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Published on *IVT Network* (http://www.ivtnetwork.com)

Microbial Contamination Concerns Linked With E-Cigarettes And Vaping Products - A Blog Post from IVT Network

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Nov 13, 2020 8:00 am EST

Introduction

Electronic cigarettes (electronic nicotine delivery systems) and vaping products containing nicotine are showing ever increasing sales, since their debut in the USA in 2007 (1). From one perspective, such products can provide a stepping stone for coming off traditional cigarettes and hence towards improved health outcomes; from another perspective, some people are taking up vaping having never taken traditional tobacco products (2); in-between this lies the concerns about respiratory damage from these types of products and a growing body of evidence linked to microbial contamination. In addition to this, users of liquid nicotine products may themselves be more prone to infection (and this is something that is of additional relevance during the time of the coronavirus pandemic).

E-cigarette fluids have been shown to contain at least seven groups of potentially toxic compounds: nicotine, carbonyls, volatile organic compounds (such as benzene and toluene), particles, trace metal elements according to flavor, bacterial endotoxins, and fungal glucans (3). It is the latter issues relating to microbial risk that this blog article is concerned with. These are important issues, given the promotion of vaping products on health grounds as a bridge to discontinued use of conventional tobacco products.

Microbial risks from vaping and e-cigarette products

The three main ingredients of e-liquid are a mixture of the humectants: propylene glycol and vegetable glycerin, flavoring chemicals, and nicotine in varying concentrations. E-cigarette liquid contains nicotine that varies between 6 and 48 mg/mL and it is not meant to be smoked completely in one sitting, representing an average 200 puffs equivalent to one to three packs of cigarettes. There are variations with aerosol mass quantity and deposition, the chemical form of the nicotine, as well as the vaping volume, frequency, and timing (4). Plus, differing standards of manufacturing.

As well as general respiratory conditions from patients who have presented with acute, severe respiratory distress after using e-cigarette (vaping) products (e-cigarette, or vaping, product use–associated lung injury) (5), there are serious concerns with bacterial toxins. The microbial elements include bacteria (Gram positive and Gram negative), bacterial spores, fungi (yeast and mold), fungal spores, cell wall components (certain glucans and flagellum), and diverse microbial toxins that include

exotoxins and endotoxins.

In humans, occupational endotoxin exposure has been associated with the development of airflow obstruction, respiratory symptoms, reduced lung function, and current atopic and nonatopic asthma (6). One study has assessed the relative risk and concluded many e-cigarettes flavors may be contaminated with microbial toxins, especially endotoxin. Additional research is needed to confirm our findings and assess potential exposures and health effects of product users.

In a different study, scientists collected samples from various e-liquid products with the highest listed nicotine content, as sold by the 10 top-selling U.S. brands. The researchers proceeded to test 2–19 samples from each of the 10 brands (equaling 75 samples) (7). The focus was on endotoxin, given that exposure to this toxin via tobacco smoking may cause adverse health effects (8). The laboratory data showed endotoxin levels above the limit of detection for endotoxin in 23% of samples (in addition, 81% of the samples above the detection limit for glucan). Results were far higher in tobacco- and menthol-flavored than in fruit-flavored products. It is reasoned that the main sources of endotoxin exposure are agricultural products with close soil contact, such as cotton, grain, hemp, and tobacco (9). Glucan, a polysaccharide, is an indicator of fungal contamination, and it is associated with atopic asthma and reduced lung function (10).

An alternative study examined 75 popular e-cigarette products, both cartridges (single use) and e-liquids (refillable material),and found that 27% contained traces of endotoxin, and that 81% contained traces of glucan, which is found in the cell walls of most fungi. Exposure to these microbial toxins has been associated with myriad health problems in humans, including asthma, reduced lung function, and inflammation.

As to what the origins of the microbial toxins are, there are different potential sources. These include the cotton wicks in cartridges, tobacco leaves as the origin of natural nicotine, storage containers for the e-liquids, and the raw materials for producing synthetic nicotine and flavoring chemicals. Weak controls around manufacturing conditions could compound the problem. Hence, contamination of the products can potentially occur at any point during the production of the ingredients or of the finished e-cigarette product (3).

In terms of the risk that these toxins present, it should be note that susceptibility to microbial toxins varies greatly between individuals and assessing the risk with a view to setting test limits remains an incomplete activity.

E-cigarette and vape uses more prone to infection

As well as the risk from contaminated products, users of nicotine products may also be more susceptible to contracting an infection. One research study identified an abundance of *Porphyromonas* (a genus of Gram-negative bacteria implicated in periodontal disease) and *Veillonella* (a different group of Gram-negatives associated with cases of osteomyelitis and endocarditis) in higher levels among vapers, suggesting that vaping alters the oral microbiome. The oral microbiome has an established relationship to overall health and it is the second and most diverse microbiota next to the gut, home to over 1,000 species of microbes. Disruptions to this community can lead to health implications.

Of particular concern is the bacterium *Porphyromonas gingivalis*. Enzymes produced by the bacterium can attack collagen. Periodontal, or gum, disease is one of the most common infectious diseases worldwide. In its more severe forms, such as periodontitis, the condition causes loss of the bone that supports the teeth. In addition to gum disease, the bacterium has been linked to rheumatoid arthritis.

Ecosystem stability can be affected by two types of disturbances: long-term influences or “presses” and short-term effects or “pulses” (11). Furthermore, the researchers discovered that interleukin (IL)-6 and IL-1?, a pro-inflammatory cytokines which indicate inflammatory responses, were highly elevated in e-cigarette users when compared with non-users. In particular, epithelial cell-exposed e-cigarette aerosols were more susceptible for infection. This led to the assessment that e-cigarette users are more prone to infection (12). This occurs because alterations to the microbial landscape, which accompanies higher levels of proteins in vapers’ mouths, signals that the immune system is more likely to activate and produce inflammation. In turn this exponentially increases the likelihood for disease.

Additionally, sequencing based studies have shown that certain species of bacteria *(Haemophilus influenzae, Streptococcus pneumoniae, Staphylococcus aureus and Pseudomonas aeruginosa)* are more strongly associated with the development of a lung community skewed towards loss of diversity (13, 14). Concerningly, these organisms are associated with declining lung function (15). It appears that e-cigarette vapor can change the way the bacteria grow, by increasing volume and the area covered by the bacteria, which can lead to infections if untreated.

The association between the oral cavity and disease is complex, with the pathogenicity of chronic periodontal disease a factor of the complex interaction of microbial pathogens, host immune response, and genetic and environmental factors (16). The drawing in of chemical vapor adds to the environmental complexity and appears to be a microbiome altering factor. However, what stands out from research is the general trend that the majority of the metagenome in e-cigarette users was shared by more than the majority of users, which contrasts with smokers and non-smokers, who do not tend to share their bacterial and fungal composition (17).

Coronavirus

Aerosols and vapor generated by electronic substance delivery systems could participate in the dissemination of the coronavirus, responsible for the 2020 pandemic, in the close proximity of coronavirus infected vapers. The spreading of the current coronavirus of concern is foremost by virus-laden droplets that are expelled at speaking, coughing, sneezing, or breathing. One of the primary means to protect an uninfected person from someone who is infected is to maintain a physical distance of two meters or more.

Contact should, however, be short because the risk continues where contact is prolonged given the ability of the virus to spread via aerosols. Such aerosols can spread over greater distances. It is possible that exhaled smoke or vapor from vaping products can enhance this mechanism.

Whether the coronavirus can be spread through exhaled vapor of an infected person will probably depend on level of mucus and saliva in the vapor and the force at which the vapor is exhaled (such as if the vapor is accompanied with a cough).

To look into the dynamics, a research group from China used numerical simulations of a typical respiratory aerosol in a turbulent jet to simulate exhaled vapor. This was based on conditions designed to replicate ambient velocity, temperature, and humidity. The study also found that with rising ambient humidity the survival time of small droplets increased (18). It should be noted that not all researchers share this opinion, countering that exhaled vapor from an infected vaper is a negligible contagion factor: it can spread very few virus carrying droplets, as much as blowing or mouth breathing. Hence, this remains an area for on-going investigation. Slightly related is with data infers that smokers (including those who vape) are more vulnerable to COVID-19 infections or more likely to develop serious complications if they contract a COVID-19 infection, compared to non-smokers or vapers (19).

Summary

As well as being associated with a growing list of pulmonary complications, termed the e-cigarette or vaping product use-associated lung injury (EVALI) epidemic, there are also several emerging health concerns relating to microbial contamination and associated infection (20).

In essence, the three main concerns highlighted in this article are:

1. Some vaping liquids being contaminated with endotoxin and fungal toxins.
2. Vaping products potentially altering the oral microbial community, making an individual more prone to disease.
3. The potential for the coronavirus to spread in exhaled vapor.

The first two points remain the subject of on-going research. The last point, considering the severity of coronavirus symptoms among vapers (as well as there being a potential risk that the exhaled vape could spread coronavirus, from an infected person, over greater distances compared with normal coughing or sneezing), adds a contemporary focus to the subject matter.

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