
I-sense
Annual Report 2020
UKRI
Engineering and Physical Sciences Research Council

Working together to track, test and treat infectious diseases.

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Adapting to our new normal

Welcome to our 2020 Annual report, the year in which almost every aspect of our lives was impacted by COVID-19. I would like to start by extending a huge thank you to our team of academics, researchers, students, support staff, advisers, collaborators, institutions, and funders who have worked tirelessly during a time of rapid change and uncertainty.

This year has been extremely challenging, but I am so very proud of the way we have come together to share skills and support each other in response to the pandemic.

In 2018, the World Health Organization (WHO) identified a list of priority diseases of epidemic potential, which included 'Disease X' representing the knowledge that a serious international epidemic could be caused by a pathogen currently unknown to cause human disease. Little did we know then that a previously unknown pathogen, SARS-CoV-2, would go on to infect over 100 million people and trigger a global humanitarian and economic disaster.

In response to the unfolding pandemic in early 2020, we rapidly developed an i-sense COVID-19 strategy, committing to support international public health responses to COVID-19, to adapt our tools and technologies and to support policy makers through advocacy roles.

Our Track flagship programme quickly developed machine learning models of online search queries that were adopted for national community COVID-19 surveillance by Public Health England, providing an early indicator of outbreaks across the UK. We also developed new strands of research using crowd-level anonymised mobility data from O2 (Telefonica UK) to study population flows during lockdown and developed the COVID RED dashboard, bringing together disparate data sets, to monitor the effectiveness of public health interventions.

Recognising the central role of data and digital technologies in the public health response to COVID-19, we published calls for better sharing of tech data in the journal Nature. Our review in Nature Medicine, captured the international use of digital technologies in the global public health response to COVID-19 highlighting the huge opportunities and also barriers to adoption, including evidence of effectiveness, privacy and the digital divide.

Our Test flagship programme, quickly adapted our ultra-sensitive diagnostic platforms to COVID-19, securing funding from the European Institute of Innovation and Technology to fast track the manufacture, clinical evaluation and regulation of QwikZyme. Our breakthrough in quantum sensing of viruses using nanodiamond was published in Nature and is being adapted to COVID-19.

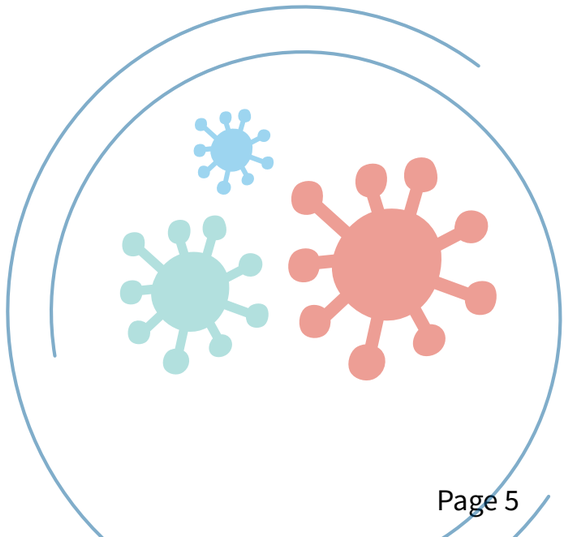
Our senior academics took on advocacy roles, advising UK and international governments, and funders. Our senior academics have been sharing expertise through policy advisory roles on UK SAGE, Independent SAGE, DELVE, Africa CDC, and at the WHO, while our early stage researchers have been seconded to positions at the Joint Biosecurity Centre and the WHO. We also launched the i-sense online Q&A series bringing together world leading experts to discuss COVID-19 challenges, and an Education Alliance career development programme to support our young researchers.

Looking at the scale of challenges that lie ahead, there is no room for complacency. Worldwide there remain huge inequalities in access to vaccines, high quality testing at the point of need, and in early warning surveillance systems. While digital technologies are not a silver bullet, the future of public health is increasingly digital. The technologies developed by i-sense are contributing to the COVID-19 response and future preparedness for future epidemics.

Finally, we are always open to new collaborations, so if you have new ideas or want to find out more then please do get in touch.

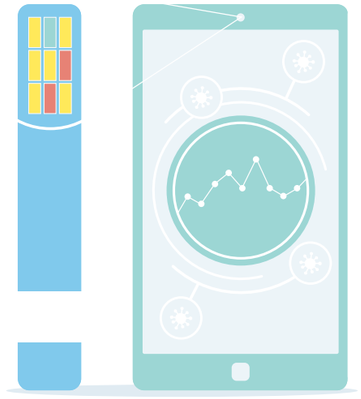
Prof Rachel McKendry

Director of i-sense EPSRC IRC
Joint Professor at London Centre for
Nanotechnology and Division of Medicine,
University College London



About i-sense

i-sense researchers are engineering a new generation of tools and technologies to track, test, and treat infectious diseases. These systems will be agile and rapidly adaptable to different diseases, antimicrobial resistant strains and different countries.



Track

We use self-reported symptoms via social media and web searches to help track outbreaks of infectious disease, potentially before people visit their doctor and in resource-limited settings. Our AI algorithms for influenza surveillance have been adopted by Public Health England to include in their weekly and annual influenza surveillance reports. This is one of the first examples of AI being adopted by Public Health England. During COVID-19, our team built a surveillance tool to track the prevalence of the virus in the community, based on web search data from Google, which has also been adopted by Public Health England for surveillance.

Throughout the COVID-19 pandemic, our team have been working with project partners O2 (Telefonica UK) and Public Health England to map mobility and care rates across the UK. A dashboard that displays the latest statistics for the find, test, trace, isolate system has also been created and made publicly available. This dashboard draws in information from publicly available resources.

Test

We are building smartphone-connected diagnostic tests to support front-line healthcare workers and self-testing, with real-time data linkage capabilities. Our low-cost device prototypes include a point-of-care test that uses ultra-sensitive nanomaterials to detect the early stages of HIV, and a multiplexed test for Ebola serology. Our portable mHealth tools and protocols have been adopted for quality assurance of HIV rapid tests by the Africa Health Research Institute, supporting healthcare workers and the local community by reducing the risk of false test results.

Through the COVID-19 pandemic, our researchers have been adapting our diagnostic tests to help in the response to the virus.

Treat

We are creating online care pathways and visualisation tools to link patients to treatment and map disease ‘hot spots’ to help inform health interventions.

Our mobile app, co-created with the Africa Health Research Institute, has been piloted with 30 participants in a local health clinic demonstrating the feasibility and acceptability of self-testing and linkage to care using mHealth technologies.

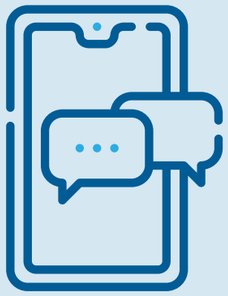
Our data dashboards, co-created with Africa Health Research Institute, were used in a HIV Treatment as Prevention trial and adopted for service delivery of the population health intervention platform.

2020 in numbers

With COVID-19 came a shift in focus and working style for everyone at i-sense. Although a number of our researchers are helping in the global effort to respond to this pandemic, much of our Core research has also been able to continue thanks to collaboration and hard work of our entire team. In 2020, we achieved:

10

publications
in *Nature*, *Nature Medicine*, *Nature Communications, ACS Sensors, bioXriv* and *arXiv*, six of which are related to COVID-19 research.



social media
140K Tweet impressions

15% increase in Twitter followers

65,000 + unique page views on i-sense.org.uk, including covid.i-sense.org.uk

77

media appearances
including Prof Andrew Hayward on BBC Channel 4 and the Guardian, Dr Vasielios Lampos in the New York Times and HuffPost, Dr Isabel Bennett in The Economic Times (India), Prof Rosanna Peeling on Bloomberg, Dr Ben Miller and Prof Rachel McKendry on Phys.org and Mail Online, Dr Mengdie Zhuang and Dr Ed Manley in The Conversation and more.

10

policy, advocacy and engagement roles
including The Royal Society DELVE (Prof Dame Anne Johnson), The Royal Society RAMP (Prof Ed Manley), SAGE (Dr Mike Short and Prof Dame Anne Johnson), Independent SAGE (Prof Deenan Pillay), World Health Organization (Dr Richard Pebody), MHRA C19 Horizon Scanning (Prof Rachel McKendry and Prof Deenan Pillay), Royal Academy of Engineering International Engineering Response (Prof Molly Stevens), and Africa CDC (Prof Rosanna Peeling).

£1.4M

in COVID-19 research funding
including from EPSRC, IET, Google, and Imperial's President's Excellence Fund.

2

visualisation dashboards
including the FTTIS data dashboard and the COVID-19 online symptom surveillance dashboard.

3

secondments
including Joint Biosecurity Centre (Dr Isabel Bennett and Jobie Budd), and the World Health Organization (Dr Polina Brangel).

6

events
including virtual Q&A sessions and internal conference, including 14 invited speakers from the Health Foundation, GSMA, WHO, and more.

01

Our response to COVID-19

Image credit: Trinity Care Foundation, Source: Flickr (CC BY-NC-ND 2.0)

Funding: Track and test

EPSRC COVID-19 Plus Award

i-sense received £500,000 in funding from the Engineering and Physical Research Council. The funding is a 12 month priming Plus Award grant to help with COVID-19 response.

The collaborative team from UCL, UCLH, Imperial, and University of Leeds, and partners at Public Health England and the World Health Organization, have been addressing challenges associated with tracking and testing COVID-19.

i-sense researchers are focusing on two main areas:

1. Developing online syndromic epidemiological surveillance systems to track COVID-19 using online search data

2. Building smartphone-connected diagnostic tests to widen access to testing of front-line health-workers, and patients

Funding: Track

Google fund modeling for COVID-19 using web search data

i-sense members, Dr Vasileios Lampos and Prof Ingemar Cox at UCL Computer Science, received USD$200,000 in funding to support their research into modeling the prevalence and understanding the broader impact of COVID-19 using web search data.

Research highlight: Track

Tracking COVID-19 with online search data

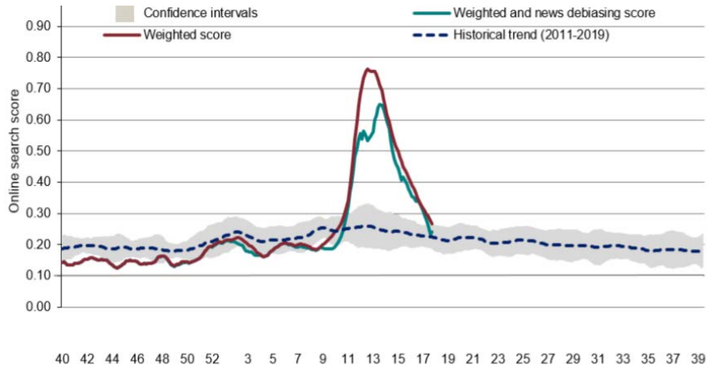


Image: Normalised Google search score for COVID-19 symptoms, with weighted score for media-de-biasing and historical trend, England Source: Public Health England Weekly Coronavirus Disease 2019 (COVID-19) Surveillance Report, April 2020 (page 5)

i-sense researchers have been looking at ways of tracking COVID-19 using online search data.

Their current analysis, which uses machine learning models to make predictions of potential prevalence of COVID-19 in a population, focuses on a number of countries, including the United Kingdom, United States of America, Canada, Australia, France, and Italy.

The model analyses a set of specific key terms from Google search queries on a daily basis. It proposes unsupervised machine learning models for COVID-19 based on weighted symptom categories taken from the NHS First Few Hundred (FF100), survey and an expanded version that incorporates the symptom of 'loss of smell' and generic terms about COVID-19. It also proposes a preliminary approach for minimising the effect that news media may have on online searches.

A transfer learning method is also being developed, whereby a supervised model stemming from daily confirmed cases and search query frequencies from a country that is further along in the epidemic curve (e.g. Italy) is mapped to other countries.

This research could help to better understand community spread by identifying potential positive cases from individuals that may never present to their doctor. Outcomes of this project are given directly to Public Health England on a weekly basis.

Yom-Tov, E., Lampos, V., Cox, I. J., and Edelstein, M. 'Providing early indication of regional anomalies in COVID19 case counts in England using search engine queries.' arXiv (2020); https://arxiv.org/abs/2007.11821

Lampos, V., Majumder, M. S., Yom-Tov, E., Edelstein, M., Moura, S., Hamada, Y., Rangaka, M. X., McKendry, R. A., and Cox, I. J. 'Tracking COVID-19 using online search' arXiv (2020); DOI: arxiv.org/abs/2003.08086

Research highlight: Track and test

Virus Watch seeks to understand COVID-19 spread

UCL launched Virus Watch (ucl-virus-watch.net/), inviting 50,000 participants to take part in one of the largest, most comprehensive household studies of COVID-19 in the UK. All household participants are asked to complete online surveys, seeks to better understand community spread of the virus.

The findings will help with understanding how populations respond to public health advice, such as social distancing, why the disease disproportionately affects some groups, and how our immune system protects us from disease. As many COVID-19 cases are mild or asymptomatic, people may never present to public health systems, so these large scale studies add to the overall picture of the pandemic.

The two part study will bring together epidemiological data and modeling of online population data based on social media and search engine queries.

The first part of the study includes at least 25,000 individuals for online symptom monitoring, and behaviour reporting through surveys.

A sub-cohort of 10,000 individuals will have tests to look for antibodies and carry out self-swabbing for detection of COVID-19 and other circulating viruses.

i-sense researcher from the McKendry group, Dr Val Turbé, has been collaborating with Virus Watch to improve image capture protocols for pictures of rapid lateral flow tests. As antibody COVID-19 self tests are being rolled out, participants are being asked to capture a photo of their test to confirm their result. i-sense researchers were approached to share experience in image capture of tests by untrained professionals.

The second part of the study will build on experience of i-sense Deputy Director, Prof Ingemar Cox, working closely with Google, Microsoft and Public Health England to estimate the household secondary attack rate and serial interval of COVID-19. These are important parameters to models of the spread of disease and improved estimates of these parameters should improve model accuracy, thereby better informing public policy.

Findings from this study may inform various aspects of the public health response to future outbreaks, including better targeted interventions, clearer allocation of resources and picture of case load, and better understanding of risks to the community.

This project is led by Prof Andrew Hayward and Prof Robert Aldridge, in collaboration with a large team across UCL, including i-sense members Prof Rachel McKendry, Prof Ingemar Cox, and Dr Valérian Trubé.

Research highlight: Track

COVID RED brings together data on pandemic response

i-sense COVID Response Evaluation Dashboard (COVID RED), an online data visualisation tool, collates and presents data from the Office of National Statistics, Public Health England, and the NHS under five categories; Find, Test, Track, Isolate and Support for those asked to Isolate (FTTIS). It presents indicators of England's performance under each of these headings, and identifies areas where more data are needed.

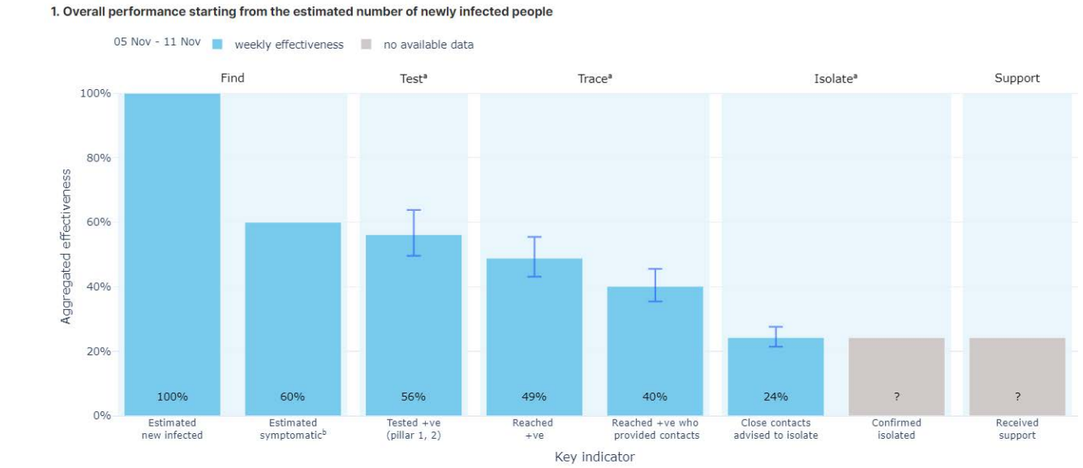


Figure: Find, Test, Trace, Isolate, Support cascade shows the overall performance for week 5 - 11 Nov 2020. COVID RED is currently the only dashboard that explores the system as a whole, with the additional function of 'isolation' and 'support' status.
Source: covid.i-sense.org.uk

Bringing together COVID-19 data from a wide range of sources into one programme, COVID RED is currently the only dashboard that explores the system as a whole, with the additional function of 'isolation' and 'support' status. This is in regard to the importance of these steps in ensuring optimal performance of the whole response system.

Increasing volumes of data shown in the media and in government press conferences as a basis for local tightening of restrictions are often from disparate sources, and are not linked together to give a more complete picture of pandemic response. This was the motivation behind our dashboard development; to contribute to the public understanding of COVID-19's spread, and support policymakers in identifying current areas of the Find, Test, Trace, Isolate and Support structure requiring strengthening.

The team have identified areas for improvement, including more data required under 'isolate' and 'support', and more frequent data release. The project is on going, with the plan to add more data, including vaccine data, when available.

This work was led by Dr Mengdie Zhuang, Prof Ed Manley, Prof Deenan Pillay, alongside co-developers Jobie Budd, Dr Isabel Bennett, Prof Rachel McKendry, Prof Christina Pagel, Steven Gray, Dr Nigel Field, Rebecca Sconza, and Erin Ma Manning, with support from Oscar Bennett.

Research highlight: Track

Data sharing for pandemic response

Open data from mobile phones, and digital footprints from web searches and social media, remain largely inaccessible to researchers and governments, however access to this information could be important in public health efforts.

Early in the pandemic a group of i-sense researchers, led by Prof Rachel McKendry wrote a *Nature* commentary, calling on technology companies to work with researchers and governments to help curb the COVID-19 pandemic by sharing their data in a legal, proportionate, ethical and privacy-preserving manner. The team suggested sharing of data in these unprecedented circumstances could have a positive societal impact.

Digital trails from web searches and social media could really help to better detect the spread of COVID-19 in communities at an early stage, especially where there is no access to testing. These important data sets could allow us to evaluate the real impact of public health interventions, such as social distancing.

McKendry, R. A., Rees, G., Cox, I. J., Edelstein, M., Eland, A., Stevens, M. M., and Heymann, D. 'Share mobile and social-media data to curb COVID-19.' Nature (2020); DOI: 10.1038/d41586-020-00908-6

Digital technologies for pandemic response

A *Nature Medicine* review, led by Prof Rachel McKendry, looks at how digital technologies have been mobilised for a global public health response to COVID-19 and the associated concerns with privacy and efficacy in an evolving digital world.

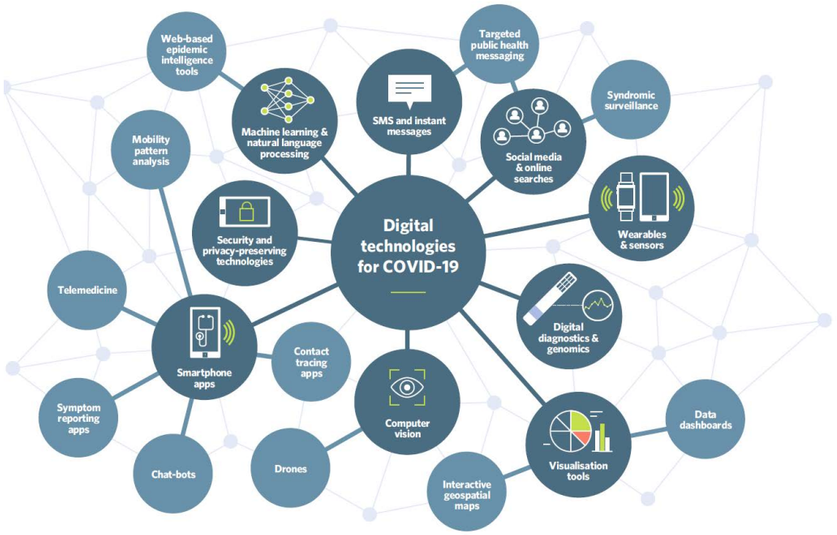


Image: Interconnected digital technologies used in the public-health response to COVID-19
Source: Figure originally published in Nature Medicine (reference below)

Our review shows that digital technologies have an important role in responding to the pandemic, alongside conventional measures. A collaborative, system-level approach is required to build and evaluate an effective digital online pathway that links rapid and widespread testing with digital symptom checkers, contact tracing, epidemiological intelligence, and clinical follow up. Technologies should be developed collaboratively with governments and healthcare providers, ensuring they meet public health needs and ethical standards.

During this pandemic, many technologies have been adapted and developed on a scale never seen before. This has highlighted the need for standardised data collection and for privacy related legislation and regulation to be develop in parallel.

Use of data to inform outbreak response should take into account the digital divide. Many interventions and surveillance methods rely on connectivity, meaning communities may be left behind or missed from statistics.

The rise of digital technologies have led to faster and more widespread communication about the pandemic and digital platforms have also made adherence to restrictions somewhat easier, allowing people to work and attend schooling from home, support community and access support.

The review suggests digital technologies should go through a rigorous evaluation to identify how they can effectively support traditional outbreak control methods, adhere to privacy and ethics frameworks, and should be built into an online pathway.

This research has been cited in a number of publications including the *Lancet COVID-19 Commission Statement on the occasion of the 75th session of the UN General Assembly* and presented at talks including to the World Health Organization and to G20 Digital Taskforce.

Budd, J., Miller, B. S., Manning, E. M., Lampos, V., Zhuang, M., Edelstein, M., Rees, G., Emery, V. C., Stevens, M. M., Keegan, N., Short, M. J., Pillay, D., Manley, E., Cox, I. J., Heymann, D., Johnson, A. M., and McKendry, R. A. 'Digital technologies in the public-health response to COVID-19.' Nature Medicine (2020); DOI: 10.1038/s41591-020-1011-4

Mobility data to track the effectiveness of distancing measures

Pandemics, such as COVID-19, are usually assumed to spread rapidly within the population. In reality, the population is more heterogeneous with regard to risk, and there will be large variation on the basis of geography, workplace and other key factors. Analysing data on a national level therefore risks hiding this heterogeneity and compromises the most effective public health response.

Analysis from i-sense researchers in the McKendry group at University College London earlier in the pandemic suggested COVID-19 has such diverse effects on the different local authorities in the UK.

The research, which was published as a pre-print on *arXiv*, draws on geospatial data highlighting local variation in mobility across the country, as well as case rate data, which shows potential hot spots of infection. Looking at data on a local level helps understand adherence to social distancing measures across different parts of the country, and helps map movement of people throughout the pandemic.

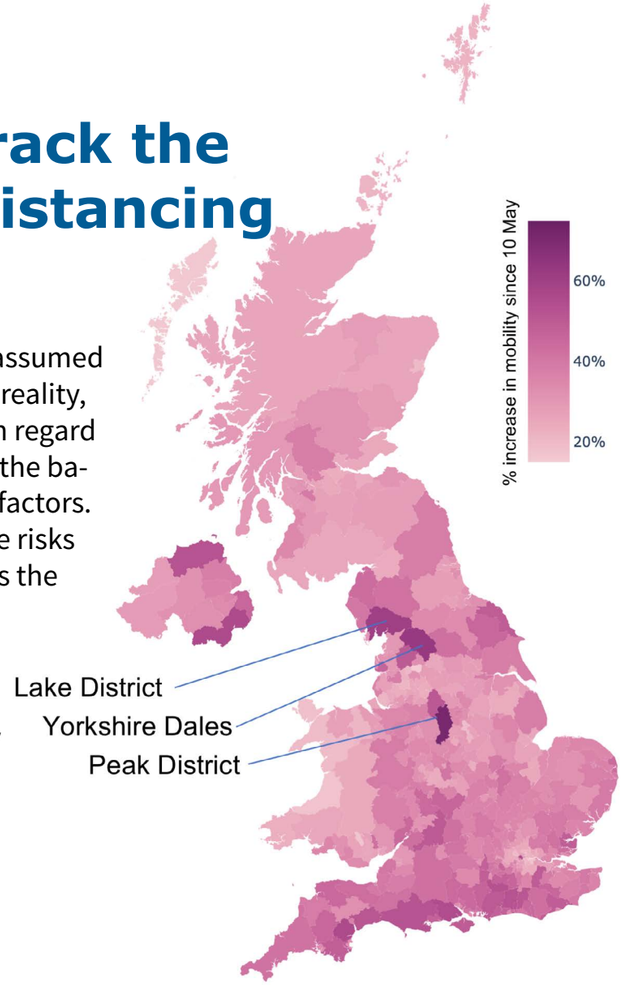


Figure: Percentage increase in non-commute trips between two weeks prior to easing of restrictions on 10 May and first week of June by local authority. Data shows trips ending in local authority.
Source: Figure originally published in arXiv:2007.02603v1

This type of anonymised aggregated population data, made available from project collaborators O2 (Telefonica UK) and Public Health England, is key to understanding population patterns in near real-time, allowing for earlier identification of hot spots.

Important to this is access to real-time or near real-time local level data, which is really important in helping to better understand the local impacts of easing lockdown.

Our analysis showed that some areas across the UK returned to near pre-lockdown levels of mobility after the second wave of lockdown easing took place on 1 June.

Looking at datasets such as case rate and mobility data on a local level can give us a better understanding of what is going on in a particular area, helping to develop policies that suit that local population.

Bennett, I., Budd, J., Manning, E. M., Manley, E., Zhuang, M., Cox, I. J., Short, M., Johnson, A. M., Pillay, D., and McKendry, R. A. 'Go local: The key to controlling the COVID-19 pandemic in the post lockdown era,' arXiv (2020); DOI: arXiv:2007.02603v1

Working in the lab during lockdown

As COVID-19 sent the world into lockdown in early 2020, i-sense researchers mobilised to help with the global effort to respond to the pandemic.

The team at i-sense have been working collaboratively across institutions to develop tools and technologies to help respond to the pandemic, including developing point-of-care diagnostic tests for COVID-19.

When the UK went into lockdown in mid-March, a group of researchers were given special access to i-sense labs in London and quickly implemented appropriate measures to ensure they could continue their work safely. Those who were unable to work in the lab have adapted to working from home, collaborating with lab users and adjusting their projects to suit desk-based research.

Throughout the first lockdown, Dr Ben Miller and Dounia Cherkaoui worked at Prof Rachel McKendry's i-sense lab based at the London Centre for Nanotechnology, UCL, while Dr Leah Frenette and Dr Marta Broto Aviles worked in Prof Molly Stevens' lab at Imperial College London, along with a team of over 25 Stevens group researchers who volunteered to assist the efforts in the lab and remotely. Since the first lockdown, the labs have opened up to more users, while remaining socially distanced.

Some of the team have been adapting existing i-sense diagnostic technologies to be suitable for COVID-19. Several projects have been ongoing including ultra-sensitive lateral flow based assays and the development of a rapid, isothermal and ultra-sensitive platform to detect the virus without the need of qPCR.

Marta has been the senior postdoc in Prof Stevens' team helping coordinate the day-to-day research of the multidisciplinary team with strong support from the Stevens group's translational team led by Dr Paresh Parmar. Leah has been working on optimising the technology for its final format including nanoparticle processing, device format and assembly, and signal amplification. The ultra-sensitive test developed will dramatically reduce the analysis time of a viral test from one day in a centralised laboratory to 15 minutes anywhere.

Dounia an i-sense PhD student, has been researching alternative testing assays for the new virus. This work was motivated by the worldwide shortage in qPCR instruments and reagents that considerably slowed down the response and hurdled the 'Find, Test, Trace, Isolate, Support' strategy that was urged by the World Health Organization. Dr Ben Miller has been printing different SAR-CoV-2 antibodies on lateral flow strips for incorporation into the assay being developed by the group at Imperial; as well as working on improving the sensitivity of lateral flow antigen testing with both existing and novel nanoparticle technologies.

The team have continued their research and development through every stage of lockdown and have made good progress. As the pandemic has continued, we have been able to increase the number of people with access to the labs so more people can carry out experiments.

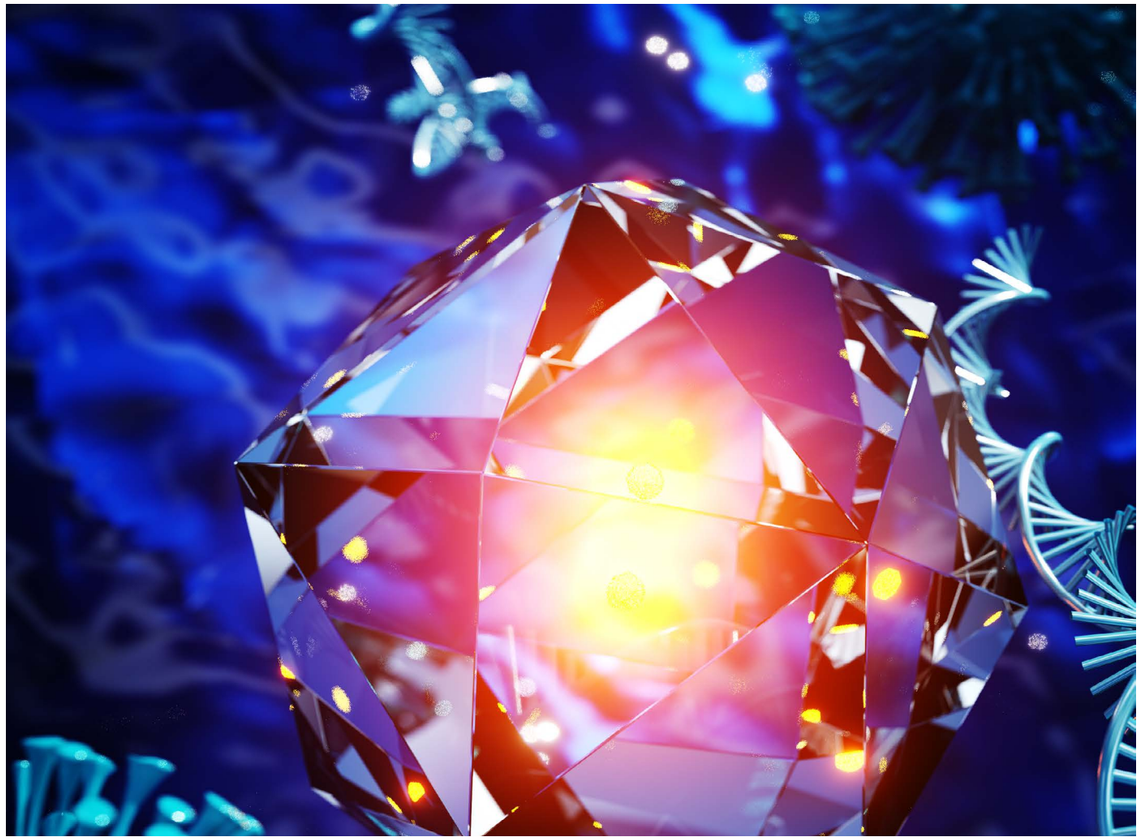


Image: Nanodiamond, viral RNA and virus in solution
Image credit: Ella Maru Studio and i-sense McKendry group, UCL

Research highlight: Test

Nanodiamonds make diagnostic test ultra-sensitive

The quantum sensing abilities of nanodiamonds can be used to improve the sensitivity of paper-based diagnostic tests, potentially allowing for earlier detection of diseases such as HIV, according to a study led by the i-sense McKendry group.

The research, published in *Nature*, found that low-cost nanodiamonds could be used to signal the presence of an HIV disease marker with a sensitivity many thousands of times greater than the gold nanoparticles widely used in these tests. Although tested with HIV in the first instance, researchers within the i-sense McKendry group are adapting this approach for use in various COVID-19 diagnostics.

The researchers made use of the quantum properties of nanodiamonds manufactured with a precise imperfection. This defect in the highly regular structure of a diamond creates what is called a nitrogen-vacancy (NV) centre.

The NV centres can signal the presence of an antigen or other target molecule by emitting a bright fluorescent light. The optical results showed up to a five orders of magnitude (100,000 times) improvement in sensitivity compared to gold nanoparticles.

This greater sensitivity allows lower viral loads to be detected, meaning the test could pick up lower levels of disease or detect the disease at an earlier stage. This is crucial for reducing transmission and for effective treatment of diseases.

The assay being developed by the researchers in the McKendry group at UCL is looking at molecular detection of SARS-CoV-2, the virus causing COVID-19. This assay will bring together the novel nanodiamond technology with a recently developed rapid isothermal amplification for COVID-19 testing, using a simple dipstick readout.

A key next step is to develop a hand-held device that can "read" the test results, as the technique was demonstrated using a microscope in a laboratory. With a handheld device the test could, in future, be performed in low-resource settings, making it more accessible to users. Further clinical evaluation studies are also planned.

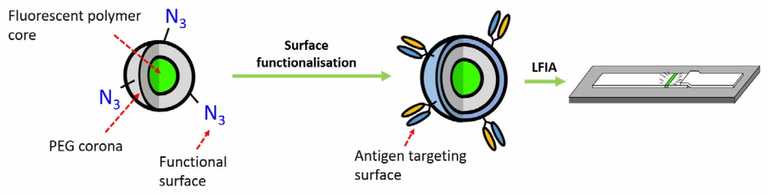
The original work, published in Nature, was led by Dr Ben Miller and Prof Rachel McKendry, in collaboration with Leonard Bezinge, Dr Harriet Gliddon, Dr Da Huang, Gavin Doud, Dr Eleanor Gray, Judith Heaney, Prof Pete Dobson, Prof Eleni Nastouli, and Prof John Morton.

Miller, B. S., Bezinge, L., Gliddon, H. D., Huang, D., Dold, G., Gray, E. R., Heaney, J., Dobson, P. J., Nastouli, E., Morton, J. J. L., and McKendry, R. A. 'Spin-enhanced nanodiamond biosensing for ultra-sensitive diagnostics.' Nature (2020); DOI: 10.1038/s41586-020-2917-1

The work adapting the assay for COVID-19 is being led by Dounia Cherkaoui, Dr Da Huang and Prof Rachel McKendry, UCL

Research highlight: Test

Fluorescent nanoparticles for COVID-19 test



The functionalisation of these particles with antibodies, antibody fragments and affibodies has also been optimised, resulting in particles which perform well in lateral flow with low non-specific binding in serum, using HER-2 as a model antigen.

We are now applying this technology towards a point-of-care test for SARS-CoV2. We have performed a full screening of antibodies to the spike protein and we have now isolated several capture/detection pairs via ELISA.

We will now focus on functionalising the nanoparticles with the detection antibodies to find the best candidate for LFIA. We are also expecting a novel COVID affibody to arrive from our collaborators in KTH which we will implement into the same screening process.

This work is led by Dr Adam Creamer, Lino Prados Martin, and Prof Molly Stevens, Imperial College London.

Funding: Test

Funding speeds up research into COVID-19

Prof Molly Stevens' team have been awarded £50,000 in funding from the new Imperial College COVID-19 Response Fund to develop point-of-care diagnostics for the current pandemic.

These rapid, ultra-sensitive tests aim to detect low concentrations of the virus, meaning that patients can be diagnosed much earlier.

Funding: Test

EIT funding for COVID-19 rapid response

The i-sense team at Imperial College London received over €500,000 in funding from the European Institute of Innovation and Technology as part of their COVID-19 Rapid Response Call.

In collaboration with partners from Imperial College Healthcare NHS Trust, the London School of Hygiene and Tropical Medicine and Abingdon Health, the team are developing a point-of-care diagnostic test, called QwikZyme, for COVID-19.

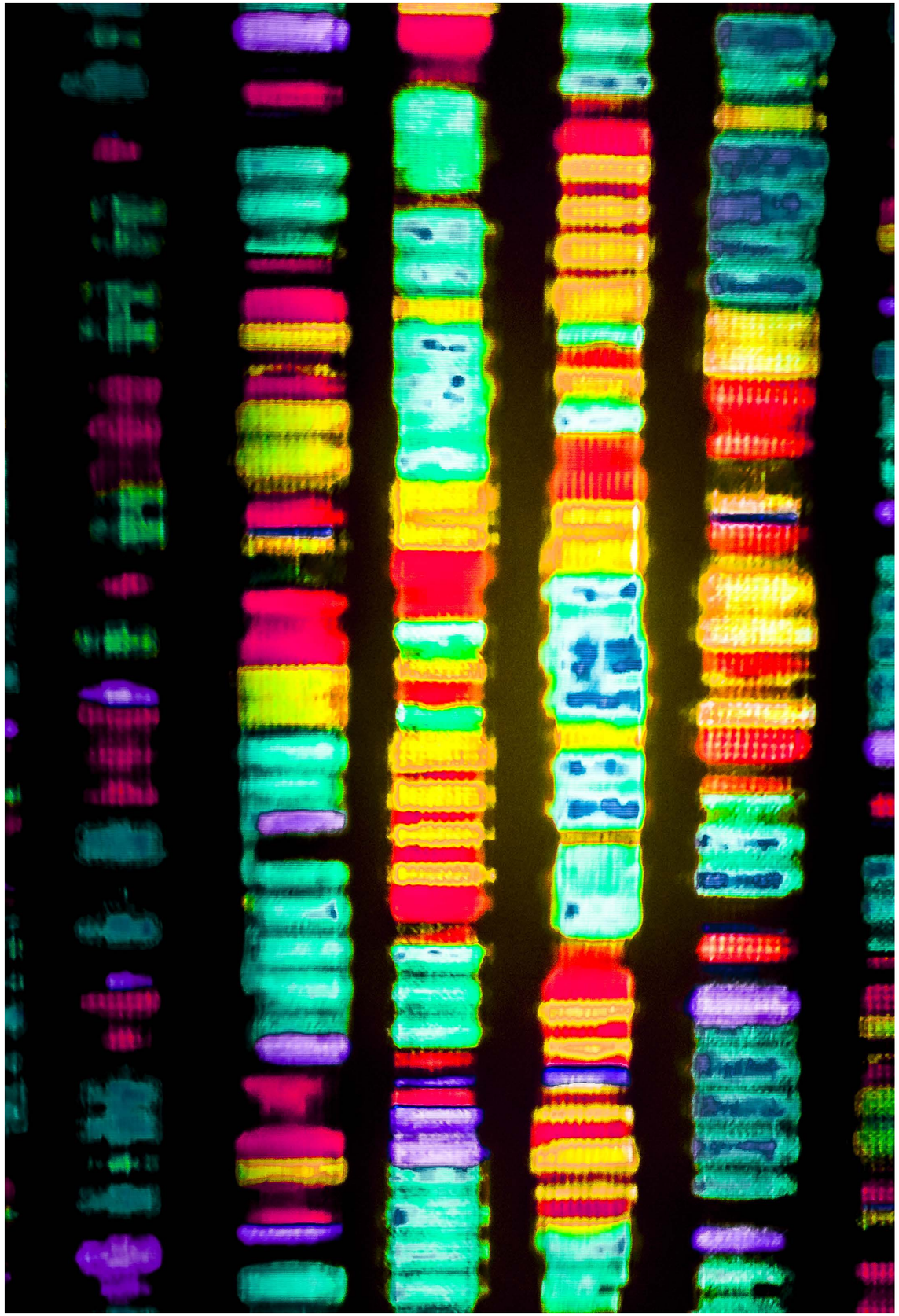


Image credit/source: Gio.tto/Shutterstock

Research highlight: Treat

Following COVID-19 mutations with genomics

Working to actively curb the COVID-19 pandemic, i-sense researchers in partnership with UCLH Advanced Pathogen Diagnostics Unit (APDU) are developing new diagnostic technologies to improve clinical care and outcomes.

Led by Head of Virology, Dr Eleni Nastouli, the APDU is a late translational research unit that has developed innovative molecular diagnostics and Next Generation Sequencing protocols, in collaboration with the Sanger Institute. From the start of the COVID-19 pandemic, the APDU has initiated a whole genome sequencing programme, and re-purposed a H2020 grant for point-of-care diagnostics to COVID-19.

Historically genomics has been utilised by the APDU as part of routine surveillance and outbreak investigations. Whole genome sequencing of virus samples allows us to identify pairs of samples that are sufficiently similar and potentially belong to the same transmission chain within the hospital environment.

Viruses mutate at different rates, but over the short period of an outbreak we would only expect a handful of differences between a pair of linked samples. By looking at samples, we can identify changes in the virus, identify which are from the same outbreak, and, with epidemiological data, understand if an infection is hospital or community-acquired.

This technique was put to the test in late 2020, making use of a genome assembly and analysis pipeline developed by i-sense member, Dr Dan Frampton, in collaboration with the APDU. Following the announcement by the UK Health Secretary of a novel COVID-19 variant of interest (14/12/2020), he was able to report back to the APDU and associated teams within the hospital on the prevalence of the variant within UCLH and other London clinics within a few hours. Subsequent collaborative research between i-sense, the APDU and clinicians at UCLH has focused on whether the genomic characteristics of the variant might influence transmissibility, or affect disease severity and patient outcomes.

The ADPU have also been working with i-sense to see what happens to viral genomes in response to treatment with drugs, such as Remdesivir. Given COVID-19 mutates relatively slowly compared to other viruses, differences in sequence that have arisen post-treatment and are seen across several otherwise unlinked patients are likely to be informative in terms of how the virus is forced to adapt in response to a particular drug.

The team have also been investigating how the virus may evolve in patients over time. Through our standard outbreak analysis, they can check that the patient has not been reinfected with a different COVID-19 lineage. Changes in sequence that have accumulated over time are then investigated to understand where these mutations are in the genome and what, if any, conclusions can be drawn about potential functionality.

The team uses Next Generation Sequencing (NGS) to generate viral genomes: this allows them to look much deeper into samples than traditional sequencing and identify mutations only present in a small minority of viral sequences within a patient sample. If mutations are observed at later time points, they can go back to earlier samples to look at whether these mutations were already present but in smaller quantities, or have arisen as a direct response to treatment or the patient's immune system.

These projects are ongoing: future research questions will involve similar analysis of the effect of vaccination and response to treatment with monoclonal antibodies.

This work is led by Dr Eleni Nastouli, Dr Dan Frampton, Dr Jude Heaney, Dr Moira Spyer, Dr Paul Grant, and Matt Byott.

Research highlight: Treat

Bringing genomics data into clinical context with dashboards

For viral infections such as COVID-19, where there is often insufficient genomic sequence diversity to rule out linkage in potential clusters of infection, access to rich clinical epidemiological data is essential.

The team are currently working with UCLH to develop a data extraction tool to automatically download core clinical datasets, thus saving clinicians considerable time and effort querying UCLH's database for electronic health records, known as EPIC, manually.

A working group, including i-sense members Dr Dan Frampton and Dr Mengdie Zhuang, the APDU and a range of UCLH clinicians, are developing a dashboard to display this information.

The aim is to build on existing solutions, putting a patient's genomic data into clinical context alongside demographic, temporal, location and other key clinical data. This will meet the needs of clinical researchers, Infection Control and virologists at UCLH, and by careful design should be sufficiently portable to be used by other clinics with similar electronic healthcare systems.

This work is led by Dr Eleni Nastouli, Dr Dan Frampton, Dr Mengdie Zhuang, Dr Jude Heaney, Dr Moira Spyer, Dr Paul Grant, and Matt Byott.

Research highlight

Understanding vaccine efficacy using historic data

Although collaborative work between i-sense and the UCLH Advanced Pathogen Diagnostics Unit (APDU) has shifted focus to COVID-19 work this year, research involving other viral pathogens continues.

Through a collaboration with Fiocruz in Brazil, the i-sense and ADPU teams are using historic data to investigate regional dynamics of influenza transmission and the efficacy of their current flu vaccine given varying levels of influenza seasonality across Brazil as a whole. This work is part funded by UCL's Global Engagement office.

This work is led by Dr Eleni Nastouli and Dr Dan Frampton, in collaboration with Dr Fernando do Couto Motta, Dr Marilda Siqueira and Dr Ana Maria Bispo de Filippis at the Oswaldo Cruz Institute, Fiocruz, Brazil.

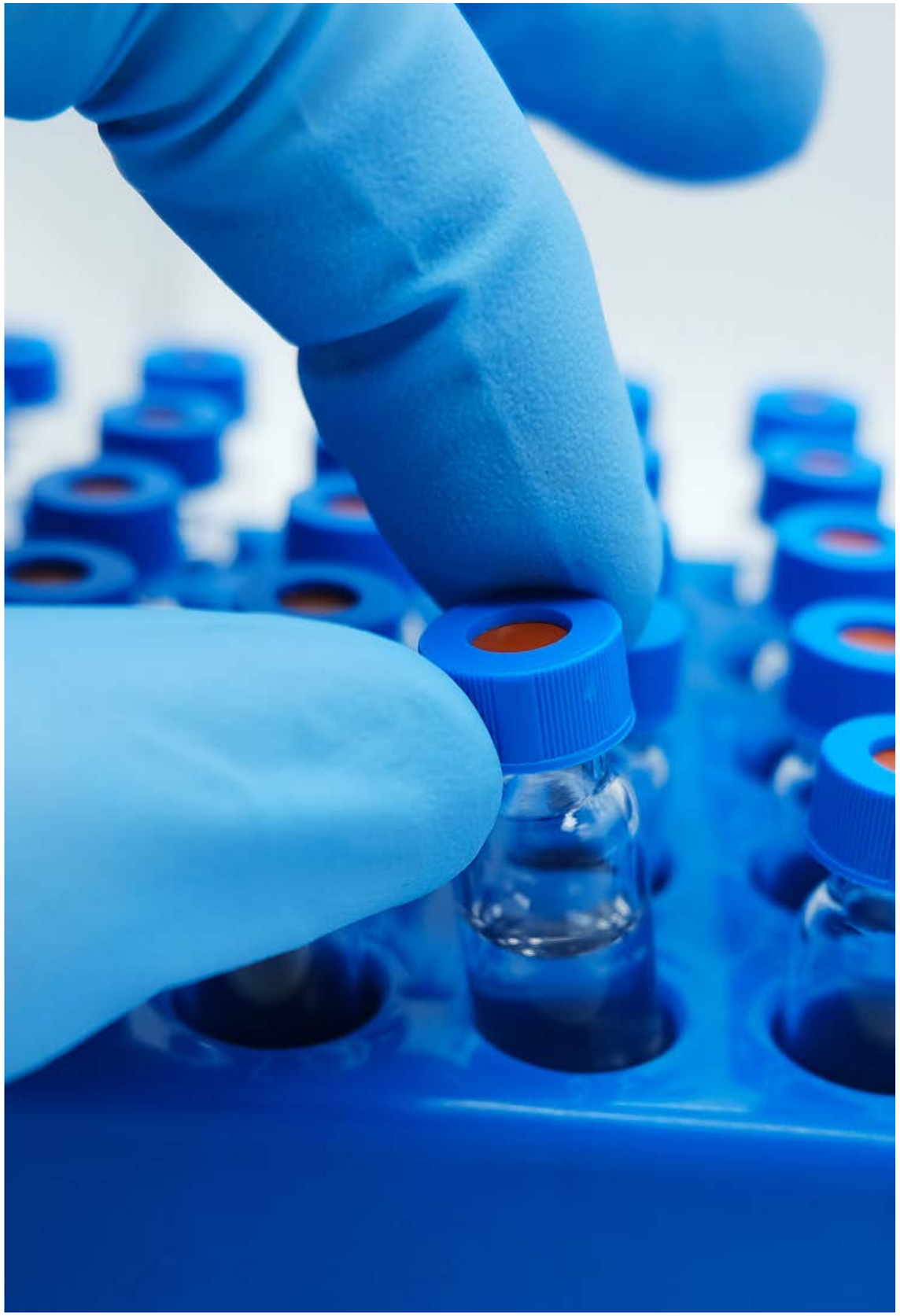


Image credit: Stockphotokun, Source: Flickr (CC BY 2.0)

02

Our core research

Research highlight: Track

Measuring uncertainty for influenza forecasting

Influenza is an infectious disease that is responsible for between 290,000 – 650,000 deaths each year, worldwide. Without proper surveillance and control, it has the potential to become a pandemic.

For this reason, it is a priority for health organisations to monitor the prevalence of influenza within a community in order to implement interventions, such as recommending use of antiviral drugs, and control transmission.

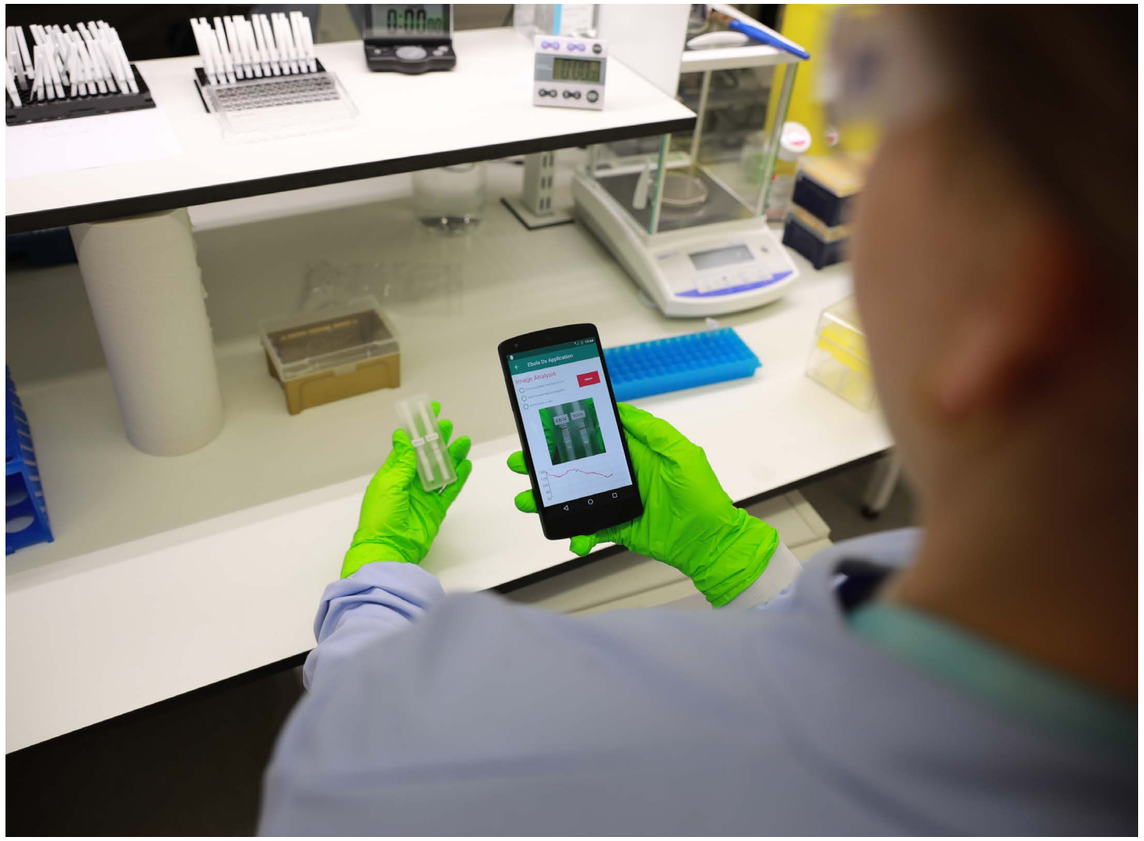
i-sense researchers have been developing machine learning algorithms that look at how people are talking about their symptoms online in order to estimate the prevalence of influenza-like-illness (ILI) in a population and predict potential future changes. This online syndromic surveillance tool has been adopted by Public Health England as part of their overall ILI surveillance.

Until recently we have focused on estimating influenza prevalence today rather than forecasting influenza prevalence in the future. For forecasts to be useful, we need to know the associated uncertainty (the more uncertain we are, the less confident we are). Uncertainty helps when bringing together information from various sources. If we know the uncertainty associated with each source, we can weight the sources accordingly, and produce an aggregate forecast that is more accurate and reliable than any individual forecast. Estimating uncertainty is also important for decision making. Once again, if a forecast is to be actionable, it is necessary to know the associated confidence.

Although there is considerable evidence that monitoring web search data can help with forecasting, models based on neural network architectures do not currently measure uncertainty for forecasting estimates. i-sense researchers have been looking into Bayesian neural networks and have shown that this method can be used without significantly sacrificing accuracy in forecasting. Their model accounts for two sources of uncertainty simultaneously: (i) data uncertainty that arises due to measurement noise, and (ii) model uncertainty that arises due to approximation in the model.

The team aim to build on this work by improving the accuracy of the forecasting models by incorporating more complex architectures and validation methods.

This work is led by Michael Morris, Dr Vasileios Lampos, Peter Hayes, Dr Simon Moura, and Prof Ingemar Cox.



Research highlight: Test

Point-of-care test for the detection of Ebola virus

Researchers in the i-sense McKendry group at UCL are working collaboratively on a smartphone-connected point-of-care test for Ebola virus.

The multiplexed lateral flow test aims to detect specific viral antigens that can be performed in just 15 minutes. This test is comprised of unique monoclonal antibodies (mAb), originally designed for therapeutics by the United States Army Medical Research Institute of Infectious Diseases.

The device is being designed to test and differentiate between two viral species; Zaire ebolavirus and Sudan ebolavirus, which have caused major outbreaks is Sub-Saharan Africa. The team have evaluated the performance of the test in physiological samples and have seen some promising results with saliva and urine.

If successful, this test could be combined with the Ebola serology test, designed by i-sense researchers in 2018, to form a highly useful system for epidemic control and population at risk surveillance.

This work is led by Dounia Cherkaoui, Dr Polina Brangel, and Prof Rachel McKendry, in collaboration with, Dr Ben Miller, Dr Val Turbe, Yiyun Chen, ans Prof Molly Stevens.

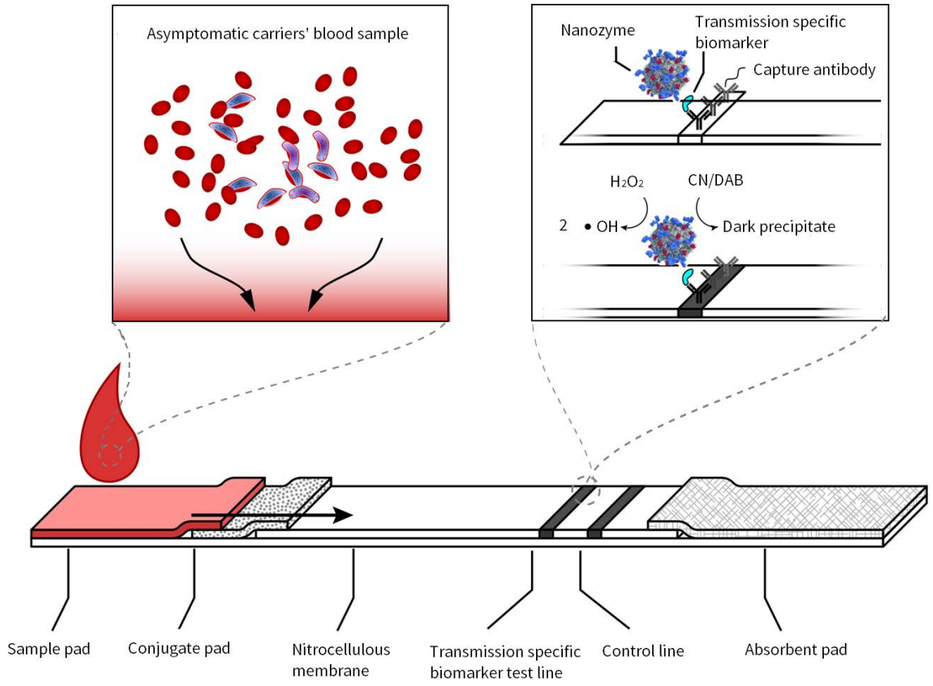


Figure: Schematic illustration of LFIA for detecting malaria transmission stage carriers

Research highlight: Test

Developing a rapid diagnostic test to end asymptomatic Malaria

Malaria is continuing to be a major cause of death in Sub-Saharan Africa. Despite immense progress in reducing malaria cases and deaths within the last decade, progress has slowed down and the number of cases are on the rise again.

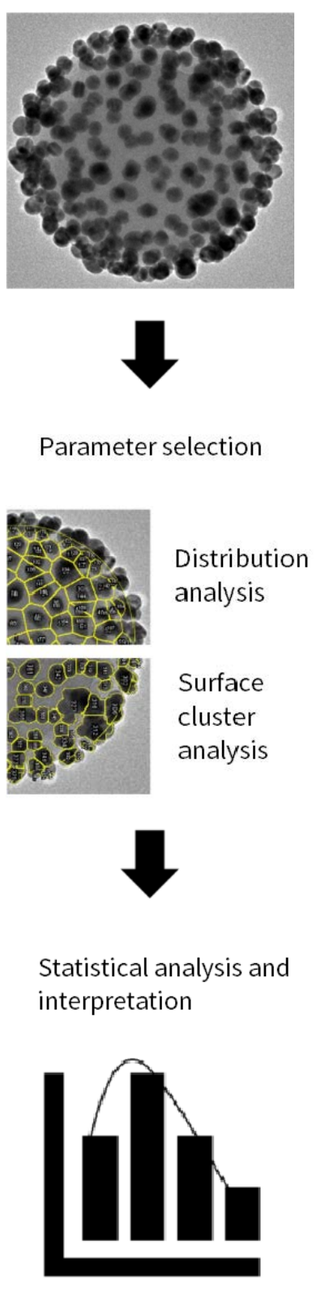
This has led to a renewed call for reinforcing efforts towards eradication, which will clearly require establishment and enrollment of additional antimalarial tools. One key technology that is still missing in order to be able to implement novel strategies for eradication are simple and sensitive diagnostic tests to detect asymptomatic parasite carriers. These asymptomatic carriers can still contribute to transmission. However, due to the low levels of parasitemia, majority of these carriers cannot be detected using the conventional rapid diagnostic tests for malaria.

i-sense researchers are developing an ultra-sensitive and simple test for detection of this reservoir of asymptomatic individuals. The test builds on previous i-sense research around the development of super sensitive platinum-based nanoparticles for catalytic amplification in lateral flow point-of-care testing and is looking at novel biomarkers for detection of transmission competency in asymptomatic carries.

This work is done by Tabasom Haghighi, Dr Marta Broto Aviles, Dr Adrian Najer and Prof Molly Stevens in collaboration with Prof Jake Baum from the Faculty of Natural Sciences, Department of Life Sciences at Imperial College London.

Research highlight: Test

Quantitative image analysis of nanoparticle biosensor



In order to obtain a deeper understanding of how certain parameters of nanoparticles, such as surface morphology, can affect their interaction with complex biological matrices (e.g. blood and saliva) and thereby help engineer better nano-sensors, researchers must first be able to produce nanoparticles with consistent and controllable characteristics.

i-sense researchers from the Stevens group are studying a specific particle model for its tunable morphology – a large nanoparticle substrate with smaller nano-seeds covered on its surface. Conventionally, characterisation is done through use of an electron microscope to visualise nanoparticles and identify key features, including distribution and clustering of nano-seeds on the substrate particle, as opposed to visualisation by eyes, which can be subjective.

To maximise the information that we can obtain from electron micrographs of nanoparticles, we have been developing a nanoparticle quantitative analysis work-flow that involves image processing and statistical interpretation.

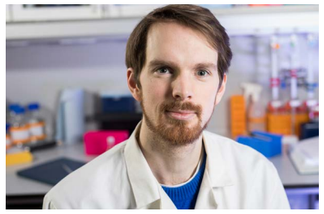
By using image analysis tools such as ImageJ, physical parameters pertaining to seed distribution and degree of clustering can be acquired. This is then followed by applying appropriate statistical models to correlate the physical parameters of interest to the experimental reaction conditions of which the particles are produced.

This is an iterative process, through the batch-to-batch analysis of particles with different characteristics, we aim to achieve reliable prediction of synthesis conditions for a desired particle surface morphology.

This work is led by Brian Chen, Dr John Goertz , Dr Michael Thomas and Prof Molly Stevens, Imperial College London, with support from Stephen Rothery, Facility for Imaging by Light Microscopy at Imperial College London.

Funding: Test

SERS research funding



New funding from a Royal Society Research Grant, awarded to i-sense Lecturer at UCL, Dr Michael Thomas, will help support research using Surface-Enhanced Raman Spectroscopy (SERS) approaches for quality control of antibody reagents.

The work will look to establish a label-free SERS sensing system in the London Centre for Nanotechnology to monitor antibody glycosylation using nanoparticle conjugates.

Research highlight: Test

Multifunctional hybrid nanoparticles for point-of-care diagnostics

Image: Adding magnetic functionality to fluorescent nanoparticles allows for easy separation and manipulation by a magnet

Inorganic nanoparticles have diverse optical and physical properties that make them attractive probes in biomarker detection. Quantum dots, have long been used as fluorescent tags within basic biomedical research due to their intense brightness, high efficiency, and resistance to photobleaching. Iron oxide nanoparticles are strongly magnetic, allowing for the magnetic separation of analytes from complex sample matrices. Use in point-of-care diagnostics for both kinds of nanoparticles, however, has been limited due to practical concerns such as stability and ease of functionalisation with disease targets.

i-sense researchers have been looking at new methods to facilitate the application of these promising materials in infectious disease diagnostics. The team have developed new methods of encapsulating different inorganic nanoparticles inside fluorescent polymer nanoparticles. In doing so, the team have lessened issues of stability and combine functionalities of both nanoparticle systems whilst simultaneously providing a simple method of attaching disease-targeting ligands through the chemical functionality of the encapsulating polymer.

The resulting nanoparticle probes are highly fluorescent and can be manipulated using a magnet to concentrate analytes from solution. They are easily functionalised with antibodies and the functionalisation methods used can be adapted for other, more stable, small molecule binders. The team is looking to further evaluate the scope of this system to include other inorganic nanoparticles, including those with catalytic properties.

This work is led by Dr Leah Frenette, Dr Adam Creamer and Prof Molly Stevens, Imperial College London.

Research highlight: Test

Diagnostics for tuberculosis

i-sense researchers, as part of the Imperial led Plus Award, aim to create innovative, rapid, sensitive, specific, and affordable point-of-care tests designed to be implemented in South Africa for diagnosis of tuberculosis (TB).

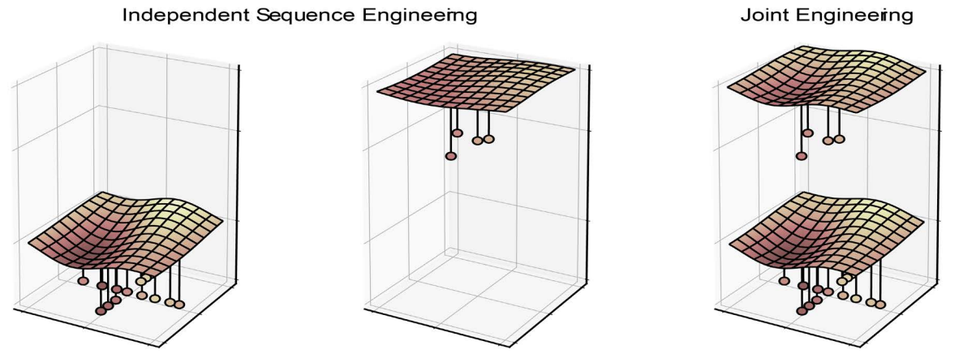


Figure: Empirical modeling and machine learning allows us to rapidly optimise a new target using information from previous targets

TB is the leading cause of death in South Africa and diagnosis is notoriously challenging, requiring long testing times and costly equipment. Complicating matters, about 60% of TB patients in South Africa are also infected with HIV, which renders the disease even harder to diagnose with current techniques.

Classical diagnostic tests generally can take about 10 days to result. More rapid and powerful techniques are expensive, hard to transport, or require specialist trained staff, which makes them difficult to perform in rural healthcare clinics.

The point-of-care test being designed by i-sense researchers will incorporate nanomaterials-based approaches, microfluidic engineering, and smartphone readout to automate all aspects of testing. Simple testing has the potential to empower clinicians to manage their patients' health and provide global healthcare organisations with improved methods to monitor TB.

At the core of this project is a technique for engineering DNA amplification to emulate the predictions of machine learning models. This recently-patented technology condenses complex patterns of multiple target molecules, in this case the expression level of multiple genes, down to a simple yes/no readout. Using model-driven design and state-of-the-art machine learning approaches, this system can be rapidly and robustly adapted to diagnose many other complex diseases in a similarly simple, easy-to-use way.

Validation studies are planned for a small pilot study with the Africa Health Research Institute, located in KwaZulu-Natal, a region of South Africa that has high rates of TB and HIV. The technology developed under this award will also be adaptable to other infectious diseases and non-communicable diseases alike, providing smartphone-based diagnostic technologies within resource-limited settings.

This work is led by Dr John Goertz, in collaboration with Prof Molly Stevens, Ruby Sedgwick, Dr Mark van der Wilk, Prof Ruth Misener, and Dr Namrata Singh of Imperial College London; Dr Ben Miller and Prof Rachel McKendry of UCL; and Harshit Harpaldas and Prof Sam Sia of Columbia University.

Multiplexed test for detecting bacterial infections

The i-sense team at Newcastle University have been developing point-of-care diagnostic tests capable of detecting the 'big five' carbapenemases, enzymes capable of hydrolysing carbapenems.

The diagnostic test is a single-plex Recombinase Polymerase Amplification (RPA), which is a type of isothermal amplification technique. Isothermal amplification techniques are alternatives to traditional Polymerase Chain Reaction (PCR) techniques, however they can be performed at a single temperature. This means they do not require the same expensive thermal cycler required by PCR, which reduces equipment costs significantly.

RPA operates between 25 and 42°C and is the only isothermal technique that has been shown to operate using body heat alone, making it applicable to resource-limited settings. RPA can also amplify nucleic acid in five to 20 minutes and these rapid results are often critical for point-of-care testing.

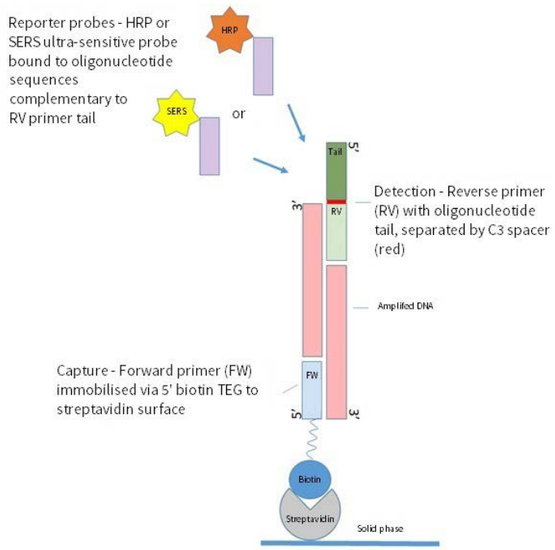


Figure: Schematic representation of solid phase amplification

The current assay that the team has developed has shown to successfully detect one of the carbapenemase genes (see figure 1), however the ultimate aim is to adapt these assays to an ultra-sensitive multiplexed point-of-care test to detect all of the 'big 5' carbapenemases in one test.

In order to achieve this the team plan to modify the assay, including substituting the HRP protein with a ultra-sensitive surface-enhanced Raman spectroscopy (SERS) reporter molecule and using streptavidin functionalised magnetic beads.

The magnetic bead format allows for tethering forward primers specific to each of the five carbapenemase genes to streptavidin coated magnetic beads (see figures 2a and 2b). The beads are added directly to the RPA reaction and provide a solid phase scaffold for amplification. Five reverse primers, specific to each of the five carbapenemase genes are also added to the RPA reaction mix. The reverse primers each have a unique single stranded tail that acts as a bio-barcode that can detect the presence of each of the five gene's cognate DNA targets.

In order to carry out multiplex detection of the five carbapenemase genes the team will use five spectrally distinct SERS probes (see figure 2b) each cross-linked to an oligonucleotide complementary to one of the five bio-barcodes (see figure 2c).

Application of SERS for point-of-care diagnostics is, to date, based on readings using high-grade spectroscopy systems in laboratory settings, in turn limiting the widespread roll-out of SERS-based assays outside clinical settings.

To address the challenge, the team at Newcastle University have teamed up with Prof Molly Stevens' group at Imperial College London, to build a low-cost, miniaturised and portable SERS reader for ultra-sensitive multiplexed SERS-based diagnostics tests for deployment at the point-of-care.

Various instrument designs have been developed and scrutinised for conformity to the criteria for price, sensitivity and robustness. The use of laser diode technology and detection on CCD camera through a transmission grating is being explored as potential route to miniaturisation. Following acquisition of signals from multiplexed SERS reporters, information across the entire spectral range collected, will be exploited to unmix active SERS reporters through advanced multivariate spectral demixing strategies.

This work is part of the i-sense Next Steps Core award, as well as the Plus Award, titled 'Ultra-sensitive enhanced nanosensing of antimicrobial resistance (u-Sense)'. The Plus Award is led by Dr Neil Keegan, Dr Chris Johnson, Matthew Setterfield, Dr Matthew Pocock, and Prof Anil Wipat, Newcastle University, in collaboration with Prof Duncan Graham and Prof Karen Faulds, University of Strathclyde, and project partners at Cambridge Life Science Ltd, iXscient Ltd, and Public Health England

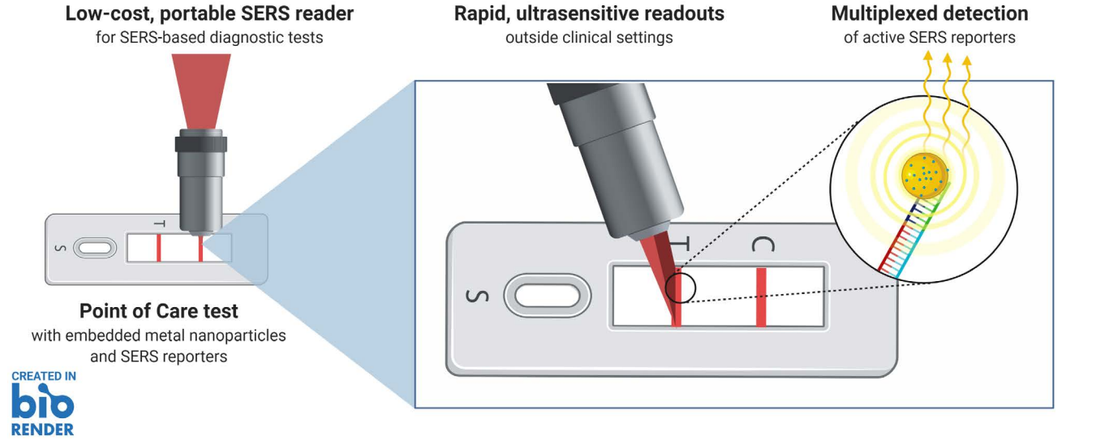


Figure: Miniaturised SERS reader combined with spectral deconvolution techniques will enable multiplexed detection of active SERS probes reporting carbapenemase genes

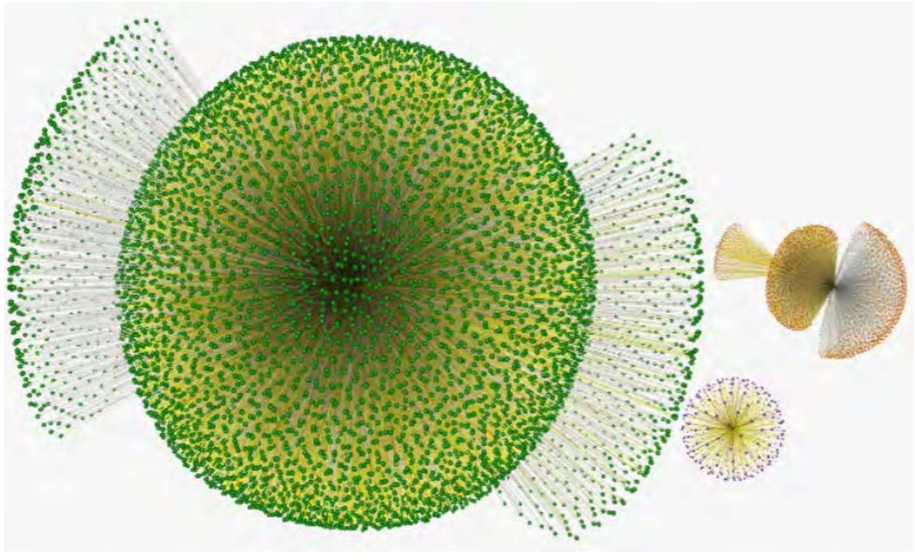


Figure: Invisiogen workflow results illustrated as a network of related genes and proteins

Research highlight: Test

Developing a bioinformatics tool to identify antimicrobial resistance

i-sense researchers at Newcastle University have been developing a bioinformatics workflow, called Invisiogen, for identifying antimicrobial resistant (AMR) genes within sequence databases. The overall aim of the system is to detect the occurrence of new AMR genes in multiple data sources as they appear, and to predict the evolution of likely problematic variants before they arise.

A user interface will present data to the user about the new variants found, sequence, variations, location, date, source, submitters, and more, and offer to design new primers for these variants. Evolutionary information about how these variants fit in the gene family at the DNA and protein level will be provided and a notification will be sent by email to the registered user to tell them when new variants arise, and give them a URL to follow to gain more information. New data visualisation techniques will be explored in this interface.

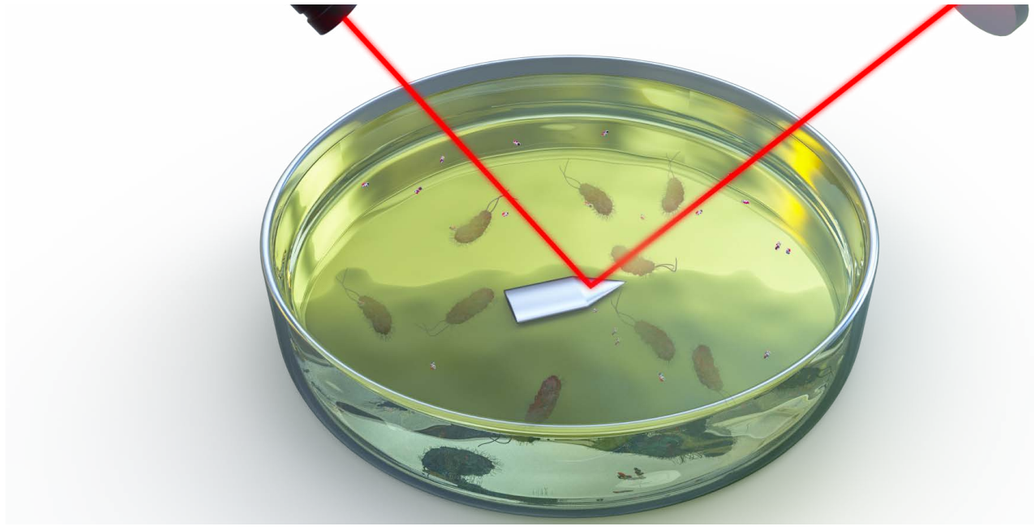
Workflows have been developed that periodically mine databases such as NCBI, Uniprot and a range of AMR data sources, such as CARDS, for the big five carbapenem genes. New variants are found by analysis of the time stamps of the entry, the annotation and sequence analysis using a statistical model. New entries are stored in a new database, in an integrated fashion. In the future, mining will be done at a DNA and protein level and the team will attempt to identify the type of vector and the host.

Work is now underway to design the look and feel and operation of the dashboard that will be built as a web application.

This research is led by Dr Matthew Pocock and Prof Anil Wipat, Newcastle University.

Research highlight: Test

Using lasers to rapidly detect antimicrobial resistance



Antibiotic resistance is a growing global concern and major threat to human health. Urgent development of diagnostic tests is needed to detect resistance and reduce over use of antibiotics.

The standard method used to detect resistance in bacteria, known as phenotypic antibiotic sensitivity testing, monitors bacterial growth over about 12 – 24 hours and is therefore a slow process.

Research published in *ACS Sensors* and conducted by i-sense researchers at University College London and the University of Sheffield, presents a novel method for detecting phenotypic antibiotic resistance in less than 45 minutes, capable of detecting single bacteria.

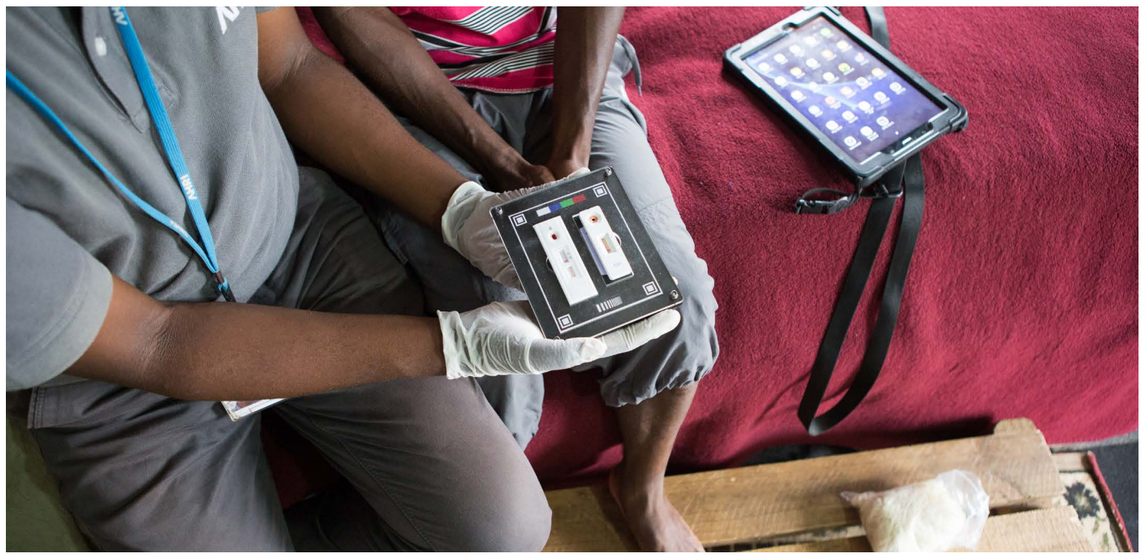
In this approach, the researchers use a sensitive laser and detector system to measure nanoscale optical changes caused by single bacterial cells present in media, with simple sample preparation. By exploiting this sensitive technology, growth in resistant bacteria, or death in non-resistant bacteria is able to be detected, providing an indication of antibiotic resistance faster than currently available methods.

The method has been successfully tested to detect resistance to multiple antibiotics in both lab and clinical strains of *E. coli.* This approach can be exploited as a new rapid phenotypic method for antibiotic sensitivity testing, to provide time-critical results to inform patient care.

This research was selected as Editor's Choice and also in the top 10 most read publications in *ACS Senors* for September 2020.

Bennett, I., Pyne, A. L. B., and McKendry, R. A. 'Cantilever Sensors for Rapid Optical Antimicrobial Sensitivity Testing.' ACS Sensors (2020); DOI: 10.1021/acssensors.0c01216

Piloting a smartphone application in the field in rural South Africa



This year i-sense researchers continued developing their smartphone app designed to assist end users perform and interpret HIV rapid tests in partnership with the Africa Health Research Institute.

Last year, our initial pilot study at a local clinic in KwaZulu-Natal, South Africa, demonstrated the feasibility and acceptability of such a tool with local teenagers taking part in the study and reporting on the experience of being guided through the steps of performing their test, as well as receiving the test result from the device rather than in person.

This year, we focus on optimising the machine learning classifier we use to automatically interpret test results based on a picture of the test captured by the end user. We successfully conducted a pilot study at the Africa Health Research Institute rural site to assess the performance of the new iteration of the app in deployment conditions.

Five local staff took part in the study; two trained nurses and three minimally trained teenagers working as community facilitators. Participants were asked to use our application to record their interpretation of HIV test results, as well as capture a picture of the tests for automatic interpretation of the result by our machine learning classifier.

The study was successful and highlighted:
1) significant disagreement in traditional visual interpretation (that is, different participants interpreting the same test by eye), highlighting the need for a more objective interpretation system;
2) end users using our application were able to capture valid pictures that could be interpreted by our automated system;
3) crucially, our system was able to correct some of the mistakes made using traditional visual interpretation. This successfully paves the way for a larger study in the future.

This research is led by Dr Valerian Turbe and Prof Rachel McKendry, in collaboration with Carina Herbst, Prof Maryam Shahmanesh, Dr Sepehr Meshkinfamfard. Manuscript submitted.

i-sense HIV Online Pathway (iSHOP)

After completing data collection for the iSHOP user testing in autumn of 2019, this year i-sense researchers focused on data analysis and optimisation of the eSexual Health Clinic HIV self-testing and self-sampling pathways.

Key findings from this analysis include:
1) Participants were generally able to interpret the results of self-tests using the manufacturer's instructions, but they also desired built in support for doing self-tests and reassurance about their interpretations of the results;

2) For those who received a reactive result, participants felt that the pathway provided clear next steps, including emphasising the importance of confirmatory testing, and that;

3) receiving emotional support in an online pathway, including out-of-hours and peer support, is desired, which is in keeping with findings from earlier iSHOP exploratory studies (see paper below).

One user testing scenario also explored the acceptability of using a prototype smartphone camera app (i-reader), which simulates reading and interpreting self-test results using the smart phone camera. Participants described i-reader as "easy to use," "helpful" and "quick." Facilitators and barriers to trust in i-reader were identified as key themes.

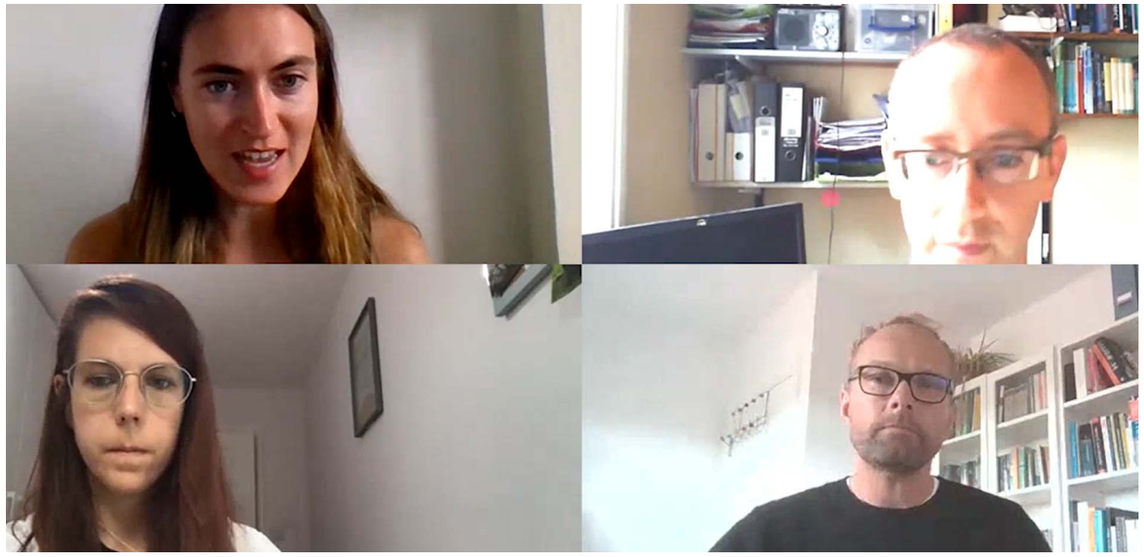
The optimisation of the online pathways has involved building in brand-specific self-testing support (embedding the manufacturer's self-test demonstration video) and visual confirmation of self-test results at results entry (option to select an image of the test result), and refined information and support for both self-testing and self-sampling pathways.

These findings have been reported in poster presentations at the 2020 British Association of HIV and Sexual Health National Conference in October, and the team are presently in the process of writing up this work for submission to peer reviewed journals. The iSHOP work is being taken forward as part of a prestigious NIHR programme grant titled 'Improving care for people with STIs in a digital NHS.' This project started in November 2020 and is led by Prof Claudia Estcourt.

Singh A, Gibbs J, Blandford A. Emotion and Experience in Negotiating HIV-Related Digital Resources: "It's not just a runny nose!" In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, paper no. 599; May 2019. p 1–14. https://doi.org/10.1145/3290605.3300829

03

Our education and engagement



Pictured: Erin Manning, UCL (top left), Richard Welpton, the Health Foundation (top right), Jess Morley, DataLab (bottom left), and Boris Wojtan, GSMA (bottom right)

i-sense Q&A series

Our new i-sense virtual Q&A series was started in August 2020, led by i-sense Communications Manager, Erin Manning. The series explores topics related to infectious disease outbreaks preparedness and response – focusing on what we have learnt from the COVID-19 pandemic, what we need to do to ensure we are ready to respond to the next infectious disease outbreak, and how can we better protect our population and healthcare systems now and in the future.

Each month we explore different themes related to developing tools and technologies to track, test and treat infectious diseases. As preparing for and responding to an outbreak is a collaborative effort, we have aimed to gain perspectives from experts in academia, government and policy, healthcare, and industry.

Over the four Q&As that were held in 2020, we spoke on topics including data sharing and privacy to vaccination and herd immunity.

We had the absolute pleasure of being joined by experts including Jess Morely from the DataLab, Richard Welpton from the Health Foundation, Boris Wojtan from GSMA, Prof Rosanna Peeling from LSHTM, Dr Jim Huggett from the Laboratory of the Government Chemist, Prof Eleni Nastouli from UCLH, Prof Michael Edelstein from Bar-Ilan University, Prof David Heymann from LSHTM/WHO, and Prof Dame Anne Johnson from UCL and the UK Academy of Medical Sciences.

We aim to continue the series through 2021.

4

topics

Data sharing and privacy during a pandemic
Diagnostic testing - lessons from the pandemic
Is herd immunity a reality?
Our environment and the spread of COVID-19

10

speakers from

DataLab, the Health Foundation, GSMA, LSHTM, Laboratory of the Government Chemist, UCLH, Bar-Ilan University, Israel, WHO, the UK Academy of Medical Scienes

Key talks, presentations and awards

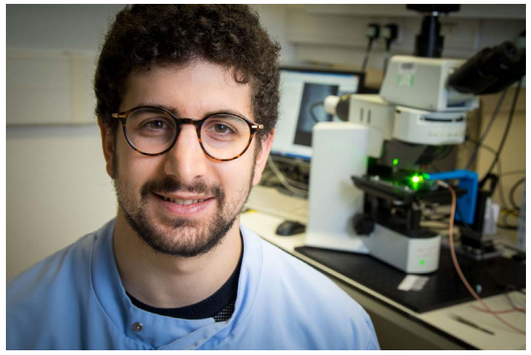
There have been many successes and highlights acorss the i-sense team throughout 2020, here are just some of the key achievements from the last year.

Dr Polina Brangel
Presented at TEDxMPI, Stuttgart, and seconded to the World Health Organization to work on COVID-19 serology.

Prof Rachel McKendry
Presented to the G20 Digital Connectivity and Covid-19 Response Workshop, the WHO Digital Health Round Table with Academia on early warning systems, and on MHRA C19 Horizon Scanning committee.

Prof Dame Anne Johnson
Elected President of the Academy of Medical Sciences and on The Royal Society DELVE and SAGE committees

Prof Molly Stevens
Elected as Fellow of the Royal Society, Awarded IET Acheivement Medal and in Colloid Chemistry, American Chemical Society. Presented at the World Economic Forum in Davos, the Miken Institute MEA Summit in Abu Dhabi, Emerging Technologies and Medical Devices Event in London, and 36th International Symposium on Microscale Separations and Bioanalysis and British Heart Foundation Centre of Research Excellence Symposium virtually.



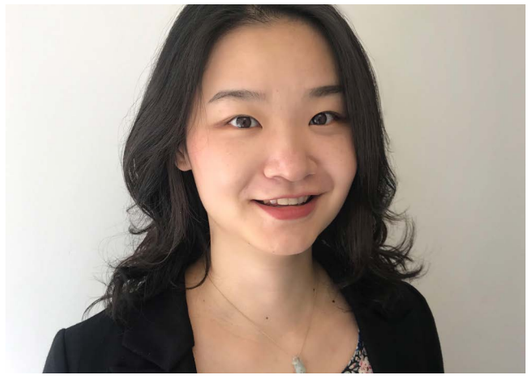
Dr Ben Miller
Presented at IOM3 Webinar and Central Saint Martins, University of the Arts London.

Jobie Budd
Seconded to the Joint Biosecurity Centre

Dr Isabel Bennett
Seconded to the Joint Biosecurity Centre, resulting in a permanent placement

Dr Dan Frampton
Presented at the UK COVID Genomics Consortium (COG-UK) in London

Dr Deenan Pillay
On Independent SAGE and MHRA C19 Horizon Scanning committees



Dr Mengdie Zhuang
Presented at ECR Festival in London

Publications

Miller, B. S., Bezinge, L., Gliddon, H. D., Huang, D., Dold, G., Gray, E. R., Heaney, J., Dobson, P. J., Nastouli, E., Morton, J. J. L., and McKendry, R. A. 'Spin-enhanced nanodiamond biosensing for ultra-sensitive diagnostics.' Nature (2020); DOI: 10.1038/s41586-020-2917-1

Bennett, I., Pyne, A. L. B., and McKendry, R. A. 'Cantilever Sensors for Rapid Optical Antimicrobial Sensitivity Testing.' ACS Sensors (2020); DOI: 10.1021/acssensors.0c01216

Yom-Tov, E., Lampos, V., Cox, I. J., and Edelstein, M. 'Providing early indication of regional anomalies in COVID19 case counts in England using search engine queries.' arXiv (2020); https://arxiv.org/abs/2007.11821

Budd, J., Miller, B. S., Manning, E. M., Lampos, V., Zhuang, M., Edelstein, M., Rees, G., Emery, V. C., Stevens, M. M., Keegan, N., Short, M. J., Pillay, D., Manley, E., Cox, I. J., Heymann, D., Johnson, A. M., and McKendry, R. A. 'Digital technologies in the public-health response to COVID-19.' Nature Medicine (2020); DOI: 10.1038/s41591-020-1011-4

Buckingham, S. D., Partridge, F. A., Poulton, B. C., Miller, B. S., McKendry, R. A., Lycett, G. J., and Sattelle, D. B. 'Automated phenotyping of mosquito larvae enables high-throughput screening for novel larvicides and smartphone-based detection of larval insecticide resistance.' bioXriv (2020); DOI: 10.1101/2020.07.20.211946

Bennett, I., Budd, J., Manning, E. M., Manley, E., Zhuang, M., Cox, I. J., Short, M., Johnson, A. M., Pillay, D., and McKendry, R. A. 'Go local: The key to controlling the COVID-19 pandemic in the post lockdown era,' arXiv (2020); DOI: arXiv:2007.02603v1

Lampos, V., Majumdar, M. S., Yom-Tov, E., Edelstein, M., Moura, S., Hamada, Y., Rangaka, M. X., McKendry, R. A., and Cox, I. J. 'Tracking COVID-19 using online search' arXiv (2020); DOI: arxiv.org/abs/2003.08086

McKendry, R. A., Rees, G., Cox, I. J., Edelstein, M., Eland, A., Stevens, M. M., and Heymann, D. ‘Share mobile and social-media data to curb COVID-19.’ Nature (2020); DOI: 10.1038/d41586-020-00908-6

Kim, N., Thomas, M. R., Bergholt, M. S., Pence, I. J., Seong, H., Charchar, P., Todorova, N., Nagelkerke, A., Belessiotis-Richards, A., Payne, D. J., Gelmi, A., Yarovsky, I., and Stevens, M. M. 'Surface enhanced Raman scattering artificial nose for high dimensionality fingerprinting.' Nat Commun (2020); DOI: 10.1038/s41467-019-13615-2

Higgins, S., Lo Fiego, A., Patrick, I., Creamer, A., and Stevens, M. M. ‘Organic Bioelectronics: Using Highly Conjugated Polymers to Interface with Biomolecules, Cells and Tissues in the Human Body’ Advanced Material Technologies (2020); DOI: 10.1002/admt.202000384

04

Our people and partners

The i-sense network

Organisational chart

External Advisory Board
Chaired by Prof David Heymann (LSHTM)

Director
Prof Rachel McKendry (UCL)

Management Committee

Strategic Operations Team
Erin Manning and Jo McHugh (UCL)

Core research

Track: Online syndromic surveillance to track outbreaks - Led by Prof Ingemar Cox (UCL) and Dr Richard Pebody (Public Health England)

Test: Smartphone-connected diagnostic tests - Led by Prof Molly Stevens (Imperial College London), Prof Rachel McKendry and Prof Deenan Pillay (UCL), and Dr Neil Keegan and Prof Anil Wipat (Newcastle University)

Treat: Real-time data visualisation tools and linkage to care - Led by Dr Ed Manley (Leeds) and Prof Deenan Pillay (UCL)

Career development education alliance - Led by Dr Neil Keegan (Newcastle University) and Prof Ingemar Cox (UCL)

Partnership, impact and sustainability - Led by Prof Rachel McKendry and Prof Deenan Pillay (UCL)

Plus Award: A smartphone-powered mRNA sequence detector - Led by Prof Molly Stevens (Imperial College London)

Plus Award: Ultra-sensitive enhanced nanosensing of antimicrobial resistnace (u-Sense) - Led by Dr Neil Keegan (Newcastle University)

i-sense COVID: Harnessing digital and diagnostic technologies for COVID-19 - Led by Prof Rachel McKendry (UCL)

Management committee

Prof Rachel Mckendry
Prof of Biomedical Nanotechnology, UCL, and i-sense Director

Dr Neil Keegan
Senior Lecturer, Institute of Cellular Medicine, Newcastle University, and i-sense Plus Award and Education Alliance lead

Prof Ingemar Cox
Prof of Computer Science, UCL, and i-sense Deputy Director and Flagship (Track) lead

Prof Ed Manley
Prof of Urban Analytics, University of Leeds, and i-sense Flagship (Treat) co-lead

Prof Deenan Pillay
Prof of Virology, UCL, and i-sense Deputy Director and Flagship (Treat) co-lead

Dr Richard Pebody
Health of Respiratory Disease Surveillance and Influenza Surveillance, Public Health England

Prof Molly Stevens
Prof of Biomedical Materials and Regenerative Medicine, Imperial College London, and i-sense Deputy Director, and Flagship (Test) and Plus Award lead

Prof Vince Emery
Emeritus Prof of Translational Virology, University of Surrey

Advisory Board

Prof David Heymann (Chair)
Prof of Infectious Disease Epidemiology, London School of Hygiene and Tropical Medicine, and Health of the Centre on Global Health Security, Chatham House

Dr Annette Bramley
Director, N8 Research Partnership

Prof John Brownstein
Associate Prof of Paediatrics, Harvard Medical School, and co-founder of HealthApp

Prof Patrick Maxwell
Regius Prof of Physics and Head of the School of Clinical Medicine, University of Cambridge

Andrew Eland
Founder, Diagonal

Dr Mike Short CBE
Chief Scientific Advisor, Department for International Trade

Prof Christoph Gerber
Prof, Swiss Nanoscience Institute, University of Basel

Dr Harpreet Sood
NHS Doctor, Co-Founder of the NHS Digital Academy, and Visiting Senior Fellow at the London School of Economics

Strategic Advisors

Prof Peter Dobson OBE
Former Director of Begbroke Science Park, University of Oxford

Prof Dame Anne Johnson DBE
Prof of Infectious Disease Epidemiology, UCL, Chair UCL Population and Lifelong Health Domain, and i-sense Deputy Director

Prof Ciara O'Sullivan
Research Prof Nanobiotechnology and Bioanalysis, Universitat Rovira I Virgili

Prof Rosanna Peeling
Prof and Chair of Diagnostics Research, London School of Hygiene and Tropical Medicine

Prof Calum McNeil
Prof of Biological Sensor Systems, Newcastle University

Key partners

UCL · Imperial College London · Newcastle University · University of Surrey · Public Health England · University of Strathclyde Glasgow · GCU Glasgow Caledonian University — University for the Common Good

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