Engineering and Physical Sciences Research Council

Optimising Disease Prediction, Diagnosis and Intervention: Case Study

Sensing a new opportunity for quick and easy disease diagnosis

Fast, practical, low-cost, ultra-convenient: a portable infectious disease detector now under development could revolutionise on-the-spot diagnosis in doctors' surgeries, hospital wards and remote communities.

Image credit: University of Southampton

Meeting the Grand Challenge:

Led by the University of Southampton, the 'Flexible Raman Biosensing Platform for Low-cost Health Diagnostics' project is developing a compact sensing device that could deliver an accurate diagnosis in a matter of minutes for many infectious diseases. Designed for 'anytime, anywhere' use, it could significantly cut time-to-treatment – a crucial criterion when seeking to optimise the tackling of disease.

Vision and Value:

Diagnosis is a pivotal link in the healthcare chain. The earlier an accurate diagnosis can be made, the greater the probability that treatment will prove successful. Currently, many diagnostic tests involve waiting for results for a day or more, while some can only be carried out in healthcare settings equipped with specialist facilities.

The Southampton team recognised the huge value, to patients and healthcare providers, of a versatile new diagnostic device that could deliver greater speed and increased convenience alongside affordability and extreme accuracy. Such a device would need to be robust and reliable, readily portable, simple to operate and cheap to manufacture, as well as offering the flexibility to be easily configured to detect a variety of illnesses.

Key Components:

Supported by a £973,000 EPSRC Standard Research grant[1] and running until 2023, the four-and-a-half-year project is combining laser technology, spectrometry, surface chemistry and optoelectronics to develop and demonstrate an innovative diagnostic device that meets all these requirements. Clinicians at University Hospital Southampton are also a vital part of the multidisciplinary team, driving the requirements, providing samples and validating results. The initial focus is on whooping cough (which has seen a resurgence worldwide) and Ebola (with project partners the Defence Science and Technology Laboratory providing specialist expertise and facilities in this area).

The device will harness a proven, low-power-demand analytical technique – Raman spectroscopy – combined with novel optical chips to identify the chemical composition of the samples it tests. Cost-cutting features include standard disposable sensor chips whose surfaces will be specially modified to optimise their sensitivity and customise them for use in this device.

[1] Flexible Raman biosensing platform for low-cost health diagnostics. Grant number: EP/R011230/1

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Outputs and Outcomes:

- The team has already successfully built an initial proof-of-concept laboratory system similar in size and weight to a home printer.
- The disposable chips have been optimised for reliability, sensitivity and ease of use.
- The instrument will be simple to operate. The process includes selection of the appropriate 'plug-in' sensor chip for the disease being targeted, application of a small drop of the patient's blood to its surface and insertion of the chip into the device.
- An electronic readout indicating a positive or negative result and (if positive) the concentration of the target species present in the sample will give the clinician key information on which to base a decision on treatment.
- The team believes the analysis time achieved by the device could be around 5 minutes.

Impacts and Benefits:

- **More effective treatment.** With its simplicity and affordability encouraging wide use, the device's suitability for point-of-care deployment in almost any setting would speed up disease diagnosis and so enable any course of treatment to commence more quickly.
- **Less pressure on healthcare resources.** By enabling more on-the-spot diagnostic testing in GPs' surgeries, for instance, and by facilitating earlier clinical interventions, the device could help reduce demand for hospital beds and services.
- **Better control of disease.** Earlier detection of cases of infectious disease would make it easier to take any necessary steps to limit spread within families, within communities, across regions and even at a national and international level.
- **Reduced antimicrobial resistance.** Rapid, accurate identification of disease will reduce inappropriate use of antibiotics and so hinder growth of antimicrobial resistance.
- **Support for remote communities.** The device has particular potential for use in remote communities, both in the UK and worldwide, where local healthcare facilities and expertise are limited.

Next Steps:

The team will produce a more compact and lightweight instrument and more sensitive, more selective optical chips. Miniaturisation, simplification and performance enhancement will be extensively explored, along with the scope to significantly increase the number of illnesses the system can detect. The ultimate aspiration is for the system, following successful development and validation, to begin establishing itself in healthcare settings within the next few years.

Behind the Project:

Professor James Wilkinson is the project's Principal Investigator. The team for this project also includes Professors Rob Read (a specialist in infectious disease), Phil Bartlett (a specialist in electrochemistry) and Michalis Zervas (a specialist in advanced fibre laser technologies), ensuring a focus on clinical objectives while providing depth of expertise in each component discipline. "We aim to find the sweet spot where cost, speed, accuracy and versatility meet to realise a versatile platform technology at the intersection of engineering, chemistry and healthcare," James says. "Such endeavours are fundamentally multidisciplinary, requiring not just different skills but also different perspectives on needs, priorities and opportunities."

Respiratory infections are ranked as the world's

4th most deadly

communicable disease

Relevant EPSRC Research Areas:

- Clinical Technologies
- Optical Devices and Systems
- Microsystems
- Sensors and Instrumentation