Novel model developed to predict the amount of nicotine emitted from e-cigarettes

July 30 2015

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Virginia Commonwealth University Massey Cancer Center researchers at the VCU Center for the Study of Tobacco Products (CSTP) have developed the first ever, evidence-based model that can predict with up to 90 percent accuracy the amount of nicotine emitted by an electronic cigarette (e-cigarette). The study was published in the journal *Nicotine and Tobacco Research*.

The researchers, working in collaboration with investigators at the American University of Beirut, collected data about the voltage and other characteristics of various e-cigarette devices, the concentration of the liquid nicotine that could be put in the devices, and the length of time a user might inhale from the device in one puff. The team then developed a mathematical model to determine how much nicotine was emitted from the devices as the device voltage and the nicotine liquid concentration were increased and the user puff duration was extended. The model predicted that higher voltage e-cigarette devices paired with high-concentration nicotine liquids could emit greater levels of the addictive substance than those of a traditional tobacco cigarette, depending on user puff duration.

"Laboratory results showed that nicotine yields from 15 puffs on an e-cigarette varied by more than 50 times across various device, liquid and user behavior conditions," said the research team member Thomas Eissenberg, Ph.D., director of the CSTP, member of the Cancer Prevention and Control research program at Massey and professor in the Psychology Department at the VCU College of Humanities and Sciences.

In a subsequent clinical study conducted at VCU, the researchers also observed that experienced e-cigarette users were more likely to take longer puffs than novice users, resulting in higher levels of nicotine being delivered to their bloodstream.

According to Eissenberg, these findings indicate that without federal regulation on these devices users could become more addicted to nicotine from e-cigarette use than from smoking a conventional combustible cigarette.

"When used as intended, an electronic cigarette should not produce a nicotine yield in excess of that of a combustible cigarette, a device that

we already know has lethal health effects. If it does, then we are essentially making an already addictive drug delivery system even more addictive," said Eissenberg.

Tobacco use remains the leading cause of preventable cancer incidence in the U.S., with the general assumption that e-cigarettes are a "safer" alternative as a nicotine delivery method. This could be true, Eissenberg stated, as long as the e-cigarette device and its liquid are not designed in a way that would deliver excessive levels of the addictive substance or other dangerous chemicals to the user. However, restrictions dictating safer design may only occur through federal regulation since product developers may not be inclined to self-impose such regulations.

With this novel nicotine mathematical model, researchers will now be able to predict with a great deal of accuracy how much nicotine will be delivered to an e-cigarette user before a device is even designed. These predictions will further enable researchers like Eissenberg and his colleagues to inform federal regulators about evidence-based recommendations on e-cigarette design restrictions that could potentially avoid a serious public health disaster as more people turn to e-cigarettes as an alternative nicotine delivery method.

This model also sets the framework for a clinical trial that has just opened at the VCU CSTP as well as Penn State University's Tobacco Center of Regulatory Science in Hershey, Pa., that will evaluate novel tobacco products, including e-cigarettes, on health indicators and cigarette smoking behavior in people who are currently smoking tobacco cigarettes and who are interested in reducing their cigarette use.

More information: The full manuscript of this study is available online at: ntr.oxfordjournals.org/content/17/2/150.full

Medical Xpress

Provided by Virginia Commonwealth University

Citation: Novel model developed to predict the amount of nicotine emitted from e-cigarettes (2015, July 30) retrieved 27 April 2024 from https://medicalxpress.com/news/2015-07-amount-nicotine-emitted-e-cigarettes.html

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