Revolutionising disease detection: The emergence of non-invasive VOC breathomics

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Breathomics marks a revolutionary approach to disease detection by analyzing the chemical composition of exhaled breath

As the world recovers from the recent global health crises, the detection and management of pandemic diseases like COVID-19, RSV, and flu have come to the forefront. The COVID-19 pandemic alone has affected over 96 million people in the US, with a devastating count of more than a million fatalities. Similarly, respiratory syncytial virus (RSV) and influenza (flu) collectively burden the healthcare system with millions of cases annually, leading to hundreds of thousands of hospitalizations and tens of thousands of deaths.

These staggering statistics underscore an urgent need for diagnostic methods that are not only swift and accurate but also non- invasive to facilitate rapid, widespread testing. Enter Breathomics—a revolutionary approach that analyzes the chemical composition of exhaled breath to detect diseases.

The principle of Breathomics

Breathomics is a unique area of science that measures the tiny chemical molecules in the air we breathe out. These molecules, known as volatile organic compounds or VOCs, are like fingerprints that can tell us a lot about what's happening inside our body. Imagine your body as a factory where different machines (cells) are working non-stop. Now, depending on how they're working, they produce a unique mix of invisible gases, which we can call 'breath signals' (VOCs). So, by analyzing the changes in our breath, Breathomics helps us catch diseases early, just by 'smelling' the signals our body gives off. It's a bit like having a health detective right in our breath!

Historical background and progress

Breathomics traces its origins to the discovery of hydrocarbons in human breath, marking the start of a journey that would transform medical diagnostics. Researchers have since identified a myriad of volatile organic compounds (VOCs) in our exhalation, enhancing our understanding of human health. Advances like time-of-flight mass spectrometry have increased the detectable VOCs to about 3,000, broadening the scope for non-invasive diagnosis. The Proton Transfer Reaction – Mass Spectrometry (PTR-MS) technology further refined this field, with its capacity to detect minute chemical traces, akin to finding a drop of ink in an Olympic- sized pool. The gentle and efficient technology foregoes extensive sample preparation and streamlines the diagnostic process.

Developing biomarkers via Breathomics melds state-of-the-art tech, data science, and clinical research. From initial breath samples through to Principal Component Analysis and pattern recognition algorithms, the journey culminates in the discovery of reliable biomarkers. Traditional methods like PCR tests and cell culture studies validate these findings. This multi-faceted approach heralds a new era of rapid, accessible disease diagnostics, aligning with global health initiatives and bringing us closer to a future where early detection becomes the norm.

Goals, outcomes, and collaborations

OU is unique in that 50% of the university is its health science center with numerous clinicians with access to patients affected by various diseases. Also, the Data Institute for Societal Challenges at OU, under the leadership of Prof. David Ebert, has state-of-the- art expertise in large data analysis and the ability to bring in AI/ML algorithms to rapidly arrive at diagnosis with high precision and specificity. In partnership with the OU Health Sciences Center (OUHSC), this Breathomics project, backed by NSF funding, targets the development of swift, point-of-care breath tests for disease detection. Embracing a multidisciplinary ethos, the project combines various specializations, from infectious diseases to bioinformatics, emphasizing the motto ‘Every Member Matters.’ ‘Every Minute Counts!’ encapsulates the project’s dedication to rapid diagnostics. The philosophy ‘Every Breath Matters’ drives the project’s core, seeking unique disease signatures in breath VOCs, with algorithms achieving over 90% sensitivity and 90% specificity.

Benefits and potential impact

Breathomics is set to transform diagnostic practices in urgent and routine healthcare settings. This innovative approach offers a non- invasive, rapid screening tool for diseases, notably various cancers, including lung and pancreatic. In emergency rooms, where timely diagnosis is essential, Breathomics can swiftly pinpoint health issues by analyzing breath at the molecular level, expediting treatment. For primary care, integrating Breathomics into regular check-ups could mean early detection of potentially life-threatening illnesses, thereby significantly boosting survival rates through early intervention. This method’s potential stretches beyond diagnosis to earlier treatment, improved disease management, and patient outcomes.

Competition and future prospects

The breath analysis technology landscape, driven by pioneers like Prof. Hossam Haick and companies like Breathonix, is rapidly evolving. Haick's team advances nanomaterial-based sensors, capturing illness-induced changes in breath composition. Breathonix's real-world application, InspectIR, demonstrates breath analysis's practicality for rapid, non- invasive COVID-19 testing. This technology is poised to revolutionize routine health screenings, significantly improving early diagnosis and treatment, especially in regions where traditional methods are not feasible.

Conclusion

Breathomics heralds a diagnostic revolution with its non-invasive, swift, and precise detection of respiratory diseases and cancer, epitomizing the 'breathtaking' strides in medical innovation. Aligned with initiatives like the Cancer Moonshot, it promises the early discovery of malignancies, integrating AI for continuous health monitoring, potentially transforming cancer from a disease detected late in the course of illness requiring aggressive, potentially life-altering, and frequently ineffective therapies, into a disease easily detectable early in its course that can be treated with less aggressive, safer, and more effective therapies.

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