

Evolving chemical landscape of e-cigarettes, 2021

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Despite more than a decade of research on the health effects of e-cigarettes, there is still much that is unknown about how the chemicals in e-cigarettes may impact human health. One of the major challenges in e-cigarette research is keeping up with the wide variety of devices and e-liquid formulations available on the market. Recently, disposable e-cigarettes, such as Puff Bar and Puff Plus, skyrocketed in popularity following the Food and Drug Administration's (FDA) restrictions on flavoured, cartridge-based products, such as JUUL. While the ban on flavoured, cartridge-based e-cigarettes was intended to reduce the appeal of e-cigarettes to youth, in reality, youth simply switched to disposable products that were not included in the flavour ban. This notion is supported by data from the 2020 National Youth Tobacco Survey, which indicates that between 2019 and 2020, the percentage of high school e-cigarette users who used disposable e-cigarettes increased from 2.4% to 26.5%.¹

Data presented in the recent paper 'Flavor chemicals, synthetic coolants, and pulegone in popular mint and menthol flavoured e-cigarettes' (Omaiye *et al*²) shed light on the chemical composition of Puff e-cigarettes and importantly, given that many JUUL users switched to disposables following the FDA's most recent restrictions on flavoured pod-based e-cigarette, compare the chemical composition of similar flavours of Puff and JUUL e-cigarettes. The data presented by Omaiye *et al* show that both mint and menthol JUUL and Puff e-cigarettes contain high concentrations of menthol; however, Puff e-cigarettes had higher levels of synthetic coolants and pulegone, a compound found in mint oil, suggesting that Puff products have the potential to be toxicologically 'worse' than JUUL.

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These findings are also relevant to the context that while the FDA plans to ban menthol as a characterising flavour in cigarettes,³ menthol is still allowed in e-cigarettes. Mint and menthol are some of the most popular flavours among e-cigarette users,^{1,4} particularly youth, and their popularity is likely to remain given current FDA regulations that may steer users towards these products by restricting other flavours of e-cigarettes, as well as menthol in cigarettes. Therefore, it is extremely important to understand the chemical compositions and toxicities of mint and menthol-flavoured e-cigarettes. The data presented by Omaiye *et al* provide an important contribution to this area and clearly demonstrate that while mint and menthol have similar chemical profiles, they are not identical, and thus may have differential toxicities. Aside from the well-known chemical components of e-cigarette liquids (such as nicotine, organic acids, flavouring chemicals and propylene glycol/vegetable glycerine), the data in this paper also show the importance of investigating other chemicals such as synthetic coolants and mint oil components. These chemicals may contribute to the palatability of e-cigarettes and may augment their toxicity, so these chemicals, and others that may serve similar functions, will need to be included in any future e-cigarette toxicity testing and regulations.

The complexity of e-liquid formulations and rapid evolution of different e-cigarette devices, coupled with regulations focused on narrowly defined e-cigarette products, have resulted in exploitation of regulatory loopholes and few substantive changes in overall e-cigarette product availability, appeal and use. Future regulations governing e-cigarette devices, flavours and chemical components will need to be rigorous and thorough, with careful consideration of ways in which companies may attempt to evade regulations by making small changes to their products. This foresight will be needed to prevent the constant emergence of new device types and formulations, which presents a massive challenge in assessing toxicity

of e-cigarettes and understanding their public health impact. Ultimately, a paradigm shift in the way e-cigarettes are brought to the market is needed so that assessment of potential e-cigarette toxicity is not constantly lagging behind consumer behaviour. Like most other consumer products brought to market, the chemical composition and potential toxicity of e-cigarettes should be evaluated prior to public sale of these devices, allowing the public to be informed about the risks of e-cigarette use and preventing newer, potentially more toxic products to gain traction, as is showcased by the data presented by Omaiye *et al*.

Correction notice This paper has been revised since first published. Authors incorrectly stated that the FDA had banned menthol as a characterising flavour in cigarettes. While on April 29, 2021 the FDA has proposed this ban, the ban has not yet taken effect. This phrase '...while the FDA has now banned menthol as a characterising flavour in cigarettes' has now been revised to read '...while the FDA plans to ban menthol as a characterising flavour in cigarettes, menthol is still allowed in e-cigarettes'.

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