cigarettes have a dramatic and positive effect on the health of those who are able to switch from cigarettes. This can have a tremendous social and economic impact if their use becomes wide spread as a substitute for cigarettes. There does not appear to be a significant health impact to never smokers who initiate use, although data is limited in this survey.

INTRODUCTION

Electronic cigarettes are devices composed of a battery and a tank which stores a reservoir of liquid usually containing Propylene Glycol (PG), vegetable Glycerine (VG), flavors and, usually, nicotine. The battery heats a coil which vaporizes the liquid which is then inhaled as an alternate nicotine delivery system to combustible tobacco products. Articles appear regularly speculating on the potential for harm of these relatively new devices, and about their potential for harm reduction when used as a substitute or diversion from smoking.

Much of the literature to date focuses on the toxins found in e-cigarette vapor and their known consequences in long term exposure. Some of these compare the levels of toxins found in e-cigarettes to the same toxins found in cigarettes.^{1, 2, 3} Some look at how e-cigarette vapor and smoke from tobacco affect human or animal cell cultures.^{4, 5, 6} There are studies that look at short term changes in respiratory and cardiovascular function.^{7, 8, 9} But little to no information has been done to look at what the actual health effects of e-cigarettes have been in those who have been using them for several years. Electronic cigarettes have been available in the modern form since 2007, although the technology is evolving rapidly. Ideally this would give us an eight year window to look for people who have been vaping or dual using and to see how their health has changed. The ideal way to look at this would be to do a prospective study, however there is mounting pressure to strictly regulate these products, which could unnecessarily restrict those who might benefit from them. The duration of a prospective study could result in additional preventable harm. Thus a retrospective analysis has immediate value.

There are over 480,000 deaths each year in the United States attributable to smoking of which 42,000 deaths were related to second hand smoke.¹⁰ Additionally, there is a cost related to direct care of health problems related to smoking and second hand smoke. According to one study these costs in 2014 were approximately \$170 billion.¹¹ According to the Department of Health and Human Services, in 2014, there was more than \$156 billion in lost productivity due to premature death and exposure to second hand smoke.¹⁰ This would put total cost for lost productivity and direct health care costs at a combined \$326 billion dollars. If we assume a linear relationship between the relative safety of e-cigarettes and the lost lives and costs, and use Nutt, et al¹² we can predict a savings of \$309 billion and 456,000 lives in the US alone.

PURPOSE

The reason for this study was to gather some basic information on vaping health and to measure some demographics of vapers. There are 4 goals in this study

1. To identify those people who have 3 or more years of vaping experience, and see how their health has been affected by changing to e-cigarettes. While it might take longer than this to see some of the potential adverse health effects, it is extremely difficult to get many people who have been using e-cigarettes longer simply because of the limited time they have been available.
2. To look at those smokers who had no known health effects while smoking, and see what, if any, adverse health effects developed subsequent to starting to use e-cigarettes.
3. To see if those who never smoked before vaping were more likely to develop adverse health consequences as a result of vaping.

4. To measure demographics of e-cigarette users.

METHODS

The source of information was an electronic survey distributed through social media to groups of electronic cigarette users and paper surveys distributed to local e-cigarette shops in the Southeastern United States. Participation was voluntary and anonymous. Several members of the social medial groups shared the survey with friends or other groups. Because of the distribution avenue, an unknown number were completed via a national group. The majority of returned surveys were from the on line format. Over a period of 6 months, March to August 2015, there were 573 surveys returned. The vast majority (527) were from the online format questionnaire. The questionnaire was made up of 2 parts. The first was demographics, the second asked about the individual's health while smoking and then again while using electronic cigarettes.

The sub-groups analyzed were

1. Smokers who had reported no adverse health events while smoking (n=136).
2. E-cigarette users who had 3 or more years of usage (n=108).
3. E-cigarette users who had not been smokers prior to use of e-cigarettes (n=10)

All respondents were asked these questions regarding diagnoses of adverse health events both while smoking and while using e-cigarettes:

'While smoking cigarettes were you diagnosed with any of the following health conditions?'

'Since starting to use vapor products, have you been diagnosed with any of the following health conditions?'

These adverse health events were the following for both questions:

High Blood Pressure (hypertension), Diabetes, Irregular heartbeat, Palpitations, Heart disease, Heart attack, Stroke, Cancer of any sort, asthma, emphysema, Chronic bronchitis, acute bronchitis, peripheral vascular disease, amputations related to circulation problems, shortness of breath, recurring respiratory infections.

A different perspective would be to look not just at any newly diagnosed adverse health conditions either while smoking or while using e-cigarettes, but to also measure whether any of the conditions diagnosed while smoking had resolved after taking up e-cigarettes. So additionally respondents were asked this question:

'If you had any of these conditions' (the same conditions outlined above), 'since you started using vapor products, have any of them resolved? If so, which ones?'

Respondents were asked about their subjective feelings of health while smoking and after switching to vaping. They were asked to rate their perception of health on a 10 point scale with 1 being poorest and 10 being the best.

RESULTS

There were 108 participants who had been using electronic cigarettes for 3 or more years. The results of their reported adverse health events were reviewed and are shown in Figure 1. On average, they had 1.78 acute or chronic adverse events while smoking. While using electronic cigarettes, they admit to an average adverse event rate of 0.07 per individual. This represents a 96% reduction in adverse health events.

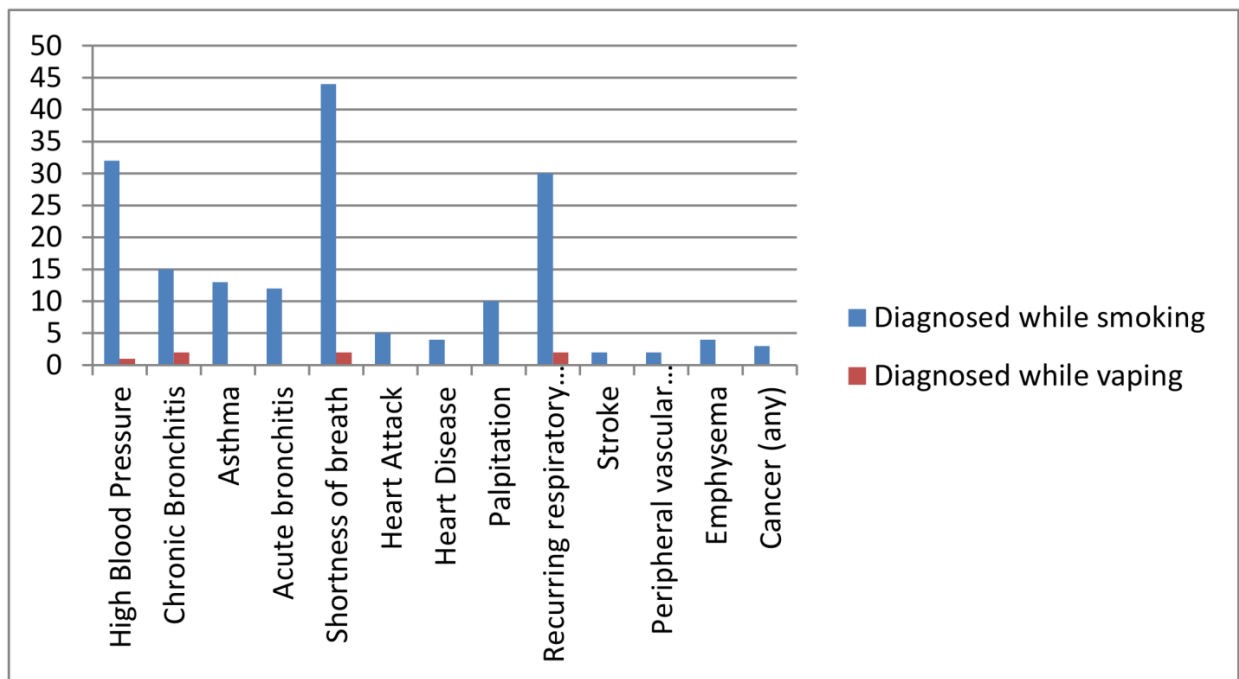


Fig 1

For the health problems that respondents reported developing prior to use of e-cigarettes, on average, respondents improved on or had resolution of 1.1 events. This is a 61.8% resolution rate of conditions that developed while smoking. The breakdown is shown in Figure 2. The largest change was in the subjective category of breathing (shortness of breath). There were also significant resolutions or improvements in Hypertension, recurring respiratory infections, palpitations and Acute or Chronic bronchitis. In the one person who reported a resolution of diabetes, which is not associated with smoking, it is possible that they had begun a healthier life

style that allowed discontinuation of their meds. This individual also reported a resolution of their hypertension.

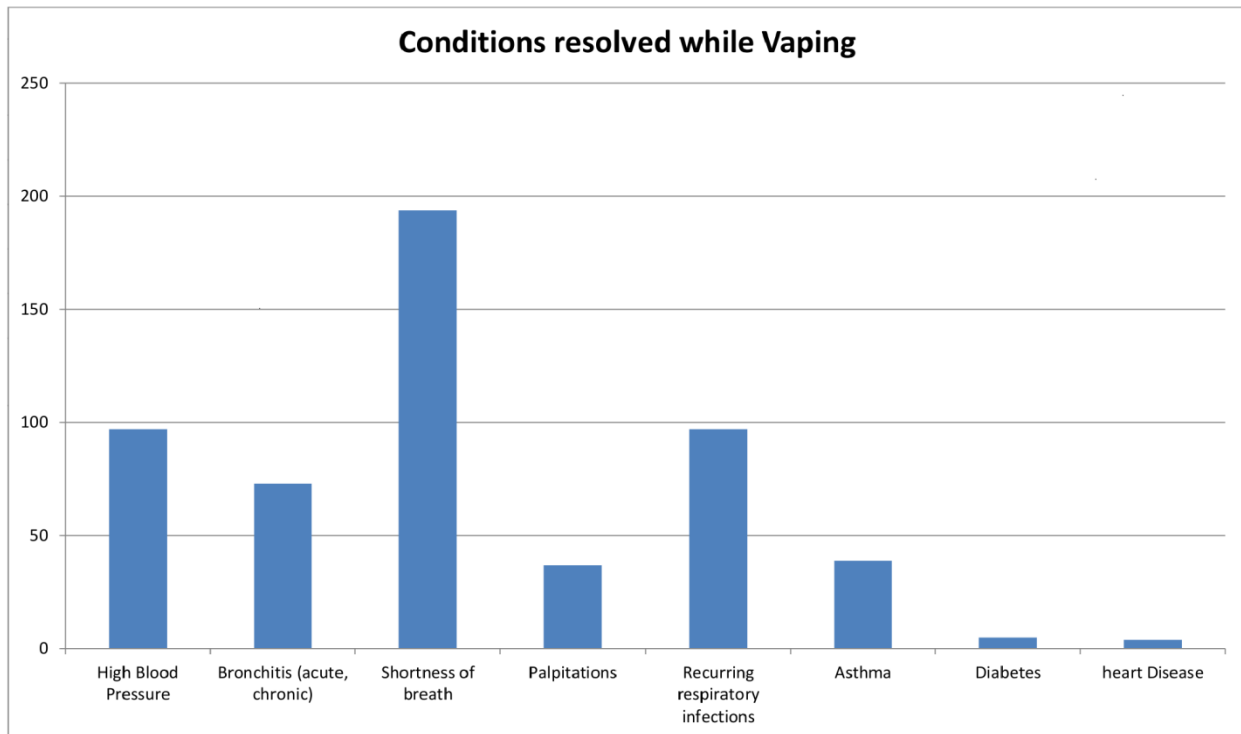


Fig. 2

Only one of 136 previous smokers, who had reported no adverse health events while smoking, developed any adverse health problems while using electronic cigarettes that could be potentially related to their use. In the group of previous never smokers who started use of electronic cigarettes, none reported developing any health problems as a result of use.

Ten out of the 573 people surveyed who admitted to be non-smokers prior to vaping. This represented only 1.7% of the total survey group. Using the CDC's statistic that 44% of those who start using e-cigarettes were susceptible to smoking, these 10 people represent about 6 people (~1% of the total group) who started to use these products with no susceptibility to smoke. There were none in this group who had reported any adverse health events prior to initiating use of e-cigarettes, and none of this group developed adverse health events after starting to use them. This survey agrees with others who have shown that there are very few people who start to use electronic cigarettes who were not already using combustible tobacco products.^{13, 14}

The results of the subjective assessment of health before and after starting to use e-cigarettes were consistent from the main group of respondents to both subgroups. For the general group, they rated their health while smoking at an average of 3.93, and after they switched to vaping

they had an improvement in their subjective health to an 8.27 average. (Figures 3 & 4) There were small variations between the subgroups, but the trend was the same. The group that started vaping with no prior cigarette use, also perceived their health as having improved by a similar margin, although they did have a slightly higher initial assessment of health at 4.25. These results are consistent with others who have assessed subjective health improvement.³

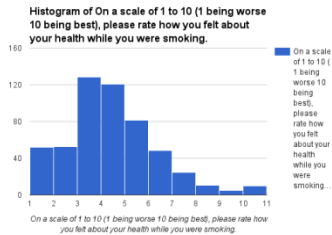


Fig. 3

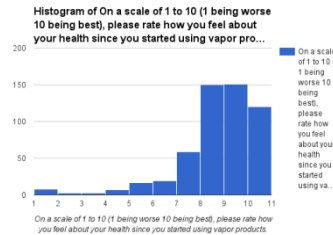


Fig. 4

DISCUSSION

Demographics

The demographics of smokers have been well studied^{15, 16}, but as yet, there is little information on the makeup of those who have made the switch to e-cigarettes. Questions were asked regarding race, education level, income and gender. Those who identify as white or Caucasian make up 90.5% of respondents. Asians made up 1.6%, Blacks or African Americans made up 1.2%, and Native Americans made up 1.4%. Both Caucasians and Native Americans made up more than their relative percentage of the population, based on the US Census Bureau statistics. (Fig. 5)

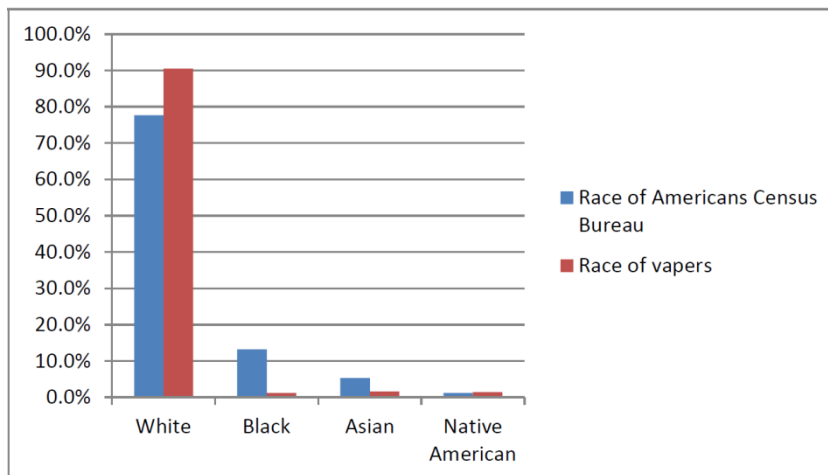


Fig. 5

This issue of racial disparity in vaping can be of consequences if vaping is definitively shown to reduce the harm of combustible tobacco products as African Americans and other minorities

have a higher prevalence of hypertension and cardiovascular disease than other racial or ethnic groups. Smoking is a major contributor to both of those diseases.

The gender distribution is shown in Figure 6. There is no surprise that males make up the majority (63.5%) of those using electronic cigarettes, as they are also in the majority in combustible tobacco products (56.5%)¹⁶. However the disparity between genders is greater in use of electronic cigarettes.

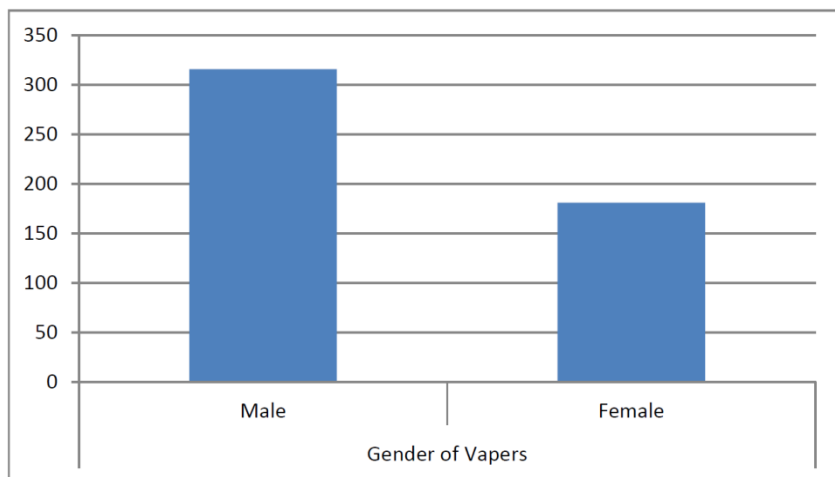


Fig. 6

The age distribution varied between the main group and the 3 subgroups measured. As measured among all respondents, the average age of all vapers was 36.38 years. Those who had 3 or more years experience were 3 years older with an average age of 39.36. Those who started vaping with no prior smoking were the youngest group by almost 6 years, with an average age of 30.63. Figure 7 is the distribution in age of all vapers who responded. There was a double peak. This largest group of users was in the 31-35 age group.

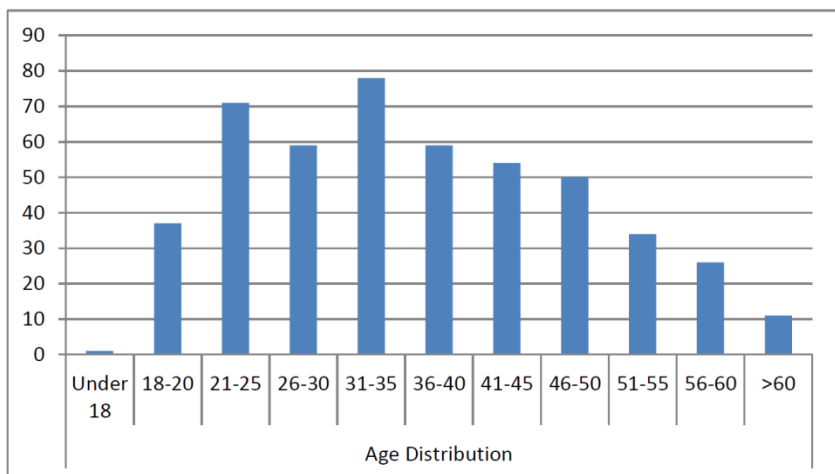


Figure 7

Education level also varied from the main group to the 3 year or more group. There was not enough data to draw conclusions from the previous never smokers group because of the

limited number of responses. The individuals who had 3 or more years of vaping tended to be better educated than the group in general with a higher percentage of college graduates and masters or doctoral degrees. See figures 8 and 9.

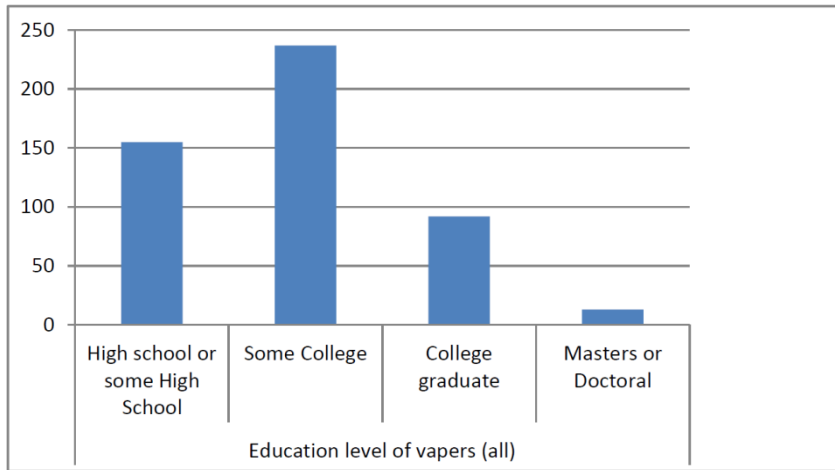


Figure 8

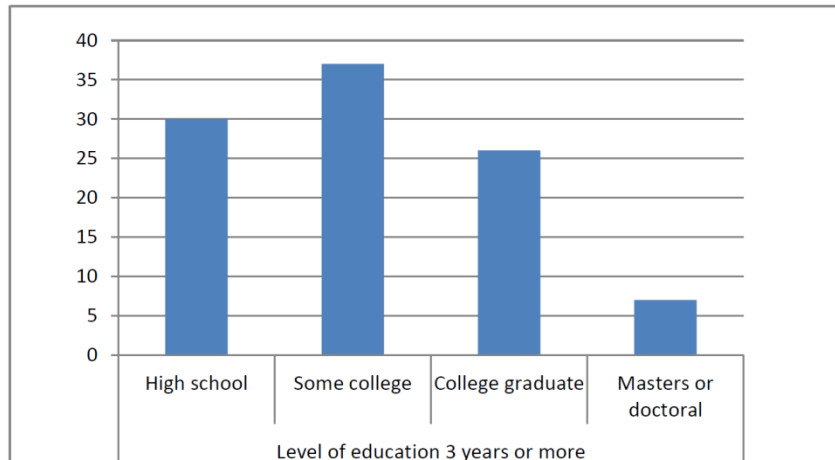


Figure 9

There was also an income difference between all vapers and those vaping 3 years or more. Figure 10 and 11

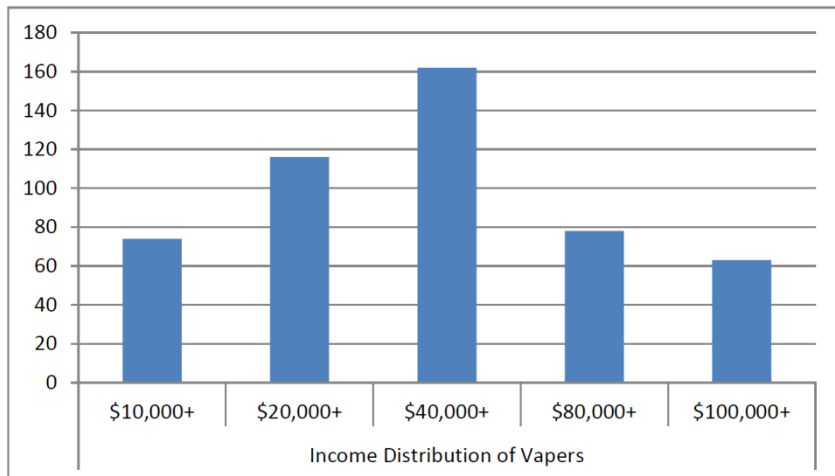


Figure 10

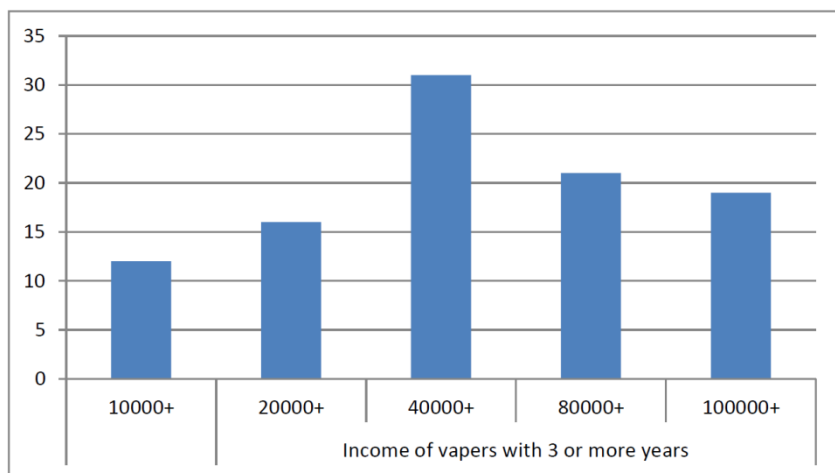


Figure 11

Vapers with 3 or more years of vaping experience tended to be older, have a higher level of education, and greater annual income than the general vaping population.

The survey also queried as to the strength of nicotine used. In older tanks, in order to achieve the needed nicotine delivery, the concentration of nicotine had to be higher. In more modern tanks, the amount of nicotine can be reduced in the liquid to achieve the same delivery. Also, the nicotine concentration would need to be higher in those who were heavy smokers in order to satisfy their needs. Figure 12 represents the distribution of nicotine concentrations in the liquids of the respondents. Approximately half of the respondents use a 3 mg concentration or less, and approximately 80% use 6 mg or less concentration.

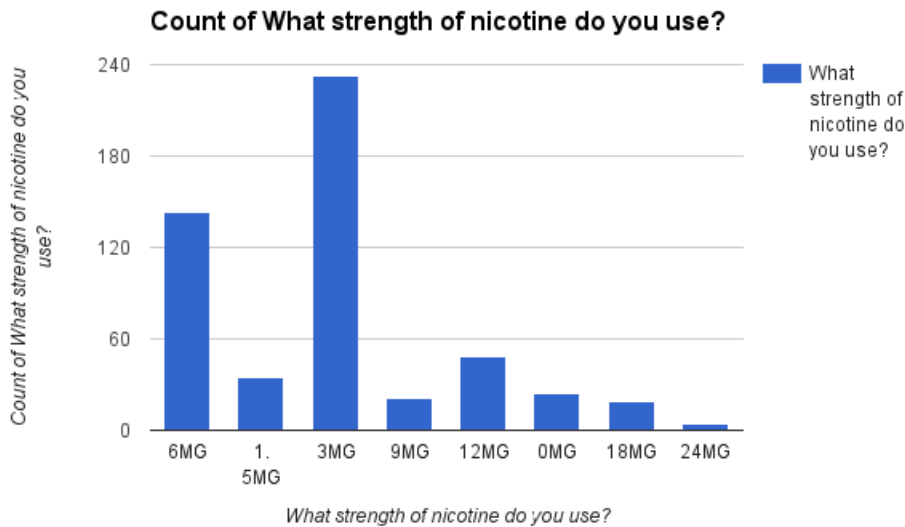


Figure 12

It's important to know the smoking history of respondents. The type of tobacco intake was asked and for cigarette smokers, how many packs per day (PPD) were consumed. Not surprisingly the survey showed a majority were regular cigarette users. They accounted for 93.9% of respondents. An additional 2.5 percent were social smokers, 2 percent used other tobacco products such as pipe, cigar and chewing tobacco. Only 1.7% had not used tobacco products previously. Figure 13.

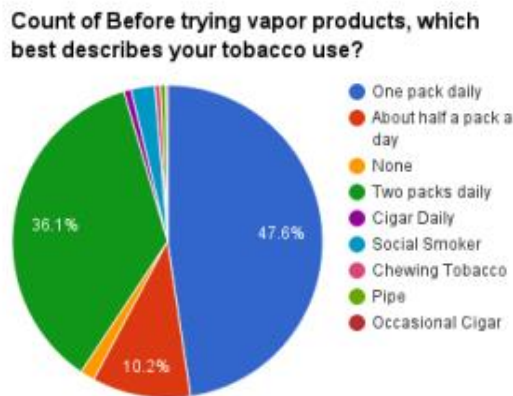


Figure 13.

Now that there has been extensive use of these products over several years, we can define the length of use of these products (Figure 14). It is of interest that 40.8% have been using for more than 2 years, and more than 10% of users have been more than 3 year users. Based on reviews of the growth of people using e-cigarettes, there were about 480,000 people using these products 3 years ago. If we assume the 10% of vapers now who were using e-cigarettes 3 years

ago is able to extrapolate to a national level using the Wells Fargo data¹⁷, there are about 250,000 of the original 480,000 people who are still vaping after 3 years. Thus, 52% of those vaping 3 years ago have continued to use the products. It is likely that, among the 48% of 3 or more year users who are no longer using e-cigarettes, a percentage of those have continued to abstain from smoking. This gives e-cigarettes a minimum of a 52% success rate in either smoking cessation or reduction at 3 or more years. Studies related to use of OTC and prescription nicotine replacement such as the patch, give an overall quit rate at 6 months of 6% to 7%.^{18,19}. This potentially gives electronic cigarettes at 3 years a success rate 7 to 8 times greater than the OTC nicotine patch or gum can achieve at 6 months.

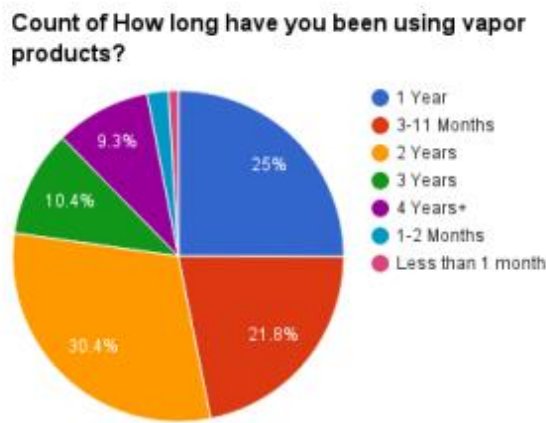


Figure 14.

Economic and Social Implications

Based on the results of this survey and a reduction in health events of 96% the annual savings on health care and lost productivity would be \$342 billion and there would be 462,000 lives saved if all smokers became e-cigarette users. The 1% of never smokers who are users of e-cigarettes will have a slight impact on the economic consequences; however, the immense benefit to society by encouraging the use of e-cigarettes far outweighs the risk to never smokers who are users.

Currently, the cost to consumer of electronic cigarettes is estimated to be significantly less than combustible tobacco products. According to statistics obtained from the CDC, the average annual cost of cigarette consumption for a smoker is about \$1480. While data is difficult to find on current consumer sales of electronic cigarettes, there was an estimate in 2014 by Wells Fargo that put annual cost of electronic cigarette use at \$1000 per user.¹⁷ This is a 32% discount compared to the cost of cigarettes, and would result in a savings of \$26.88 billion dollars to consumers if this technology is generally adopted.

Concern has been expressed about the never smokers who initiate e-cigarette use, especially in the pediatric population.^{20, 21} If e-cigarettes are in fact 95% safer than combustible tobacco products, that still exposes never smokers to a measurable, but unknown, risk if they initiate use. However, the impact on society in general from use of combustible tobacco products is enormous. Diversion of smokers away from these products would have a much greater benefit to society than the negative impact of never smokers taking up e-cigarettes. We cannot completely prevent never smokers from either vaping or smoking. It has been shown that 44% of e-cigarette users who were never smokers, were already at risk of smoking and that they would likely have been smokers had e-cigarettes not been available as a diversion.¹⁴ If that figure is applied to this survey, there were 6 people found who were not at risk for smoking, but who started e-cigarette use. Thus, the question becomes one of magnitude. Is it of benefit to society for 99% of vapers to have been reformed smokers when it is 95% safer than combustible tobacco products, and to allow a small increased risk of harm to less than 1% of those using e-cigarettes? Of note is that this survey did not intend to assess whether never smokers who started use of e-cigarettes subsequently were at risk of going on to become tobacco users. This 'gateway' risk has been looked at in other articles, and appears to be a negligible risk. In one study only 0.4% of regular e-cigarette users had been never smokers.²²

CONCLUSION

Most studies to date regarding the health effects of vapor products have focused on the toxins found in e-cigarette vapor, how those toxins affect the physiology of certain organ systems, how they impact cells in vitro, and then project the potential for harm based on how cigarettes affect the body with higher levels of toxins, assuming there is a linear progression of health events related to a linear decline in toxins.^{1, 2, 4, 5, 6} There have been few to no studies to show how vaping has actually affected the health of people who have been using these products over the last several years. It is important to study the physiology, but it is equally important to see what the outcomes have already been in vivo as the effects on the population, may not be easily projected by the measurable effects of these chemicals on tissue cultures alone. Even if some damage is shown in tissue cultures, this does not account for in vivo healing capabilities of the human body. There have been many years use of electronic cigarettes in the population which should allow us to identify individuals who have extensive time using these products. In this study we surveyed people using these products, found a significant subset who had been using them for in excess of 3 years and asked them how their health had been affected, based on self-reports of adverse health events.

Health effects related to changing to e-cigarettes were pronounced and very positive. In the subgroup of vapers with 3 or more years of use, adverse health events decreased from 1.78 while smoking to 0.07 after starting to vape. This amounts to a 96% reduction in self-reported

adverse health events, and would be predictable by the study of Nutt, et al¹². The group as a whole reported on average a decline of 1.1 (61.8%) adverse health events (resolution of existing condition, or improvement) after starting to vape. In the group of smokers who started vaping who had no prior reported adverse health events, new onset of adverse health events was unusual. There was only one out of 136 who reported new onset of health problems that could be related to use of e-cigarettes (respiratory), and one who reported onset of diabetes, which is not likely to be related to smoking. This is an incident rate of 0.8% in this subgroup.

This study found 108 individuals who had used electronic cigarettes in excess of 3 years. At least one had been a 7 year user. There was a significant reduction in self-reported adverse health events in the group who were 3 or more year users when compared to the same groups health while smoking. Additional Health surveys need to be done to identify those with extensive use of electronic cigarettes with an attempt to find people who have even more time of use than this study. While the number of never smokers using e-cigarettes is low in all studies, there are still enough of them to gather information as a basis of harm potential to never smokers as a result of use of vapor products. This study showed no increased adverse health events in the limited pool of 10 individuals found. We cannot assume that a 95% harm reduction in smokers means a 5% risk of harm to never smokers.

Significant demographics are reported for the e-cigarette user which measured the racial, gender, education, income, age, smoking history, and duration of use of e-cigarettes. These demographics show a predominantly male distribution (63.5%) in a similar but more pronounced shift as compared to cigarettes. E-cigarette use is predominantly by Caucasians (>90%). There is a small but measureable shift toward higher income, older individuals, and higher level of education in those who have been using e-cigarettes for 3 years or more. Of those using e-cigarettes, 99% were previously smokers only 1% began using e-cigarettes with no previous smoking history.

There is inequality in the distribution of vapers between gender and race. Many of the groups who would benefit from the harm reduction of e-cigarettes are not using them in sufficient numbers. This survey shows a significant reduction in hypertension in people who are able to successfully switch to vaping. In minority groups who have a higher incidence of hypertension and hypertensive related heart disease, using electronic cigarettes could result in a tremendous savings of life, medical expenses, and lost time from work. Keeping these products inexpensive, avoiding punitive taxes and encouraging smokers to try vaping if they have been unable to quit using other methods are going to be important to reverse the impact of years of damage from combustible tobacco products.

This study raises interesting questions regarding the health impact of use of electronic cigarettes on smokers. We know the risks related to smoking, but not specifically related to use

of e-cigarettes. In order to assess this there are significant numbers of people who have been using these products for many years. Additional studies should be done on this group so the questions of what, if any, risks are associated with the use of this new technology, and to assess if those risks are significantly lower than that of smoking. The risk to never smokers who take up vaping is still unknown and should be studied.

REFERENCES

1. Goniewicz ML, Knysak J, Gawron M, et al. Levels of selected carcinogens and toxicants in vapour from electronic cigarettes. *Tob Control*. 2014;23(2):133-139. <http://www.ncbi.nlm.nih.gov/pubmed/23467656>.
2. McAuley TR, Hopke PK, Zhao J, Babaian S. Comparison of the effects of e-cigarette vapor and cigarette smoke on indoor air quality. *Inhal Toxicol*. 2012;24(12):850-857.
3. van Staden SR, Groenewald M, Engelbrecht R, Becker PJ, Hazelhurst LT. Carboxyhaemoglobin levels, health and lifestyle perceptions in smokers converting from tobacco cigarettes to electronic cigarettes. *South African Med J*. 2013;103(11):865-868.
4. Romagna G, Alliffranchini E, Bocchietto E, Todeschi S, Esposito M, Farsalinos KE. Cytotoxicity evaluation of electronic cigarette vapor extract on cultured mammalian fibroblasts (ClearStream-LIFE): comparison with tobacco cigarette smoke extract. *Inhal Toxicol*. 2013;25(6):354-361. <http://www.ncbi.nlm.nih.gov/pubmed/23742112>.
5. Scheffler S, Dieken H, Krischenowski O, Förster C, Branscheid D, Aufderheide M. Evaluation of E-cigarette liquid vapor and mainstream cigarette smoke after direct exposure of primary human bronchial epithelial cells. *Int J Environ Res Public Health*. 2015;12(4):3915-3925. doi:10.3390/ijerph120403915.
6. Bahl V, Lin S, Xu N, Davis B, Wang YH, Talbot P. Comparison of electronic cigarette refill fluid cytotoxicity using embryonic and adult models. *Reprod Toxicol*. 2012;34(4):529-537.
7. Benowitz NL, Gourlay SG. Cardiovascular toxicity of nicotine: Implications for nicotine replacement therapy. *J Am Coll Cardiol*. 1997;29(7):1422-1431.
8. Farsalinos KE, Polosa R. Safety evaluation and risk assessment of electronic cigarettes as tobacco cigarette substitutes: a systematic review. *Ther Adv Drug Saf*. 2014;5(2):67-86. doi:10.1177/2042098614524430.
9. Farsalinos KE, Tsiapras D, Kyrzopoulos S, Savvopoulou M, Voudris V. Acute effects of using an electronic nicotine-delivery device (electronic cigarette) on myocardial function: comparison with the effects of regular cigarettes. *BMC Cardiovasc Disord*. 2014;14:78. <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4077146&tool=pmcentrez&rendertype=abstract>.
10. Department of Health U, Services H, for Disease Control C, Center for Chronic Disease

Prevention N, Promotion H, on Smoking O. Executive Summary (The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General).

11. Xu X, Bishop EE, Kennedy SM, Simpson SA, Pechacek TF. Annual healthcare spending attributable to cigarette smoking: an update. *Am J Prev Med*. 2015;48(3):326-333. doi:10.1016/j.amepre.2014.10.012.
12. Nutt DJ, Phillips LD, Balfour D, et al. Estimating the Harms of Nicotine-Containing Products Using the MCDA Approach. *European Addiction Research*. 2014:218-225.
13. Bhatnagar A, Whitsel LP, Ribisl KM, et al. Electronic cigarettes: a policy statement from the American Heart Association. *Circulation*. 2014;130(16):1418-1436. doi:10.1161/CIR.000000000000107.
14. Health CO on S and. Smoking and Tobacco Use; E-Cigarettes; Youth Intentions. http://www.cdc.gov/tobacco/basic_information/e-cigarettes/youth-intentions/index.htm. Accessed September 26, 2015.
15. CDC - Fact Sheet - Current Cigarette Smoking Among Adults in the United States - Smoking & Tobacco Use.
16. CDC - Fact Sheet - Fast Facts - Smoking & Tobacco Use.
17. WELLS FARGO SECURITIES, LLC Tobacco EQUITY RESEARCH DEPARTMENT 2 Exhibit 1. Examples of eGo Tanks and Mods (VTMs).
18. Hughes JR, Shiffman S, Callas P, Zhang J. A meta-analysis of the efficacy of over-the-counter nicotine replacement. *Tob Control*. 2003;12(1):21-27. doi:10.1136/tc.12.1.21.
19. Shiffman S, Rolf CN, Hellebusch SJ, et al. Real-world efficacy of prescription and over-the-counter nicotine replacement therapy. *Addiction*. 2002;97(5):505-516. doi:10.1046/j.1360-0443.2002.00141.x.
20. Durmowicz EL. The impact of electronic cigarettes on the paediatric population. *Tob Control*. 2014;23 Suppl 2:ii41-ii46. doi:10.1136/tobaccocontrol-2013-051468.
21. Bunnell RE, Agaku IT, Arrazola RA, et al. Intentions to smoke cigarettes among never-smoking US middle and high school electronic cigarette users: National Youth Tobacco Survey, 2011-2013. *Nicotine Tob Res*. 2015;17(2):228-235. doi:10.1093/ntr/ntu166.
22. Schoenborn, C and Gindi R. Electronic cigarette use among adults: United States, 2014. 2015;(217).