Review Article

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IMPACT OF SECONDHAND EXPOSURE TO E-CIGARETTES: A REVIEW

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ABSTRACT:

Background: Electronic Cigarettes have gained popularity in recent years as newer replacements to traditional cigarettes, marketed to combat the adverse health effects of cigarette smoking. Despite their popularity as safer alternatives to cigarette smoking, little is known about their health effects. The perceptions of potential risks and benefits associated with E-Cigarettes vary widely among the public, users of E-Cigarettes, health care providers and the public health community.

Conclusion: This review shows that while there is not much literature available on the safety and long-term health effects of these devices, the presence of toxicants in E-cigarette aerosols, although at comparatively low levels, suggest that even secondhand E-cigarette exposure is not entirely risk-free. More rigorous research is required that delves into both acute and long-term health effects of vaping.

Practical Implications: E-Cigarettes are fast becoming a new tobacco industry that could reduce the incidence of traditional smoking. More quality research about the practical uses, short-term and long-term effects of these devices need to be conducted soon, before vaping becomes a serious public health issue.

Keywords: e-cigarettes, nicotine, secondhand smoke, passive smoking

INTRODUCTION:

The impact of environmental tobacco smoke from conventional smoking on the indoor air quality has been intensively researched in the past decade with the identification of the release of harmful particulate matter and organic compounds from the combustion of tobacco products. E-Cigarettes do not burn or smoulder the way conventional cigarettes do, so they do not emit side-stream smoke; however, bystanders are exposed to aerosol exhaled by the user.[1] The concentrations of the exhaled compounds during vaping differ with respect to the composition of the applied liquids, the type of E-Cigarette in use, the age of the E-Cigarette, length of the puff, and the interval between the puffs. E-cigarette vapour contains high concentrations of particulate matter (PM) that range in size from few nanometers to micrometres. These particles can penetrate the alveoli of the lungs and induce inflammation and translocate into the bloodstream.[2] Secondhand and Thirdhand smoke exposures related to these are a cause for concern regarding their private/public use especially, as there is evidence of an age-exposure relationship.[3] Various online and market vendors with over 400 brands and >7000 flavours of E-cigarettes exist, each

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differing in chemical profile and constitution.[4] For clinicians, knowledge about these constituents, and toxicology is needed as they encounter various patients who are vapers and who wish to stop smoking. However, the degree of harm reduction as claimed by E-Cigarette companies is uncertain. This study, therefore, attempts to review the literature on the varying levels of toxic byproducts of secondhand E-Cigarette vaping and its effects on health.

Environmental Nicotine-

Nicotine is difficult to remove from surfaces and must be done with an acidic cleanser (most soaps are alkaline).[1,5] These, however, can be used to clean only walls; it is quite impossible to use it on a carpet. Nicotine from tobacco smoke has been shown to react with oxidizing chemicals in the air to form secondary pollutants, such as carcinogenic nitrosamines.[6] Despite the small emissions of nicotine from E-Cigarettes as compared to tobacco cigarettes,[7] E-Cigarettes might be a source of particles and organic compounds that can contaminate the air and expose children and nonsmokers.

PARTS & WORKING-

E-Cigarettes are usually cylindrical, with many variations. While some E-Cigarettes look like traditional cigarettes, many are available in pen-styles, tank-styles etc.[8] The primary parts that make up an E-Cigarette are the Mouthpiece, Cartridge and Atomizer. The Cartridge is a tank-like reusable filter linked to the batteries. It has an inbuilt atomizer and holds the E-Liquid. One end screws onto the batteries and the opposite end houses the mouthpiece. The atomizer is a small heating element that vaporizes E-liquid. [9] When the user pushes a button [10] or activates the pressure sensor by inhaling, the heating element ionizes the E-liquid, which forms the vapour that is inhaled.[9] The body of the E-Cigarette is the battery which powers the device. When the user begins inhaling or triggers the battery by turning it on, the sensing unit triggers the battery, which in turn activates the atomizer. The battery is a Lithium-Ion Cell which is rechargeable and is highly effective. E-Cigarettes also includes an LED light on one end and are available with charging tools to charge the device.[11,12]

Operation- On activation, vaporization of E-Liquid occurs in the atomizer; the process is dependent on the fundamental properties like each constituent's vapour pressure, and temperature of the heating coil. Therefore, the composition of the resultant vapour is determined by the vapour pressure for each component of the E-Liquid at a given pressure and temperature.

Aerosol generated in the atomizer is a mass of droplets that are formed after the phase change of the E-Liquid constituents, from the supersaturated vapour phase to the condensed phase. When the E-Cigarette aerosol is drawn into the mouth and lungs, the nicotine and other constituents can be absorbed from the particles depositing on the various tissue surfaces. Particles less than 1 nm in diameter are known to be

delivered very effectively into the lung, but the deposition efficiency is generally low, and these particles are readily exhaled. Deposition occurs by mechanisms of sedimentation and Brownian diffusion and the constituents that evaporate from the aerosol particles can be absorbed from the gaseous phase through the same issues. [13]

EFFECTS OF VAPOUR CONTENTS-

1. Contents from E-Liquid-

E-cigarette use is regarded by many as being likely to have substantially lower levels of risk than smoking tobacco cigarettes. [14] Support for this position comes from in vitro biological studies [15] and the relatively simple composition of E-cigarette aerosols in comparison to cigarette smoke with its thousands of constituents. [16] However, some chemical substances reported in E-Cigarette refill solutions, cartridges, aerosols and environmental emissions include nicotine, aldehydes, acetone, tobacco-specific nitrosamines, various metals, tobacco alkaloids like cotinine, polycyclic aromatic hydrocarbons volatile organic compounds and certain drugs like amino-tadalafil and rimonabant [17,18] These compounds are harmful or potentially harmful constituents that are also released during the smoking of conventional cigarettes, and their public health risks have been studied extensively.

In a study by Margham J, et al., 2016, E-Cigarette aerosol was shown to contain 150 constituents (tobacco smoke-harmful and potentially harmful constituents) of which, 104 could not even be detected, 21 had a laboratory background, 9 were present at levels too low to be quantified and the remaining 16 were generated in whole or in part by it from i) major E-liquid constituents (nicotine, propylene glycol (PG), and vegetable glycerine (VG); ii) recognized impurities in pharmacopoeia-quality nicotine; and iii) 8 were thermal decomposition products of PG or VG. Close to 100 constituents alone were detected in mainstream E-cigarette vapour.[16]

These devices also use solvent carriers, such as propylene glycol and glycerol as humectants in E-liquids to produce aerosols that simulate conventional cigarette smoke. These humectants undergo oxidation and have shown to produce aldehydes found in conventional cigarette smoke when the aerosol generation process uses a heating voltage greater than 3 Volts. [18] E-cigarettes pollute the air less than conventional cigarettes, but their emissions are not 'harmless water vapour'. The toxicant intake varies depending on the type of E-liquids used, the type of vaporizers, battery power settings and vaping regimes. [19,20]

2. Indirect Effects-

Other toxicants include those which are not directly present in the E-liquids but are instead released from hardware components of an E-cigarette such as metal and silicate particles.[21] Increasing battery outputs also generate increasing levels of some residues such as carbonyls.[22] The surface of the heating coil can reach temperatures as high as

110 °C when using batteries>10 watts; this can condition the level of volatile substances emitted by the E-cigarettes.[23] The effect that E-cigarettes may have in the uptake of inorganic elements-contained in E-liquids or as part of the electronic device to the individual is unknown.[15]

Free radicals are found in high concentrations in cigarette smoke (>1016 molecules/puff). Similarly, studies have shown relatively high levels of reactive free radicals in E-Cigarette aerosols (>1013 molecules/puff) by electron paramagnetic resonance (EPR). Free radical generation is highly dependent on the propylene glycol content of the E-cigarette liquid.[24] Khlystov A, et al.,2016, found that toxic aldehydes are produced primarily from the decomposition of flavour compounds during vaping.[25]

The nicotine concentration in E-liquids has been demonstrated to have a negative relationship with puff topography; E-Cigarette users tend to take shorter duration puffs from those devices containing higher nicotine concentrations compared to lower concentrations.[26] Liquids with greater proportions of PG, relative to VG, have an increased concentration of nicotine in their aerosols, which may suggest that PG/VG concentrations could alter plasma nicotine concentrations following E-Cigarette usage.[27]

Additional compounds have been identified in the emissions of E-cigarettes that have historically received little focus in the prioritization of cigarette smoke toxicants are ethylene glycol and diethylene glycol, glyoxal, methylglyoxal, diacetyl and acetyl propionyl, acetoin, copper, and zinc. [28-30]

PASSIVE EXPOSURE TO E-CIGARETTE VAPOUR-

Evidence suggests that the mean air-borne nicotine in vapers' homes is close to 6 times more than in homes of nonsmokers/non-vapers.[31] Increased amounts of nicotine from the E-Cigarette vapour remain suspended in the indoor air and are often deposited in floors and glass windows [6,32] Regarding indoor cotinine levels, passive E-Cigarette exposure produces a similar increase in atmospheric cotinine just as conventional cigarettes. [33]

Under laboratory conditions, mice exposed to E-Cigarette vapour are proved to weigh less than other mice, while those exposed to E-Cigarettes containing nicotine had elevated cotinine levels and impaired lung growth. [34]

Levels of carbonyls in these devices can approach those of traditional tobacco cigarettes, especially under dry-puff conditions when E-liquid transport to the atomizer is insufficient for the applied electrical power setting. Two studies that were conducted independently to study carbonyls in E-Cigarettes reported that under very high E-cigarette power settings, level of carbonyl emission was higher than those found in cigarette smoke, attributable to the overheating of the E-liquid in the atomizer. [21,35]

The presence of toxicants in E-cigarette aerosols suggest that E-cigarette use is not risk-free. Although the levels of

toxicants in E-cigarette aerosols have commonly been reported to be a fraction of those found from conventional tobacco cigarettes, the carbonyls, formaldehyde, acetaldehyde, and acrolein are an exception to this general trend. Indirect exposure studies by various authors have also shown that the concentration of PG, VOCs, formaldehyde and acetaldehyde in the indoor atmosphere of areas where E-Cigarettes were used had increased multifold.[7,36,37]

An increased amount of Particulate matter ($PM_{2.5}$) remain suspended in rooms where E-Cigarettes have been smoked;[6, 38, 39] higher levels were observed when E-liquids without nicotine were used than with nicotine. [39, 40] $PM_{2.5}$ concentrations and the indoor air quality two days before, during and two days after a 2-day E-Cigarette event were higher than $PM_{2.5}$ concentrations reported previously in hookah cafés and bars that allowed cigarette smoking, as observed by Soule EK, et al., 2017 [41] This study indicated that indoor E-Cigarette use exposes non-users to secondhand E-Cigarette aerosol. The International Agency for Research on Cancer now considers particulates such as $PM_{2.5}$ to be carcinogenic.

THIRDHAND EXPOSURE to E-CIGARETTE VAPOUR-

Another important aspect of the discussion about E-Cigarettes is the effect of Thirdhand smoke that mainly describes human exposure against residues of smoking on clothes, furniture, and other indoor surfaces, and such a risk exists from exposure to nicotine from E-Cigarettes. [6] In the case of E-Cigarettes, the solvent of the liquids may remain on available surfaces and be a source for the contamination of residents. Even more important might be the accidental spilling of liquids that can lead to unintended uptake of nicotine by skin permeation- an effect that is intentionally used for nicotine patches.[7] It can be assumed that the health impact of E-Cigarette use is mainly influenced by the safety and quality of the applied liquids.

REGULATIONS-

There are no current governmental or U.S. Food and Drug Administration (FDA) manufacturing standards for E-Liquid. The FDA has sought to regulate E-Liquid through use of the Tobacco Control Act, passed into law in 2009. While there is a limit in the United Kingdom on the nicotine content, meaning the nicotine strength of any E-Liquid cannot exceed 20 mg/mL (2.0%), no such manufacturing standards or regulations for neither nicotine nor other constituents are mandatory in most countries. [42] Wilson N, et al., in 2017 explored some of the arguments for and against extending indoor smoke-free laws to cover vaping.[5] Allowing E-Cigarette use in indoor public places could encourage smokers to switch from conventional smoking, by making it relatively more attractive as it would be allowed where tobacco smoking is not and could minimize any discomfort that they may

experience from nicotine withdrawal when being in such settings. However, normalizing vaping indoors for smokers could normalize vaping for non-smokers as well. It could also pave the way for renormalization of tobacco smoking in such places. Prohibiting E-Cigarette use in indoor public places and smoke-free indoor environments could help and encourage vapers to reduce the level of their vaping or to quit the habit.

EFFECTS ON HUMAN HEALTH-

One of the major obstacles in regulating E-Cigarettes is that the possible long-term adverse effects are still unknown. Effects of vaping on human health are inconclusive due to the extreme paucity of empirical research investigating the presence of E-Cigarette induced health hazards and/or benefits and the variety of customizable options available in these devices. Although a few studies are available with mixed results, the data is insufficient to draw any conclusion. The effects of E-Cigarettes in altered medical conditions such as asthma, chronic obstructive pulmonary disease (COPD) or even pregnancy have not been investigated. There is a lack of studies focusing on the effect of chronic E-Cigarette exposure on blood-brain barrier permeability and this is quite concerning and should be addressed.[43] On the other hand, nicotine has been shown to have beneficial effects on Parkinson's and Alzheimer's disease. Further, nicotine's major non-addictive metabolite cotinine has been proven to reduce the burden of post-traumatic stress disorder and schizophrenia.[44] Perhaps apart from the recreational purpose, E-Cigarettes could be reconfigured as efficient nicotine delivery systems (devoid of all the other chemicals and flavouring agents) to treat these disease conditions but extensive preclinical and clinical studies need to be performed to prove substantial therapeutic efficacy.

While the evidence seems to support the protection of the public from involuntary exposure to second-hand aerosols, a major drawback is the lack of properly validated quantitative and qualitative analytical methods. Dissimilar experimental conditions and tools with diverse detection limits can impact data reproducibility and comparison, thus hampering their translational relevance.

DISCUSSION:

The individual and public health effects of E-Cigarettes remain unclear, even so, their effectiveness in facilitating switching from tobacco cigarettes, consequences of their use by nicotine-naïve adolescents, and their long-term health effects. [21] Marketers of E-Cigarettes often claim that these devices are much safer alternative products than conventional cigarettes and that their use facilitates smoking cessation. [18] However, manufacturers neither provide complete information on the chemicals used in the manufacturing process nor on the chemicals that may be released or synthesized during the aerosol generation process.

E-Cigarettes were reported to cause secondary exposure to nicotine but a lesser extent when compared to traditional cigarettes. The exhaled E-Cigarette aerosol is also free from combustible toxic ingredients present in traditional cigarettes. Studies on indoor vaping have shown that following the evaporation of the solvents from the exhaled E-Cigarette aerosols, the residual nicotine deposited on solid surfaces reacted with atmospheric nitrous acid yielding carcinogenic tobacco-specific nitrosamines.[45,46] As for the use of E-Cigarettes during pregnancy, no data is currently available to assess the potential risks to the foetus.[44]

Nicotine concentrations are intentionally formulated to create target strengths, yet measured levels may not match the label claim.[47] Gaining a further understanding of nicotine emissions of E-Cigarettes will answer these questions, as nicotine causes the dependence which is responsible for producing the reinforcing effects that promote the continued use of other tobacco products. [21] Safety concerns also exist regarding the exposure of the E-Cigarette user and their surroundings to harmful and potentially harmful constituents which have the potential to cause adverse events, alongside addiction. [48]

CONCLUSION:

Passive vaping poses a serious health risk to bystanders and its impact has the potential to lead to adverse health effects. However, the risk from being passively exposed to E-Cigarette vapour is lesser than the risk from secondhand exposure to conventional cigarette smoke.

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