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Vaping zebrafish suggest E-cigarette exposure disrupts gut microbial networks and neurobehavior

Researchers at Kyushu University hope to spark broader public discussion on the health risks of e-cigarettes and provide scientific evidence to support a reassessment of existing regulations

Fukuoka, Japan—Electronic cigarettes (e-cigarettes), widely marketed as a safer alternative to traditional cigarettes, are now hooking younger generations. World Health Organization data from 2025 show that at least 15 million adolescents aged 13–15 now vape. As colorful, fruit-flavored devices become a new social norm on playgrounds and campuses, we must rethink whether they are truly harmless as advertised.

A recent study from Kyushu University, with collaborators from Hong Kong and Taiwan, published in *Science of The Total Environment*, offers biological insights into the potential health risks of vaping. Using a zebrafish model, the researchers show that exposure to e-cigarettes alters gut microbiota composition and affects neurobehavior.

"The gut microbiome is sensitive to environmental exposure, and its balance and stability are closely linked to overall health," notes Tse Ka Fai William, Associate Professor at Kyushu University's Faculty of Agriculture. "We therefore investigated how e-cigarette vapor changes bacterial communities and what that might mean for the organism."

The researchers turned to zebrafish, a commonly used model in toxicology and biomedical research that shares approximately 80% of human disease-causing genes. They designed a water-based exposure system, bubbling e-cigarette liquid—with and without nicotine—into fish tanks over seven days. Doses and device settings mimicked typical vaping conditions, with unexposed tanks used as controls.

Chemical analysis revealed that heating e-cigarette liquids produced harmful byproducts, including formaldehyde and acetaldehyde, which are classified as carcinogens and can cause respiratory and skin irritation.

Following exposure, the researchers found disruptions in the zebrafish gut microbiome, with reduced microbial network stability and altered community composition.

"Some bacteria become dominant and replace others, forming a new microbial community," explains the paper's first author Thi Ngoc Mai Dong, a master's student at Kyushu University's Graduate School of Bioresource and Bioenvironmental Sciences. "The changes suggest that the fish, or rather the bacteria, can 'feel' the toxic substances in the water and want to adapt to the new environment."

For instance, in nicotine-exposed fish, *Fusobacteriaceae*, key contributors to gut health and mucosal integrity declined significantly, while *Sphingomonadaceae*, bacteria that known for their ability to degrade xenobiotic compounds, became dominant. In nicotine-free vapor exposures, *Shewanellaceae* and *Barnesiellaceae* were enriched, potentially reflecting responses to environmental stresses and altered immune regulation. Bioinformatics analysis further showed enrichment of microbial pathways involved in xenobiotic degradation and oxidative stress responses, suggesting both direct chemical metabolism and secondary stress adaptation.

"We also see that the microbiome is actively breaking down flavoring chemicals in vaping liquids," adds Carl Andersen Macaraeg Tan, an undergraduate student who joined the dual-degree program at Kyushu University's School of Agriculture and the second author. The researchers expressed concern that the chemical compositions of many e-cigarette flavors are not fully disclosed, limiting evidence-based risk assessment.

Given that gut microbial metabolites may influence neurological function, the team further studied zebrafish behavior. They found that regardless of nicotine content, e-cigarette exposure caused behavioral changes and impaired escape responses. The team is now exploring the underlying biological mechanisms and, drawing on its expertise in developmental biology, plans to examine whether vaping exposure of adult fish may affect the health of their offspring.

While based on an animal model and cannot be directly extrapolated to humans, the study aims to raise awareness among the public, educators, and policymakers of the need for further investigation of the potential risks posed by vaping.

"This research was partly motivated by our international students, who noticed e-cigarette use becoming more common among their peers, not only in Japan but worldwide," says Tse. Through the English-taught International Undergraduate Program at the Faculty of Agriculture, Kyushu University provides young students with early research opportunities, and students from diverse cultural backgrounds bring fresh perspectives to global health concerns.

"We hope these findings can make consumers aware that e-cigarettes produce harmful substances, and support more transparent risk communication and regulation," Tse concludes.

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For more information about this research, see "E-cigarette vapor alters gut microbiota composition in zebrafish," Thi Ngoc Mai Dong, Delbert Almerick T. Boncan, Carl Andersen Macaraeg Tan, Da-Wei Liu, Hsin-Yu Sun, Ting-Wei Huang, Chen Hsu, Kuo-Chang Chu, Zulvikar Syambani Ulhaq, Keng Po Lai, Douglas Robert Drummond, Yukiko Ogino, Yun-Jin Jiang, May-Su You, Jen-Kun Chen, Ting Fung Chan, William Ka Fai Tse, *Science of The Total Environment,* https://doi.org/10.1016/j.scitotenv.2025.181199

About Kyushu University

Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutions of higher education, consistently ranking as one of the top ten Japanese

universities in the Times Higher Education World University Rankings and the QS World Rankings. Located in Fukuoka, on the island of Kyushu—the most southwestern of Japan's four main islands—Kyushu U sits in a coastal metropolis frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Its multiple campuses are home to around 19,000 students and 8,000 faculty and staff. Through its VISION 2030, Kyushu U will "drive social change with integrative knowledge." By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society's most pressing issues.

Using a zebrafish model, researchers at Kyushu University found that exposure to e-cigarette vapor—regardless of nicotine content—disrupted the gut microbiome, reducing microbial network stability and altering community composition. At the same time, the fish showed weakened behavioral inhibition and impaired escape responses.

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