

News and Perspectives

Advanced Olfactory Cancer Detection: When E-Noses Sniff the Skin

Liam Critchley, JMIR Correspondent

Abstract

Cancer detection and diagnosis are rapidly moving beyond imaging and blood tests to even less invasive—and increasingly sophisticated—methods. In this *News and Perspectives* article, JMIR Correspondent Liam Critchley reports on recent advances in the growing field of olfactory cancer detection.

Key Takeaways:

- Cancer detection has evolved to include “e-noses,” devices that can detect gaseous cancer biomarkers.
- E-noses are typically used to detect these biomarkers in the breath, but recent research suggests they can also be placed on patients’ arms to detect volatile compounds emitted from the skin, with a high degree of accuracy and sensitivity.

Despite years of research and medical developments, cancer is still one of the leading causes of death around the world today, partially due to difficulties in diagnosing and treating many cancers before they progress.

Scientists continue to develop new screening methods and [diagnostic platforms](#) that are more sensitive and have a higher specificity to make early cancer diagnosis easier to achieve.

Traditional methods may be invasive, like biopsies, or time-consuming, like diagnostic imaging, but one of the latest technologies that has the potential to revolutionize point-of-care cancer diagnosis is electronic noses (e-noses).

E-Noses at the Forefront of Olfactory Cancer Detection

An e-nose is a specialized type of sensor device that detects gaseous vapors. Much like our noses detect vaporized odors in the air using biological receptors, e-noses use their own sensor array as synthetic receptors to detect different vapors and gases. They can detect a wide range of volatile organic compounds (VOCs)—chemicals typically present in industrial, commercial, or household products that have evaporated into the air—including those that might be odorless or otherwise undetectable to our human noses.

In medical applications, e-noses are usually used to detect some type of vaporized biomarker or biomolecule of interest. These devices are usually smart devices and use pattern recognition algorithms to identify the gaseous molecules that interact with the sensor array. The first early stage e-noses were thought to have originated as early as [1982](#), but the concept of wanting to “measure a smell” dates back to Alexander Graham Bell in [1914](#).

“The most significant development in olfactory cancer detection in recent years has been the growing use of

electronic nose (e-nose) systems for non-invasive early cancer diagnosis,” says Abraham Binson, PhD, research scientist on e-noses at Saintgits College of Engineering.

“Researchers have increasingly demonstrated that VOCs present in [exhaled breath](#) can serve as biomarkers for cancers such as [lung](#), breast, gastric, and colorectal cancer.”

E-noses have been constantly improving in capabilities and becoming smaller. The integration of nanomaterial-based gas sensors and advanced pattern recognition algorithms has significantly improved sensitivity, selectivity, and classification accuracy, with portable and real-time clinical screening devices becoming more established.

“The ability for olfactory systems to recognize complex VOC patterns has increased diagnostic accuracy,” says Binson. “Portable and miniaturized e-nose devices are also making these technologies more practical for real-world healthcare applications.”



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Abraham Binson, PhD

From Breath to Skin

“Breath analysis can often provide results within minutes and is non-invasive and more comfortable for patients and suitable for repeated screening and continuous monitoring,” says Binson. “However, one of the major challenges in olfactory cancer detection is the complexity and variability of VOCs in human breath.”

This complexity is due to VOC profiles being influenced by many factors including diet, smoking, medications, environmental exposure, age, and other diseases. This makes it difficult to consistently identify cancer-specific biomarkers, but novel digital technologies may be able to circumvent this issue.

“Researchers are addressing this challenge by using advanced machine learning and deep learning algorithms that can recognize subtle patterns within complex sensor data,” confirms Binson.

While advancements are being made on breath analysis, it’s not the only e-nose avenue being explored. Another approach is to detect VOCs that are “exhaled” through the skin. Pathological biochemical processes can change the composition of VOCs emitted by the skin, with volatile [biomarkers](#) of heavy hydrocarbons, aromatic amines, heavy ketones, and alcohols all changing when something is not “normal” in the body. The [sensors](#) inside e-noses can be functionalized with specific receptors to detect skin-emitted VOCs associated with cancer.

New Quantum-Dot E-Nose Designed for Detecting Cancer on the Skin

A [new pilot study](#) in the *Journal of Analytical Chemistry* developed a quantum-dot-based e-nose—which uses nanotechnology to improve sensitivity and customizability—to detect VOCs emitted by the skin at the patient’s bedside.

The e-nose was tested on both hospital patients diagnosed with cancer and healthy volunteers. This allowed participants’ chemical signatures to be compared, as well as key indicators of cancer progression.

Cadmium sulfide quantum dots—nanocrystals whose extremely small sizes cause their electrons to respond to stimuli in unique and measurable ways—were chosen for the e-nose sensor array because they could be easily modified, giving the e-nose specific biomarker receptors for detecting VOCs. Quantum dots are highly sensitive to any molecules binding to the receptors, which enabled the e-nose to have a low limit of detection and high sensitivity for identifying VOCs of interest—crucial for measuring small amounts of gas exhaled by the skin.

Keywords: neoplasms; early detection of cancer; biomarkers; tumor; volatile organic compounds; breath tests; biosensing techniques; artificial intelligence; pattern recognition; automated

The differences between the skin VOC composition of healthy participants and patients with cancer were calculated using signals from the sensor array alongside calculated parameters and calibrations for the sensors. It was also found that the metabolic mixture of emitted VOCs in the healthy group showed almost identical compositions, including at different times of the day—whereas the emitted VOCs from patients with cancer were more erratic and variable across different days and times of day.

Using this data, researchers identified potential biomarkers indicating the presence or absence of a malignant tumor. They developed a theoretical model estimating the probability that someone had cancer based on the sensor signals, then validated this model with further testing under varying conditions and on volunteers with and without cancer. Notably, they found that the e-nose, and the model they’d developed to interpret its signals, identified whether the participants had cancer with an accuracy and sensitivity of 100%.

The e-nose went further than simply distinguishing between healthy participants and those with cancer—it also assessed the changing dynamics of a patient’s condition, including classifying its severity or stability. The e-nose has the potential to not only improve diagnosis accuracy, but also provide ongoing insights into the changing health of a patient while they undergo medical treatment.

The Future of Olfactory Cancer Detection

In this latest quantum dot e-nose development, the researchers have stated that they plan to expand the volunteer groups and will use the data to identify the difference in chemical composition of the “exhaled skin breath” across a wider range of participants, including outpatients.

As a wider context, Binson noted, “The future of olfactory cancer detection is very promising, particularly with the rapid advancements in artificial intelligence, nanotechnology, sensor fabrication, and biomedical data analysis. Researchers are increasingly moving from proof-of-concept studies toward clinically applicable systems that are portable, real-time, and capable of detecting multiple diseases simultaneously.”

As a longer-term scenario, Binson also believes that “we may begin to see selective implementation of these technologies in specialized hospitals and research oriented clinical centers within the next 5 to 10 years, particularly as complementary diagnostic tools rather than replacements for conventional imaging or biopsy methods.”

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