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Vaping Is Far From Harmless

1. Vicki Beckmann exhales a thick, sweet-smelling mist into the air of Vapor Worx, an e-cigarette shop in St. Charles, Missouri. "I like more of the fruity stuff," she says of the e-cigarette flavorings that line the walls of the shop.

2. Beckmann, an employee of Vapor Worx, began using an e-cigarette to quit regular cigarettes four years ago. She convinced her father to do the same. Her dad was warned smoking would kill him, she says. "I told him, just try it, and I'll buy it for you." Now, he's been cigarette free for three years, she says. And Beckmann is slowly lowering the levels of nicotine in the "juice" that fills his e-cigarette device. "He doesn't wake up in the morning coughing all the time anymore. He just generally feels better," she says.

3. As e-cigarettes take off in popularity, Beckmann's story is not unique. The devices, which contain no tobacco but instead use heat to vaporize a nicotine-laced liquid, can be seen as a less toxic alternative to traditional cigarettes.

4. Where you find smokers, you'll find demand for e-cigarettes or "vaping" products, and Missouri is no exception, with 21% of adults smoking tobacco, one of the higher rates in the country. E-cigarettes first emerged online in the mid-2000s, and the business has since grown to become a $6 billion industry worldwide, eclipsing the total sales for all nicotine replacement therapy products. Today, it's estimated that the industry is growing at an estimated rate of 42% per year, in part due to spending by big tobacco companies as they buff up their versions of e-cigs.

5. There are now hundreds of different devices and thousands of different flavors for those devices. But the hazy, lazy days at the vape shop may be numbered. This May, the FDA ruled that e-cigarettes products will be subject to the same regulation applied to cigarettes. In addition to prohibiting the sale of e-cigarettes to those under 18, this means that manufacturers and retailers of vapor "juices" will have to register ingredients with the FDA, a process that could be onerous and expensive for small operators.

6. For now, Vapor Worx owner Cliff Brown is waiting to see how it all plays out. "We have no idea of who is really going to be policing it," he says.

7. The reason for the confusion among health researchers and retailers is that an e-cigarette is not just one single device or chemical, making it hard to track and regulate. E-cigarettes can work in a couple of different ways. The most common are pen-shaped rechargeable devices that have a refillable tank that holds a nicotine-laced liquid flavor compound. The liquid is then vaporized but not burned by a heating element to produce an aerosol that delivers nicotine to the user. Many people assume that e-cigarettes are less toxic than standard cigarettes, but there is little data to back that up.

8. But if someone is trying to switch to e-cigarettes from cigarettes, are they ultimately doing themselves a favor? "The short answer, is no," says Dr. Stanton Glantz, a professor of medicine at the University of California, San Francisco. Glantz analyzed a number of different studies that examined the use of e-cigarettes in quitting smoking. He found that use of e-cigarettes in fact lowered a person's chance of successfully quitting cigarettes by 28%. This aligns with another recent study that found that the most successful way to quit smoking is to go cold turkey instead of slowly weaning off cigarettes. "The evidence is quite consistent that, for most people, they make it harder to quit," Glantz says. "That doesn't mean that some people don't use some to quit. They do, but that's a small fraction."

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9. Not everyone has come to the same conclusion, though. Muhannad Malas, a researcher at the University of Toronto, says that the lack of long-term randomized placebo-controlled studies has been problematic. In lieu of those, reviews of observational studies, like Glantz's, are the next best thing. Malas's own review of more than 60 studies comparing e-cigs with smoking cessation aids found that they may be helpful for some smokers in quitting or reducing their cigarette smoking but, "the evidence was definitely inconclusive."

10. The more scientists learn about e-cigarettes and their impact on human health, the more complicated the picture becomes. For one, no one knows exactly how toxic these products are because their use varies from person to person. And, contrary to what marketing materials may say, e-cigarettes produce a lot more than just "harmless" water vapor.

11. E-cigarette juice contains a mix of propylene glycol, glycerin, nicotine, and flavoring agents approved by the FDA as "Generally Recognized As Safe" (GRAS) for consumption. When this mix is heated, a group of compounds known as carbonyls are produced. This includes compounds such as formaldehyde and acrolein. While cigarettes generally produce a thousand times more carbonyls because of the combustion process, e-cigarettes produce a varying amount depending on the ratio of glycol to glycerin in the vaping fluid and how much of it is heated, says Daniel Conklin, an environmental cardiologist at the University of Louisville.

12. Conklin has investigated how e-cigarettes might affect cardiovascular disease using a type of mouse bred with a disorder that mimics heart disease seen in humans. Acrolein is of particular concern because it is considered to be the main contributor to the increased risk of cardiovascular disease among cigarette smokers, he says.

13. For 12 weeks, the animals were exposed to traditional cigarette smoke and an e-cigarette aerosol at two concentrations of nicotine, ten and 36 milligrams per milliliter, which spans the range of nicotine usually found in electronic cigarette juices. The mice were also exposed to acrolein by itself at 0.5 and 1 parts per million (levels typically found in cigarette smoke). Lastly, a group of mice were exposed to just nicotine in water.

14. One puff of an e-cigarette is probably less toxic than a traditional cigarette, but we don't know how many puffs the typical e-cigarette user is taking. Unsurprisingly, standard cigarette smoke had the greatest effect, increasing atherosclerosis risk about three times over the baseline. Oral nicotine doubled atherosclerosis risk, while acrolein "seemed to have a dose dependent increase" with risk doubling at higher levels. E-cigarettes seemed to also have a dose dependent result. At the higher concentration, 36 milligrams per milliliter of nicotine, the e-cigarette aerosol doubled the risk of atherosclerosis. Even nicotine alone appeared to induce atherosclerosis acceleration in mice, Conklin noted.

15. Although he stresses the limitations of one experiment performed on mice, they are cause for concern. He also stresses that how these products are used changes rapidly. For example, some e-cigarettes can be tweaked to deliver more vapor. "There is some concern that we don't really know how much aldehyde like acrolein is being generated by these modifiable electronic cigarettes."

16. How e-cigarettes are used also adds to the confusion. While there is decades worth of data on how a traditional cigarette is smoked, there is little consistency in how e-cigarettes deliver nicotine and flavor compounds. One study found that these products might deliver different levels of nicotine during each use and there were significant differences between "labeled and true levels" of nicotine in juices. One puff of an e-cigarette is probably less toxic than a traditional cigarette, but it's not known how many puffs the typical e-cigarette user is taking. "We don't really know what that frequency does to the health outcome," Conklin says.

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17. Back at Vapor Worx, Beckmann tells me that she used to smoke real cigarettes "for the calming effect more than anything," she says. "I can't really say that I enjoyed the flavor of it." Just as there is no standard use pattern for e-cigarettes, it's impossible to pin down a single taste preference for vaping. There are thousands of different flavors, ranging from those that mimic a cigar to bubblegum or blueberry.

18. When Beckmann was able to switch to e-cigarettes, she found the fruity flavors "more enjoyable," she says. "For my dad it was the opposite. It just depends on each individual."

19. E-cigarette fluids come in myriad flavors, which can produce potentially dangerous compounds when heated. The profusion of flavors further complicates the public health picture. Though the different flavors are approved by the FDA as safe for consumption, the environment in the stomach is very different from the lungs.

20. Take popcorn flavoring, for example. Back in 2000, eight workers from a microwave popcorn processing plant became sick with severe lung disorder, later dubbed "popcorn lung." A subsequent investigation linked their sickness to airborne exposure to butter flavoring chemicals including diacetyl, which is used in a variety of food products. How diacetyl and similar compounds might damage lungs isn't understood, but one hypothesis suggests that these chemicals impair the function of immune cells in the respiratory system. Regardless, the chemical is now categorized under OSHA regulations as an "inhalation hazard". Flavor compounds could suppress immune function more broadly than cigarettes. Beckmann is aware of the dangers of diacetyl, and she says that flavor makers are phasing it out, and if they're not, they'll have disclaimers. "We stay away from it."

21. In one recent experiment, scientists examined the effect of cinnamon-flavored e-cigs containing cinnamaldehyde on tissue cells from smokers' nasal cavities. The cinnamaldehyde-containing e-liquids seemed to compromise the function of immune cells such as macrophages, natural killer cells, and neutrophils. The same researchers, led by toxicologist Ilona Jaspers at the University of North Carolina, also took tissue samples from non-smokers, cigarette smokers, and e-cig users to study the impact of smoke and vapor on immune gene function. As expected, smokers' samples showed suppression of immune genes in the nasal mucosa. E-cig users not only had the same immune gene changes, but they also showed suppression of additional immune genes, suggesting that the flavor compounds could suppress immune function more broadly than cigarettes.

22. For scientists it just adds to the growing list of unknowns. There are over 7,000 flavors right now and several hundred e-cig products and probably hundreds more if you include modified versions, Conklin says. Combined with how frequently people are vaping, he adds, "it's not clear at all how that influences the toxicity."

Kicking the Habit

23. If vapor devices were just used to transition away from cigarettes, they might not cause an alarm among public health researchers. But the products are also quickly becoming popular with young people who don't smoke at all. A recent survey from the CDC found that 32% of highschoolers reported trying cigarettes, while 45% have used electronic vapor products.

24. The new regulation from the FDA should help keep vapor devices away from teenagers, but what's less clear is if the laissez-faire vaping culture helps or hinders more people trying to quit cigarettes.

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25. Despite stories like Beckmann's, "for most people, they inhibit quitting," Glantz says.

26. I found my way to Beckmann's shop because, like her, I wanted to help my father kick his pack-a-day habit. But, then I wondered: if he succeeds in switching from a pack of cigarettes to hundreds of daily puffs of a cigar-flavored vapor, will that make a notable dent in his cardiovascular health? So far, it's a moot point because he has yet to try the vapor products we bought him months ago. And therein lies the problem: everyone's addiction and smoking preferences are different.

27. Methods for quitting cigarettes can vary widely by the individual, but those who are using smoking cessation devices found more success when part of a counseling program, Glantz says. "It may be that informal use of nicotine replacement keeps people smoking, as opposed to when it's consciously being used as part of a supportive smoking cessation effort."

28. No matter who manufactures or sells e-cigarettes, the end result is the same. "You're inhaling hot aerosol ultra-fine particles, aldehyde and nicotine," Glantz says, "and that's not so good." "There's a lot we don't know about e-cigarettes," he adds. "But I think we already know enough to know that they are less dangerous than a cigarette, but they're not safe."

29. The medical community must prepare itself to face the new challenge concerning e-cigarettes and vaping as a "harm reduction" tool. As a consequence of past lessons learned from "Big Tobacco" companies, the medical community is suspicious of e-cigarettes and has routinely advised against their use. The medical community advises on the side of caution, indicating that very little scientific evidence is available to show, one way or the other, that e-cigarettes are safe to use, or that they help in the smoking cessation process. In addition, many physicians fear that patients who vape are merely substituting one form of nicotine addiction for another.

30. While there are certainly potential perils associated with vaping, smoking, the leading cause of preventable disease in the United States, is likely to be more dangerous than vaping, especially when considering the myriad of known toxins found in cigarette smoke and the diseases which they promote. Assuming this premise is true, what should the primary medical focus be for a patient who has successfully transitioned from conventional cigarettes to e-cigarettes? Should it be to maintain smoking abstinence, or should it be to quit vaping? Would it not be prudent for a patient who is unwilling to quit smoking or give up nicotine to vape instead of smoke? Given these circumstances, how should patients be advised?

31. The potential health hazards of nicotine addiction from smokeless tobacco products have previously been reviewed in a policy statement by the American Heart Association and include hemodynamic effects, endothelial dysfunction, thrombogenesis, systemic inflammation, and other metabolic effects.

32. Understandably, the medical community is concerned that increased availability of e-cigarettes could increase worldwide nicotine dependence, especially among the young as they are enticed by the various flavor options e-cigarettes have to offer. Since vaping does not produce smoke from burning tobacco, the opponents of e-cigarettes fear that traditional smokers will substitute vaping for smoking in settings where smoking is not permitted without any real intention of quitting conventional cigarettes. Furthermore, vaping in public places, coupled with recent e-cigarette commercials on national television, could possibly undermine or weaken current antismoking regulations. Health care professionals will need to consider and weigh what is more harmful to the public, continued smoking or increased nicotine addiction. As e-cigarettes gain greater popularity among smokers, these challenges will undoubtedly occur with increasing frequency.

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Consumer-Based Surveys

33. Surveys have shown that awareness of e-cigarettes has quadrupled between 2009 and 2011 and that they have a high adoption rate among traditional smokers. Many current and ex-smokers use e-cigarettes as a nicotine replacement therapy (NRT) to help them reduce or quit smoking while others use e-cigarettes as a less harmful alternative to smoking. It is possible that the decreased daily consumption of conventional cigarettes among e-cigarette users, as seen in some studies, is at least partially due to a psychological element involving smokers' motivation to quit.

34. A concern of the FDA and the medical community is that availability of e-cigarettes will entice teens and young adults toward vaping, which could ultimately lead to smoking conventional cigarettes. Currently, there is little or no concrete evidence confirming the validity of this concern. Cho et al. used data collected from a Korean Health Project to determine awareness and use of e-cigarettes. They found that 10.2% of 4353 students were aware of e-cigarettes, but only 0.5% of those students had actually tried e-cigarettes.

35. Pepper et al. conducted a national online survey of 228 male adolescents (ages 11–19) and determined that $<1\%$ of these individuals actually tried e-cigarettes. On the other hand, 67% of the respondents were aware of e-cigarettes with awareness being higher among the older boys. Of those individuals who never tried e-cigarettes, 18% were willing to experiment with no preference toward flavored versus unflavored e-cigarettes. Other strong correlates of e-cigarette use among adolescents include male gender, and having parents who smoke. While a small percentage of young non-smokers experiment with e-cigarettes, it is more likely that young smokers will experiment with e-cigarettes. One fact emerges from these studies; as e-cigarette popularity increases, so does awareness of them among young individuals. How increasing awareness will ultimately affect e-cigarette usage by adolescent and young adults remains to be seen.

Chemical Analysis of E-Cigarette Cartridges, Solutions, and Mist

36. The ingredients found in e-cigarette cartridges and solutions are relatively few, and for the most part non-toxic and non-carcinogenic, especially in the low quantities delivered. They include nicotine, propylene glycol, glycerin, and tobacco flavoring. Propylene glycol, an FDA-approved solvent used in foods, a vehicle for intravenous diazepam, and as the major ingredient found in e-cigarette fluids, makes up about 90% of the solution.

37. Certain contaminates, most of which are derived from tobacco flavoring, have been detected in e-cigarettes. A small amount of diethylene glycol (approximately 1%), a known carcinogen and an ingredient in anti-freeze, was also detected in one out of 18 cartridges analyzed by the FDA. The source of the diethylene glycol contamination is not clear but could reflect the use of non-pharmaceutical grade propylene glycol. In comparison, cigarette smoke from burned tobacco products contains thousands of compounds, many of which have been shown to induce or promote carcinogenesis; specifically the trace metals (i.e., cadmium, arsenic, chromium, nickel, and lead), the tobacco specific N-nitrosamines (TSNA), the polycyclic aromatic hydrocarbons (PAHs), and the volatile organic compounds (VOCs).

38. While investigations have shown some of these hazardous compounds to be present in e-cigarette cartridges, solutions, and mist, there are only a few reports detecting levels of these contaminates high enough to be of significant risk to humans. The HNZ study found levels of arsenic cadmium, chromium, nickel, and lead to be undetectable in e-cigarette cartridge liquid. In contrast, Williams et al. found levels of lead, chromium, and nickel in e-cigarette aerosol to be equivalent to, and in some cases higher than, what has been reported for cigarette smoke. They

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indicate that the primary source of these trace metals are the filaments inside the e-cigarette cartomizer (i.e., the aerosolizing component of the e-cigarette), and conclude that improved quality control of e-cigarette design and manufacturing would greatly reduce the presence of these trace metals.

Nicotine Content, Delivery, and Pharmacokinetics

39. E-cigarettes are designed to deliver nicotine in an aerosolized manner that simulates an authentic smoking experience without the real smoke. For e-cigarettes, the nicotine is delivered through cartridges prefilled with a nicotine solution or cartridges that the user fills with a nicotine refill solution. In either case, the nicotine concentration of the solutions or cartridges can be purchased in strengths ranging from 0 to 24 mg or more, according to user preference. Unfortunately, the amounts of nicotine specified on the labels of various brands of e-cartridges and solutions have not always been accurate or consistent. The FDA confirmed the ability of e-cigarettes to deliver nicotine, but stated there is too much variability in the amount of nicotine delivered per puff of any e-cigarette cartridge for them to be considered safe.

40. Vansickel and Eissenberg also reported an increase in heart rate, which is not surprising since smoking and nicotine have long been known to stimulate heart rate and blood pressure. It is interesting to note that the 2010 Vansickel et al. study, and in Czogala et al., heart rate and nicotine levels were significantly increased in smokers, but not vapers. However, the 2013 Vansickel and Eissenberg study reported that both smoking and vaping-induced similar concomitant increases in heart rate and blood levels of nicotine.

41. As suggested by Farsalinos et al., this discrepancy could be attributed to differences in experimental design, and puffing topography of the participants in each study (i.e., different daily durations of vaping, experience with e-cigarette devices, personal puffing characteristics to include the amount of vacuum created on every puff, and the vaping-induced deposition of nicotine into the oral cavity and / or size of the aerosolized particles).

42. Trtchounian et al., determined that smoke / aerosol density remained fairly constant while puffing on a conventional cigarette from start to finish (approximately 10 puffs), although variations did exist between brands of conventional cigarettes. The aerosol density for e-cigarettes, while higher than conventional cigarettes in three out of the four brands tested, also remained fairly constant for the first 10 puffs of a new e-cigarette cartridge. However, a decremental decrease in aerosol density was observed as each cartridge approached its terminal life. Consequently, this decrease in aerosol density would require the person vaping to generate more vacuum to maintain an aerosol density equivalent to the initial puffs and could be a reason contributing to longer puff duration for electronic cigarettes than for conventional cigarettes. Similar variations in the rate of airflow required to produce aerosol between and within brands of e-cigarettes were also reported by Williams and Talbot (86). According to Goniewicz et al., these studies demonstrate the importance of the initial nicotine content, the efficiency of the vaporization process that determines how much of the nicotine gets aerosolized, and the individual's puffing topography on the efficacy of nicotine delivery from e-cigarettes.

43. Many smokers claim that smoking cigarettes increases cognitive awareness, reduces stress, and induces a pleasurable feeling of wellbeing. Consequently, this is what makes smoking cigarettes so enjoyable and addictive. It is suggested that smoking has some psychological beneficial effects relating to job performance, vigilance, and mnemonic tasks, and that these effects are induced by nicotine, the addictive ingredient in tobacco. Similar effects have also been noted in non-smokers after a single dose of nicotine, and it is also worth mentioning that nicotine may have an ameliorating effect on both Parkinson's and Alzheimer's patients.

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44. Dawkins et al. found a decrease in the desire to smoke and reduced withdrawal symptoms associated with tobacco abstinence (1–10 h) among smokers vaping e-cigarettes with nicotine in comparison to e-cigarettes without nicotine. Furthermore, the nicotine from the e-cigarette also improved prospective memory and working memory performance. Nicotine is a central nervous system (CNS) stimulant, and as such it is possible that a psychological need to enhance cognitive functioning reinforces addiction in smokers. Nicotine is also known to stimulate adrenergic and dopaminergic neurons in mesolimbic areas of the brain involved with reinforcing pleasurable reward behavior.

45. Monoamine oxidases (MAO) normally reduce nicotine-induced adrenergic and dopaminergic activities by oxidizing them to inactive metabolites, and thereby limiting reward behavior. For cigarette smokers, however, nicotine is made even more addictive by synergizing with MAO inhibitors known to be present in cigarette smoke. Supporting evidence has been shown by Fowler et al. in which the activities of both MAO-A and MAO-B were reduced in various brain regions of smokers but not of non-smokers. Lewis et al. indicate that there are at least six different MAO inhibitors present in cigarette smoke. In contrast, Laugesen et al. were unable to detect any MAO inhibitors in e-cigarette cartridges or the inhaled aerosol mist. These studies suggest that nicotine from e-cigarettes and other FDA-approved NRTs may be less addictive than nicotine from burned tobacco products, and may be the reason why e-cigarette users report a suppression of smoking and nicotine cravings. These investigations support the rationale behind NRT treatment for smoking cessation, which is that nicotine from NRTs, and possibly e-cigarettes, does not occupy the nicotinic receptors to the same extent as nicotine from tobacco smoke. The effect is reducing withdrawal symptoms and cravings for cigarettes while possibly still providing some enhanced cognitive awareness and pleasurable reward.

Clinical and Physiological Effects of Acute Vaping

46. The harmful effects of smoking on human health are obvious and well documented. In contrast, effects of vaping on human health are inconclusive due to the extreme paucity of empirical research investigating the presence of vaping-induced health hazards and / or benefits. Few studies have actually reported deleterious effects of vaping. In one report, McCauley et al. present a case study concerning a 42-year-old woman diagnosed with exogenous lipoid pneumonia due to e-cigarette use. She presented with a 7-month history of dyspnea, productive cough, and fevers which coincided with her use of e-cigarettes. Samples of her sputum, and bronchoalveolar lavage revealed lipid-laden macrophages. Glycerin, an ingredient added to e-cigarette solutions for the purpose of producing visual smoke when vaping, was thought to be the causative agent.

47. Computed axial tomography (CAT) images of her lungs revealed areas of patchy ground glass superimposed on interlobular septal thickening, a pattern typical of a restrictive ventilatory defect with diffusion impairment, and consistent with the patient's diagnosis. Cessation of e-cigarette use resulted in improvement of her symptoms that was verified by follow-up lung radiography, however, pulmonary function testing still indicated mild diffusion impairment. Since the case study does not reveal if the patient is a current or ex-smoker and for how long, it is unclear whether the persistent diffusion impairment is a result of a concurrent or previous smoking habit, the use of e-cigarettes, or the after effects of lipoid pneumonia per se.

48. In another report, Vardavas et al. found that 5 min of acute vaping among healthy smokers had no effect on basic pulmonary parameters [i.e., forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC), peak expiratory flow (PEF), or midexpiratory flows at 50 (MEF50) and 75 (MEF75) percent]. This is in agreement with Flouris et al. who reported the FEV1 / FVC ratio after acute vaping to be non-significantly reduced by 3.0%. This study, also reported the FEV1 / FVC ratio after acute tobacco smoking to be significantly reduced by 7.2%.

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49. Vardavas et al. did find decreased amounts of exhaled nitric oxide and increased peripheral airway resistance and impedance in smokers who vaped for 5 min. From these results they concluded that acute vaping has "immediate adverse physiological effects similar to some of the effects observed with smoking" but that the long-term health effects of vaping are not known and potentially harmful. The authors went on to qualify their conclusion by stating that although the differences in exhaled nitric oxide, airway resistance, and impedance were statistically significant, the differences are probably not clinically important.

50. It is possible that the increased airway resistance and impedance demonstrated by Vardavas et al. is partially due to the nicotine inhaled from the e-cigarettes. Evidence for this is seen in a study reporting that non-smokers who inhaled nicotine (0–64 mg / ml) showed a dose-dependent increase in both the amount of coughing and airway obstruction, suggesting that nicotine stimulates afferent nerve endings in the bronchial mucosa which then triggers parasympathetic cholinergic pathways leading to bronchoconstriction.

51. In recent years there has been an effort to clinically use exhaled nitric oxide as an important non-invasive adjunct to pulmonary function testing in order to monitor the degree of airway inflammation and eosinophilia commonly observed in conditions such as asthma. Unfortunately, interpretation of exhaled nitric oxide levels in the clinical setting is complex and confusing requiring adjustments for gender, age, height, respiratory infection, allergies, and smoking. Given these difficulties, its validity is controversial. The major consensus in the literature is that the amount of exhaled nitric oxide is reduced in long-time smokers, as compared to non-smokers. In addition, it has been shown that smoking cessation is associated with an increase in exhaled nitric oxide back toward non-smoker levels.

52. A possible mechanism of action for the opposing relationship of exhaled nitric oxide in smokers versus non-smokers could be the high levels of carbon monoxide present in cigarette smoke since there is strong evidence suggesting that carbon monoxide inhibits nitric oxide production by blocking nitric oxide synthase activity. This mechanism is unlikely to occur with long-term vaping since carbon monoxide levels in e-cigarette mist are negligible.

53. Bahl et al. investigated the effects of a number of e-cigarette refill fluids on cultured human embryonic stem cells (hESCs), and human pulmonary fibroblasts (hPFs) and found that nicotine in e-cigarette refill fluids had no effect on hESC or hPF cytotoxicity at any concentration. However, they did report a positive correlation between hESC cytotoxicity, and the number and concentration of other chemicals used to flavor e-cigarette refill fluids.

54. Similar results were published by Romagna et al. who demonstrated that an extract of e-cigarette mist was less cytotoxic to cultured murine fibroblasts than an extract of tobacco cigarette smoke. A further indication that there are differences in the inflammatory responses between vapers and smokers is illustrated in a study reporting an absence of increased inflammatory indices in smokers asked to vape for 30 min compared to smokers who were asked to smoke for 30 min. Acute smoking has long been known to increase white blood cell count, which is a sign of acute inflammatory load. Flouris et al. were able to confirm elevations of white blood cell count, lymphocyte count, and granulocyte count in active smokers but not in active vapers. Support for this is seen in a recently published case report where a 36-year-old male with a nine pack-year history of smoking exhibited reversal of chronic idiopathic neutrophilia symptoms after he quit smoking and started vaping.

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Conclusion

55. Despite the popularity e-cigarettes have gained worldwide, very little rigorous research has been done regarding the effects these devices have on human health. When compared to the harmful effects of smoking, studies suggest that vaping could be used as a possible "harm reduction" tool. There is evidence supporting e-cigarettes as an aide for smoking cessation, at least as successful as currently available FDA-approved NRTs.

56. Less evidence exists to suggest that e-cigarettes are effective in recovery from nicotine dependence. More rigorous research is essential before any solid conclusions can be drawn about the dangers, or usefulness of e-cigarettes. In particular, more rigorous research is required delving into both acute and long-term cardiopulmonary effects of vaping, especially those experiments comparing the effects of vaping with those of smoking.

57. E-cigarettes are fast becoming a new "tobacco" industry that could reduce the incidence of traditional smoking. It is also possible that e-cigarettes may either decrease or increase the incidence of nicotine addiction. Given these uncertainties, will the availability of e-cigarettes provide for healthier world populations, as harm reductionists hope, or will other more dangerous ill effects ultimately emerge?

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