

Part of the conference series
Transforming our future and
FORUM programme

Diagnostics: Building capacity and capability in the UK

Held on 12 October 2021

Conference report

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Introduction

On the 12 October 2021, the Royal Society and the Academy of Medical Sciences held an online symposium to explore advances in the diagnostics sector and the opportunities and challenges towards building capacity and capability within the UK.

The objectives of the event were to give an overview of the diagnostics sector, examine how to translate and commercialise innovative diagnostics research and showcase breakthrough science and technologies. The symposium concluded with a panel discussion focusing on broader issues within the diagnostics sector.

Supported by AstraZeneca the meeting forms part of the Royal Society's wider Transforming our Future series and the Academy of Medical Sciences' FORUM programme, and was organised by Professor Dame Anne Mills CBE FMedSci FRS, The London School of Hygiene and Tropical Medicine, Professor Rebecca Fitzgerald FMedSci, University of Cambridge, and Dr Ian Campbell OBE, LifeArc.

Each conference in the Transforming our Future series brings together key stakeholders from across a sector to address a major scientific and technical challenge of the next decade. The series is organised through the Royal Society's Science and Industry programme which supports the Society's commitment to integrate science and industry across its activities, and to promote science and its value by building relationships and fostering translation.

This report is not a verbatim record, but a summary of the discussions that took place during the day and the key points raised. Comments and recommendations reflect the views and opinions of the speakers and not necessarily those of the Royal Society or the Academy of Medical Sciences.

Executive summary

The experience of the COVID-19 pandemic has brought increased awareness of the importance of diagnostics to the general public and provides a platform to capitalize on the pandemic-driven growth in technological development and innovations, and to develop the diagnostics sector further.

The pandemic has created a new impetus behind point-of-care and home testing, which, if adopted more widely could help the healthcare system to clear a backlog of tests and increase capacity in the long-term.

Technological advances in novel techniques such as breath biopsy and imaging allied with bespoke artificial intelligence tools can more rapidly diagnose and monitor disease as well as provide clinically useful prognoses for patient triage and treatments. Integration of rapid screening platforms with patient healthcare records and the use of patient-centred diagnostics, have the potential to shorten the time taken to direct patients to the most appropriate treatments and avoid the cost and health risks of using ineffective medicines.

Significant challenges remain in how novel diagnostics are discovered, funded, regulated, and supported. As diagnostics are often not attractive for traditional venture capital funding, alternative funding mechanisms need to be developed to finance innovation in diagnostics that doesn't require such high returns on capital and can provide longevity of support during development.

Key actions to enhance the capability and capacity in the diagnostic sector in the UK will include:

- Articulation of need from the health service to make it clear to diagnostic developers that a product has a potential market.
- Appropriate funding and support mechanisms to support innovators as an alternative to venture capital financing.
- A clear articulation from the MHRA about regulation of diagnostics and compatibility with the EU regulatory framework..
- A means by which the NHS can incentivise the adoption of diagnostics innovation and and differentiate if from procurement of other goods and services.

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“The UK is in a prime position to be a pioneer in a new era of medical diagnostics with our track record in technological innovation such as digital health, genomics and artificial intelligence. The Covid-19 pandemic led to rapid growth in diagnostics and we have an unprecedented opportunity to build on this momentum to tackle a range of public health challenges.”

Professor Rebecca Fitzgerald FMedSci,
University of Cambridge

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COVID-19 and diagnostics: An opportunity for renewal and growth

Professor Sharon Peacock CBE FMedSci, Professor of Public Health and Microbiology, University of Cambridge and Executive Director and Chair of the COVID-19 Genomics UK Consortium discussed the opportunities COVID-19 has provided for the diagnostics sector.

The COVID-19 pandemic has emphasised the importance of diagnostics to health and the economy for researchers, the public, and the Government. Key to managing the pandemic was testing and large-scale studies on the prevalence of the virus in the population over time.

There is a need to build on the investment, collaboration, and momentum that has come from the COVID-19 testing response. Specifically, four major activities have taken place over the last two years that could be capitalised on:

- The investment in labs, people, manufacturing, and logistics.
- Acquisition and use of data from mass and targeted surveillance, combining data sets, and opening of data for research.
- Increase in public awareness of diagnostics through point of care (POC), home testing, and of public health and research.
- Collaboration between the NHS, academia and industry, and across government and internationally.

All these activities have implications for a new vision for surveillance where innovations in diagnostics, their manufacture, and rapid adoption will result in better public health.

Building a sustainable diagnostics sector in the UK

Recent workshops run by the Academy of Medical Sciences have focussed on how to build a sustainable diagnostic sector¹ and how to translate elements of the pandemic testing to develop a more sustainable diagnostic sector in the future.² Key messages included the need for leadership and collaboration, nurturing innovation, optimising the use of resources, and engagement with the public.

During the pandemic, new relationships developed between academia, the NHS and industry, which need to be exploited for effective future collaboration. Clinicians and the diagnostics industry need to work more closely together to define unmet need and use cases.

The long-term sustainability of the diagnostics sector in the UK requires manufacturing capabilities and an environment that supports companies of all sizes. A critical hurdle is the speed of uptake by the NHS of innovation generated by both SMEs and global companies. Greater access to clinical samples and data for academic and industrial partners would enable the NHS to be a powerful research and innovation platform for generating high-quality evidence for diagnostic development.

Industry could be incentivised to develop new diagnostic technologies by setting clear goals for what tests need to achieve to be approved, and by developing a health economic model that places an appropriate value on diagnostics. Once target product profiles are developed, industry, academia and the NHS should come together to define how these needs might be met through collaboration and mutual knowledge exchange.

The pandemic has created a new impetus behind point-of-care and home testing, which if adopted more widely could help the healthcare system to clear a backlog of tests and increase capacity in the long-term. The case for the value of diagnostics made to funding bodies and policymakers should not be limited to perceived value-for-money but focussed on health benefits.

1. The Academy of Medical Sciences, Building a sustainable UK diagnostics sector, March 2021. See <https://acmedsci.ac.uk/more/events/forum-diagnostics-workshop> (accessed: 5 April 2022).

2. The Academy of Medical Sciences, Antimicrobial resistance research: learning lessons from the COVID-19 pandemic, December 2021. See <https://acmedsci.ac.uk/more/events/AMR-learning-applied-from-covid-19> (accessed: 5 April 2022).

Key steps taken to maximise the use of resources built during the pandemic could include repurposing new facilities, such as the network of Lighthouse Labs, for routine clinical diagnostics while retaining capacity for future pandemics. The opportunity should be taken to use these large, highly centralised laboratories for innovation and to ensure that new skills gained by the thousands of scientists and support staff now trained in COVID-19 testing are not lost.

Over the course of the COVID-19 pandemic, millions of people in the UK have taken a PCR test and several million people have consented to and carried out home testing. There is a new awareness and willingness among the public to be more involved in public health surveillance and biomedical and health research. This engagement needs to be retained for future diagnostic initiatives.

There is now a great opportunity to capitalise on the pandemic-driven growth in technological development and innovations, and to develop the diagnostics sector further.

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“The extensive diagnostic capabilities developed during COVID-19 should challenge the scale of our ambition as we consider the future of innovation in diagnostics for better public health.”

Professor Sharon Peacock, University of Cambridge, COVID-19 Genomics UK Consortium (COG-UK)

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“There’s been an explosion in public awareness around point of care testing, with many people having done these in their homes and workplaces.”

Professor Sharon Peacock, University of Cambridge, COVID-19 Genomics UK Consortium (COG-UK)

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The digital health revolution: empowering the consumer

Elaine Warburton OBE, QuantuMDx Group, Chair ReadyGo Diagnostics Ltd, and Strategic Advisor Javelo Health Ltd spoke about her vision for a decentralised health data platform.

Empowering the consumer to use diagnostics outside clinical settings would help relieve pressure periods on the NHS, such as over the Christmas holiday. Tapping into the changes driven by COVID-19, consumers have become used to healthcare diagnostics routinely deployed outside of healthcare settings. Consumers have also become more familiar with the diagnostic concepts of sensitivity, performance and specificity and the use of digital self-monitoring devices.

Representing a revolution in consumer diagnostics, self-testing has become routine and its incorporation within a simple and safe workflow to get rapid diagnosis is a critical opportunity.

Linked data

In the UK, it should be possible to combine NHS patient records with existing technology and software into one seamless and effective decentralised testing system. Implementing this would allow 90% of cases to be managed within the community, freeing up vital NHS resources needed for more complex treatments.

Rapid and effective data uploads would also reduce the costs of testing and treatment and speed up diagnosis. Multiple companies already provide compact point of care platforms designed for decentralised testing for a range of diseases. A common problem for these products is sample preparation, countered by sampling the nose or mouth, which allows the use of established instruments.

Linking novel diagnostic devices to data analytics platforms and a mobile app which can upload into a centralised system allows further integration with existing health records.

The internet of life

The concept of connecting devices together with genomic data has been called the 'Internet of Life' by Jonathan O'Halloran at QuantuMDx and could be used for monitoring public health, health outbreaks and identifying pathogen outbreaks.

The real-time data produced would split into three packages:

- Clinical results – uploaded to electronic patient records
- Operational data – providing user skill and supply chain information
- Anonymised geo-stamped data – aggregated 'in the cloud' and used to monitor outbreaks, or identify antibiotic resistance hot spots so resources can be mobilised before the outbreaks take hold

A vision was presented whereby a remote primary care physician can triage a patient to the NHS or to the pharmacy to take a rapid test. The results of the test either direct the patient into a more complex diagnosis pathway, or request they stay at home with an over the counter treatment. The use of a mobile app would educate the patient, extract, and package data generated to improve user experience, and be used to develop new products to produce an integrated health record.

Empowering the consumer with different tools and technologies with linked data can start them on a patient journey that improves health outcomes through earlier diagnosis with the use of rapid diagnostics.

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“Self-testing has become routine, even for children...there is a huge consumer diagnostics revolution going on.”

Elaine Warburton, QuantuMDx Group

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Empowering the patient in the UK diagnostics vision

Jo Pisani is a non-executive director and trustee to medical charities and UK start-ups; Trustee for FindACure and LAM Action Board member for LifeArc, the UK Dementia Research Institute, and London's. Jo covered the diagnostics experience from the patient perspective and shared her own experiences for her own diagnostic journey with Lymphangiomyomatosis (LAM).

“Clearly diagnostics is absolutely key to measuring health outcomes.”

Jo Pisani, FindACure, LAM Action, MedCity

Diagnostics that centre on the patient experience are key at all stages of disease management through initial screening, diagnosis, and management of the disease through treatment. Patient centred diagnosis is an iterative dialogue between doctor and patient that respects the patient's needs and circumstances, as well as providing them a sense of control in the process.

Examples of patient centred diagnosis

Routine screens should include counselling to help understand positive results; diagnosis pathways need to be as short as possible; accurate diagnosis and biomarkers should be used to avoid “trial by treatment”. With severe asthma, 50% of the patient population are given ineffective steroids in the absence of specific biomarkers that would identify the different types of asthma.

Increasingly, multiple tools are being used together for diagnosis and treatments including conventional diagnostics, digital tools, and therapy. Prescribing the digital app alongside the product itself can lead to patients logging results and therefore adhering better to their treatments thus avoiding wasted effort, money, and worse health outcomes.

Post treatment, accurate diagnostics are used to measure health outcomes and for assessing outcome-based schemes for providing drugs to the NHS, which is important as company remuneration depends on product success.

Early diagnosis: a case study

Lymphangiomyomatosis (LAM) is a rare cystic lung disease. Rare diseases have multisystem features which may be treated in isolation leading to diagnostic delay and missed opportunities for screening or therapy.

LAM displays as a progressive disease affecting lungs and sometimes kidneys and lymphatics seen almost exclusively in women with two in a million-national prevalence. There is no cure and lung transplantation was the only approved treatment option before rapamycin was repurposed in 2015/2017. The rate of diagnosis and access to specialist care varies by region with the mean diagnostic delay for LAM of four years, and the failure to treat active disease over this period results in a mean loss of lung function of 17%. Women are often misdiagnosed as having asthma when they present with some symptoms of breathlessness and put on steroids and inhalers before LAM is discovered, or they're diagnosed when they present with lung collapse or undergo computer tomography (CT) for another reason. CT screening non-smoking women aged 25-52 years at first pneumothorax (collapsed lung) identifies LAM in 5% of these subjects and is predicted to be cost effective.

The LAM Centre at the University of Nottingham is working on early diagnosis of rare cystic lung disease (RCLD) and identification of undiagnosed community RCLD subjects using artificial intelligence to develop a data driven predictive tool for helping to diagnose LAM.

The MedCity Diagnostic Growth Hub³ is a growing partnership with the NIHR's In Vitro Diagnostics Co-operative. The hub is a collaboration with universities and charities aimed at developing novel diagnostic technologies by connecting innovative companies with expertise from the London health and life sciences ecosystem.

3. MedCity: Diagnostics Growth Hub. See <https://www.medcityhq.com/our-programmes/diagnostics-growth-hub/> (accessed: 5 April 2022).

Integrated radiogenomics for unravelling tumour heterogeneity and treatment monitoring

Professor Evis Sala, University of Cambridge, discussed how next generation diagnostic imaging can be used quantitatively to track and predict tumour dynamics using the example of ovarian cancer.

The radiogenomic framework in Cambridge aims to refine treatment response assessment and outcome prediction in a neo-adjuvant treatment setting using whole-volume tumour segmentation and multi-omics data integration. The dynamic tracking of tumour heterogeneity (dissimilar elements found within the tumour) using novel image-based methods for accurate tissue sampling of habitats allows guided habitat biopsy. These new tools can have applications in novel clinical trials and in everyday clinical practice at multidisciplinary team meetings (MDTs).

Understanding the tumour microenvironment

High grade serous ovarian carcinoma is characterized by three factors: early spread throughout the abdomen, the absence of any 'actionable' oncogenic mutations in the complex chaotic genomes of the cancer cells, and resistance to therapy that is driven by clonal evolution. Increased heterogeneity is linked to poorer patient outcomes as measured by progression free survival. The challenge is quantifying and mapping of the entire tumour microenvironment (TME) and associated heterogeneity. Conventional approaches use computed tomography (CT) images to qualitatively assess the spread of the disease.

New AI based computational methods have been developed to capture both spatial and temporal heterogeneity of the entire tumour and unravel the distinct phenotypes of the TME and then integrate the imaging data with genomics. By combining radiomic or texture analysis on CT, images can reveal heterogeneity imperceptible to the naked eye, which can also be quantified. In combination with clinical, genomic and histopathology data a personalized prediction for patient treatment response can be generated, and allows for precision oncology.

Results were presented from 100 patients treated with neo antigen cancer therapy for ovarian cancer, which had integrated several sources of data into the machine learning algorithm and showed increased ability to predict response to treatment.

Combining imaging tools

Imaging methodology can map out heterogeneity to reduce the number of biopsies required and guide them to more informative areas, potentially replacing biopsies altogether with 'virtual biopsies'. This is not limited to CT, the technique can be applied to magnetic resonance imaging (MRI) for anatomical detail and functional/physiological information and positron emission tomography (PET) for showing metabolic activity.

In collaboration with Canon Medical Systems, the Cambridge team fused ultrasound with CT scans that have the habitats overlaid in real time to guide needle biopsies to accurately target and sample tumour heterogeneity in these tissue habitats. These techniques allow real-time tracking of tumour dynamics in clinical trials, generating image-defined habitats for guided *in vivo* sampling and can be integrated with other clinical and data sources for predicting outcomes.

These tools will also be able to make an impact on everyday clinical practice. An integrated multidisciplinary dashboard for use by MDTs is being developed to simplify focus and give context to all the clinical information on a patient. 'Bioflags' can be raised that combine various measurements to give a readout on patient status, response to current therapy, and give comparisons to previous patients with a similar disease in the database.

The 5-year vision of the Cambridge group is to develop these integrated frameworks for cancer that bridge the gap between imaging and cellular scales. They aim to predict response to cancer treatment using machine learning to deal with the large amount of complex data generated and use IT tools to engage interactively with clinicians and cancer patients. These approaches will give more control over the treatment journey and achieve a new paradigm for personalized cancer medicine.

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“It takes hours for a specialist radiologist to outline and quantify the disease properly. The segmentation tool takes a matter of seconds and is as good.”

Professor Evis Sala, University of Cambridge

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Volatile organic compound analysis as a non-invasive breath test to detect cancer

Professor George Hanna, Imperial College London, discussed his work towards faster diagnosis of gastrointestinal cancer through analysis of the breath.

Gastrointestinal cancer (GC) represents 21% of all cancers and has a 27% mortality. For these types of cancer early diagnosis is critical to improve prognosis. Diagnosis by General Practitioners (GPs) is a challenge as patients present with nonspecific symptoms that could indicate a variety of different cancer types preventing appropriate referral for further diagnosis. In addition, some GC symptoms are shared with some infectious diseases such as Lyme disease, which may cause a delay in diagnosis.

GC patients are typically prescribed medication and allocated a 'wait and see' approach. If the symptoms persist, they are referred for endoscopy or a CT scan and if symptoms improve, they continue the medication. A simple and rapid diagnosis could save lives.

Volatile organic compounds

Volatile organic compounds (VOC) are carbon containing compounds found in a patient's breath and can be detected in the gas phase at room temperature. More than 100 different compounds in breath are distinguishable by gas chromatography.

Testing of volatile compounds is common practice eg the detection of alcohol in breath for drivers, a urea breath test for H. pylori, a hydrogen and methane test for small bowel bacterial overgrowth and nitric oxide for asthma. A breath biopsy triage test for cancer could replace the 'wait and see' method. Patients testing positive would then be referred directly for endoscopy or a scan, and if negative, continue with the medication or be retested later.

Breath biopsy triage

Compounds taken by breath biopsy can be analysed at room temperature immediately or stored for up to 3 months prior to analysis. Using a customized, quality controlled high throughput system up to 250 tests per day can be analysed.

Cancer cells and tissues produce altered lipid profiles (longer and more unsaturated) which generates aldehydes with signature characteristics due to altered aldehyde detoxification genetic regulation. These aldehydes are increased in tissues and in exhaled breath from oesophageal cancer patients (OCP). In initial experiments, clinical data shared from OCP and other cancers demonstrated the link between an increase in cancer specific VOCs both near the tumours and in the airways. In addition, further testing showed that the VOC markers for pancreatic, colorectal and oesophageal cancers are different and can be used to improve diagnosis.

Recently, refinement of the process has shown increased reproducibility through standard protocols and now there are plans to continue clinical trials in 20,000 patients in oesophageal, colorectal, and pancreatic cancer. In the future, breath tests could be a platform to look at multiple tumours: a GP could test for a range of cancers using a noninvasive method that would be very acceptable to patients. To take this forward would require independent larger scale validation studies, and formal quality accreditation to ensure the process is acceptable in clinical practice.

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“Quality control is crucial...we need to make absolutely certain whatever we do will be reproducible in clinical practice.”

Professor George Hanna, Imperial College London

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The promise of digital pathology and artificial intelligence in histopathology

Professor Clare Verrill, University of Oxford, discussed how AI can be used to assist pathologists in identifying disease from complex samples.

Histopathology was highlighted in the UK Government Life Sciences Industrial Strategy as being ripe for innovation. The strategy suggested that samples should be routinely digitized with AI assisting pathologists in making diagnoses. These tools would help generate novel insights in disease biology and permit the use of pathology networks for increased efficiency in diagnosis.

The advantages and challenges of using AI in histopathology

The UK Government aims to realise its Life Sciences Strategy by creating AI centres of excellence. These include a digital consortium (the PathLAKE consortium) to digitise NHS cellular pathology, creating a ‘data lake’ of anonymous scanned images to train AI tools, that would streamline and increase accuracy of diagnoses, thus supporting precision medicine. AI use in pathology has generated much excitement, for example in prostate cancer. However, it is not trivial to build and implement an AI algorithm to be able to be used in clinical practice and getting regulatory approval. Collaborations with industry are often needed to get around some of some of the more challenging steps.

Preparation of samples for digital pathology is a simple process. Whole sample slides can be scanned and uploaded onto a database for viewing, analysis, and remote reporting. The COVID-19 pandemic has accelerated the uptake of digital pathology, demonstrating the benefits of having this extra layer of robustness to the service. However, many labs currently don’t have scanners available for diagnostic purposes. Other challenges include the ability to handle the overwhelming volume of data, access to funding for equipment and software, and a lack of interoperability between systems making cross platform sharing difficult.

Specific AI tool examples

Half of prostate biopsies assessed using Hematoxylin and eosin (H&E) stains, need additional samples taken. This can incur a two-day delay to diagnosis.

An AI tool in the PathLAKE programme can read the slides, decide if it can’t be reported on H&E alone, and can request extra stains before the slide is viewed by the pathologist, saving time and duplicated effort. Another study in collaboration with the Finnish Institute of Molecular Medicine uses AI to derive novel features of outcome that are too complex for a human to see. The team built a deep learning network that could predict a low or high risk for five-year survival in colorectal cancer patients and, on comparison, the AI was superior to expert human pathologists.

Software assistance tools already help day-to-day prostate biopsy analysis. Recently, the University of Oxford has been awarded an NHS Artificial Intelligence (AI) in Health and Care Award to use a prostate cancer detection tool, ‘Paige’, in a pathology-led, multi-centre health economic study. The tool works alongside pathologists screening the slides and can flag up areas that are suspicious for cancer or are cancer confirming results and help to standardise grading assessment, limiting human subjectivity.

Humans and AI make a perfect partnership. Whereas the AI works tirelessly to screen, double checks and is not subjective, humans have the expertise and the interpretation skills to place a case in context and incorporate common sense elements. It is known from public outreach work that these human elements are important to the public when it comes to implementation of AI in healthcare.

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“We have created and utilised AI algorithms to work alongside pathologists assisting with diagnoses and also developing novel insights into disease biology that the human observer can’t do.”

Professor Clare Verrill, University of Oxford, Oxford University Hospitals NHS Foundation Trust

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Point of care diagnostics

Dr Helen Lee, Diagnostics for the Real World, spoke about how point of care testing had now become familiar to the population due to the impact of the Covid pandemic and her experiences of rising to the challenges facing a small diagnostics company supporting delivery of these tests in both clinical and non-clinical settings.

Point of care testing has become the new normal 'post Covid'. In comparison to the 1918 Spanish flu pandemic, which resulted in 228,000 fatalities, the current COVID-19 pandemic has already resulted in 138,000 deaths in the UK. Approximately 8 million cases have been diagnosed in the UK, with half a million hospitalised. At this level, the rapid triage and identification of infected patients was critical, but it would take around 72 hours to receive the results from the centralized service.

Nucleic acid amplification SARS-COV-2 tests pick up the disease earlier and detect viruses for longer than antigen or lateral flow tests. Winter will also bring other respiratory infections aside from SARS COV-2, such as influenza and respiratory syncytial virus (RSV), making continued investment important.

There have been over 200 independent clinical trials that validate PoC testing. In the UK this included 39 antigen tests, 15 molecular tests and around 90 LAMP (Loopmediated isothermal amplification) based assays.

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“The next pandemic will see rapid PoC machines at the airports and hospitals from the very beginning.”

“POC testing, obviously speeds up the service and enables procedures and treatment plans to start much quicker. This will make it clear that there is both a route to market for new innovations and a receptive market once a product is produced.”

Dr Helen Lee, Diagnostics for the Real World

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Challenges and opportunities for biotech companies providing diagnostic tests

The impact of COVID-19 on the diagnostic industry has been huge. Rapid, easy to use, point of care tests have been adopted systematically for the first time in hospitals. These machines are now placed in care centres across the UK with two benefits: increased speed of treatment, and reduced cost.

This new approach could be extended to other emergencies in the future, beyond acute respiratory infections where multiplex testing has already been implemented, but also to diarrhoeal or in genital infections. More new assays will be developed for POC platforms, making testing increasingly relevant in hospitals, healthcare facilities and perhaps transport hubs.

Initial challenges in procurement of reagents and chemicals needed for diagnostic tests caused issues. Although requiring significant validation work, these were solved with planning and the use of multiple vendors. New procurement challenges focus on lack of access to materials such as cardboard, and increased shipping costs and delays globally.

The SAMBA platform

The Real World Diagnostic company is a spin out from the University of Cambridge supported by the Wellcome Trust. Their desktop point of care platform SAMBA (Simple AMplification Based Assay) can perform 12 tests per day with a result delivered in 70 minutes. Based on the competition for raw materials they made the strategic decision to limit supply to the UK. The device can test for HIV, Hepatitis C Virus (HCV) and SARS-COV-2. They will also be launching the multiplex test that includes Covid, Flu A/Flu B, and Covid/ RSV.

All the reagents are heat stable, removing the requirement for cold chain transport or storage. The sample collection buffer inactivates the virus so that it can be reused, and the test can be performed anywhere such as care homes, airports or schools. The test uses a patented extraction chemistry which, unlike almost all nucleic acid amplification tests, does not require guanidine, thus avoiding the byproduct of cyanide on exposure to bleach.

Companies that do COVID-19 tests, whether they are antigen tests or molecular tests, will continue to arise in the future, leading to increased competition and consequent cost reduction, but the importance of quality will need to be maintained. Dr Lee predicted that the next pandemic would see rapid PoC machines at airports and hospitals from the initial outbreak.

Innovation and commercialisation, adoption by the NHS and general population, and the challenges of funding and policy

Chaired by Dr Ian Campbell, LifeArc, with panelists, Dr Rebecca Todd, Longwall Ventures, Dr Jane Kinghorn, University College London and Dr Michael Kipping, Innovate UK.

Summary of key actions to enhance the UK's capability and capacity

- Clear articulation of need from the health service, and an appropriate funding and support mechanism to support innovators. This will make it clear that there is both a route to market for new innovations and a receptive market once a product is launched.
- A clear articulation from the MHRA about regulations and how they comply with the EU regulatory framework. Developers do not need another set of regulations which only apply to 3% of the market.
- Creative thinking about identifying appropriate funding models for diagnostics. More venture capital or more ways to get more venture capital does not address the problem.
- A means by which the NHS incentivises adoption of innovation, and makes it clear how a company can encourage the system to look at the proposition of a diagnostic slightly differently from procurement, which is how it is regarded today.

Funding diagnostics and discoveries

- Diagnostics are predominantly funded by UKRI and NIHR, or charities and patient advocacy groups. The return for investors is typically lower than for therapeutics but carries similar risks and challenges – only 10% of products that are CE marked remain after two years. This does not incentivise private investment in diagnostics.
- Challenges include proving clinical relevance, a clear route to market, regulatory approval, and often clinical trials. However, investors see greater competition for diagnostics with MedTech and novel life science research tools than therapeutics

- Most new medical devices and diagnostics are developed by SMEs and are of little interest to large medical technology companies to acquire and scale. However, they are meeting an unmet clinical need and so should be supported to succeed.
- One solution might be to find alternative ways to finance innovation without the requirement for such high returns on capital. There is a potential role for Government funding.
- Funding from Research Councils and InnovateUK is locked into a three-year cycle that does not match development time.
- Continuation funding usually requires an extensive analysis of results which can cause loss of project momentum and sometimes also of trained staff during the pause.
- For product development, this lack of longevity should be discussed further.

Criteria for investments and regulations

- To make a difference, diagnostics need to target biomarkers with real clinical utility. Innovators should work with clinicians to validate targets and scope out the discovery pathway, identifying the regulatory standards and capacity needed for ISO standards.
- Development costs of a diagnostic can be from \$20-\$100 million; the return on investment needs to be threefold to cover the risk and make a satisfactory return.
- Before investment, there must be a demonstration of health and economic benefit that can be articulated to funders, charities, and other investors.
- There remains a significant challenge to adoption into the clinic, led by a need to show where existing expenditure is saved in the NHS irrespective of benefit to the patient. Appetite for risk from funders may be higher outside of the UK.

- At early stages, innovators need support and guidance more than finance. At later stages ie pre-Phase1 clinical trial, there is a need for a clear regulatory and business strategy for market access.
- Key items needed for funding at early pre-seed stage include scientific rationale, identification of the unmet need, the freedom to operate, and understanding of the risk. Innovators should also consider early engagement with clinicians, building a platform technology, and having a realistic view of the market.
- Uncertainty around new regulatory requirements can significantly increase the amount of evidence the developer needs to produce, as well as increasing cost and time to approval.
- Recent UK reports suggest that for businesses producing IVDs (in vitro diagnostics), 20% of products are expected to disappear from the market due to these new conditions, so there is an imminent challenge in terms of product supply.
- There may be an opportunity to speed up product approvals using regulatory science such as using virtual trials, virtual data, and novel evidence mechanisms.

Integration of clinical tests into diagnostic developmental pipeline

- It is not trivial to decide when to integrate clinical evaluation during development because diagnostics vary greatly: from genomic testing to blood borne protein testing and to imaging.
- Most researchers seeking sponsorship for performing clinical evaluation will already have some clinical data. However, they will still need support to move to a bigger sample collection, or validation through a larger clinical trial or evaluation with more samples.
- It used to be possible to develop ‘homegrown’ tests and move them into the clinic under the hospital exemption regulations, this is no longer possible. These must be reevaluted to the appropriate regulatory standards, and this will be an issue for many hospitals, especially those that are treating rare diseases, where there are many such ‘homegrown’ tests.
- It may be necessary for regulators such as the MHRA to provide exemptions on a specific clinical need, such as seen during the COVID-19 pandemic.

Expansion of home testing and data collection

- While the experience of the pandemic has increased awareness of diagnostics in society, and home testing is empowering individuals and patients to visit the doctor with much more information, the use of the information from the tests needs to stay at the expert level.
- These experts should be making decisions based on information and test data at the population level on the utility and effectiveness of the tests.
- However, the raised awareness may have revealed a user-generated pull for diagnostics from consumer-patients, in contrast to the usual clinician driven pathways for novel diagnostic adoption, and this may form a trend for the future.
- Many diagnostics have patient engagement within their proposition. It is possible that the process of having daily engagement and reporting may better engage patients with their illness and might improve the outcomes of the patients for specific clinical areas
- Global clinical guidelines have revealed healthcare inequalities, and the pandemic has heightened this. We need to aspire to have appropriate diagnostics that don't have inequality built in, and to increase the access to our available technologies, and to avoid using data that contains inherent bias but does encompass data from the populations that we want to treat. This may not be possible with the traditional noninvasive tests that are required for large scale imaging, ie CT and MRI, but may be possible with POC testing by moving testing out of hospitals, GPs, and pharmacies, and into the community. The adoption of the new technologies, such as smart phones, may help so long as there remain multiple avenues for access. Inequality should be addressed from the very start of any new approach.



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The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine. The Society's fundamental purpose, as it has been since its foundation in 1660, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

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The Academy FORUM

The Academy's FORUM was established to catalyse connections across industry, academia and the NHS. The network brings together researchers, research funders and research users from across academia, industry, government, and the charity, healthcare and regulatory sectors. We are grateful for the support provided by the members and are keen to encourage more organisations to take part. If you would like further information on the FORUM or becoming a member, please contact forum@acmedsci.ac.uk.

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Glucose meter used to check blood sugar level.

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