Institution: Imperial College London	

Unit of Assessment: 02 Public Health, Health Services and Primary Care

Title of case study: Real-time surveillance to improve situational awareness of COVID-19: the REACT study

Period when the underpinning research was undertaken: May 2020 - present

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Paul Elliott	Chair in Epidemiology & Public Health Medicine	1995 - present
Helen Ward	Professor of Public Health	1993 - present
Steven Riley	Professor of Infectious Disease Dynamics	2010 - present
Graham Cooke	NIHR Professor of Infectious Diseases	2006 - present
Wendy Barclay	Action Medical Research Chair Virology	2007 - present
Christl Donnelly	Professor of Statistical Epidemiology	2000 - present
Deborah Ashby	Chair in Medical Statistics & Clinical Trials, Director School of Public Health	2008 - present
Christina Atchison	Principal Clinical Academic Fellow	2018 - present
Lord Ara Darzi	Professor of Surgery	1999 - present

Period when the claimed impact occurred: June – December 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Routine surveillance data do not accurately reflect levels of SARS-CoV-2 infection or immunity in the community. The Real-time Assessment of Community Transmission (REACT) programme has been estimating prevalence of SARS-CoV-2 infection and antibodies in random samples of the population in England since May 2020. REACT data informed control strategies including the timing of the second national lockdown in England, reinforcing the need for the 'rule of 6' for social gatherings, providing key data underpinning school closure policy, and contributing to the recommendation of interventions to protect those living in large households.

2. Underpinning research (indicative maximum 500 words)

Interpretation of data generated from routine testing for infection can be hampered by limited availability of tests, changes in the propensity to be tested, a bias towards enumerating only symptomatic and more severe cases, and by collecting only limited participant characteristics. To overcome these challenges, the Imperial team of scientists and clinicians, led by Professor Paul Elliott, designed the REACT programme, commissioned by the Department of Health and Social Care (DHSC). It comprises two linked studies that are powered to provide reliable data for every local area (1). Both draw on random samples of the population, use home self-sampling and provide timely data, analyses and interpretation to government and the public on the spread of SARS-CoV-2 infection across England. The programme measures and rapidly reports key parameters of the pandemic including prevalence of infection, R number, prevalence of antibodies, local variation, and differential sociodemographic risks. Ipsos MORI provide logistical support.

The REACT programme is one of two large studies (the other being the Office for National Statistics Coronavirus Infection Survey) that feeds data regularly into government on the community prevalence of SARS-CoV-2 infection based on random samples of the population.

REACT-1 involves cross-sectional surveys of viral detection (virological swab for RT-PCR) tests in repeated non-overlapping samples of 120,000 to 180,000 randomly selected individuals from the NHS England patient list (1). From May to December 2020, over one million people aged 5 years and above were tested during seven rounds of data collection. REACT-1 estimated low R values through spring and into summer 2020 in England, before detecting the start of the second wave at the end of July (2). The study also identified both high prevalence and R substantially above one across most English regions at the end of October 2020. At the end of November, REACT-1 highlighted unexpected growth in parts of the South East, London and East of England which was later found to have been the initial signal of the B.1.1.7 (Kent) variant of concern.

REACT-2 measures the prevalence of antibodies to SARS-CoV-2 in England as an indicator of past infection. It uses a self-administered lateral flow immunoassay (LFIA) test for IgG antibodies in repeated non-overlapping samples of 100,000 to 170,000 adults aged 18 years and above. This research included preliminary evaluation of the performance of candidate LFIAs (3). In parallel, in the largest ever community evaluation of acceptability and usability of a home-testing diagnostic method, the LFIAs were evaluated in over 14,000 randomly selected adults (4). From June to November 2020, over half a million adults in England completed an antibody test as part of this research.

The first round of REACT-2 provided a high-resolution snapshot of the extent of the first wave, estimating that 3.4 million adults had detectable antibodies by mid-July 2020. It also showed that there was higher prevalence in people of Black or South Asian ethnicity compared with white ethnicity, while revealing that age- and sex-specific infection fatality ratios were similar across ethnicities (5). Subsequent rounds showed that antibody prevalence from the first wave declined 27% between June and September 2020, suggesting waning in antibodies over time such that only 4.4% of the adult population had detectable antibodies at the time of the second wave (6).

3. References to the research (indicative maximum of six references)

(1) Riley, S., Atchison, C., Ashby, D., Donnelly, C.A., Barclay, W.S., Cooke, G.S., Ward, H., Darzi, A., Elliott, P., React Study Group. (2020). REal-time Assessment of Community Transmission (REACT) of SARS-CoV-2 virus: Study protocol. *Wellcome Open Research*; 25; 5: 200. DOI.

(2) Riley, S., Ainslie, K.E.C., Eales, O., Walters, C.E., Wang, H., Atchison, C., Fronterre, C., Diggle, P.J., Ashby, D., Donnelly, C.A., Cooke, G., Barclay, W., Ward, H., Taylor, G., Darzi, A., Elliott, P. (2020). Resurgence of SARS-CoV-2 in England: detection by community viral surveillance. *medRxiv*; 13 Sept 2020. (*Science* 2021). DOI.

(3) Flower, B., Brown, J.C., Simmons, B., Moshe, M., Frise, R., Penn, R., Kugathasan, R., Petersen, C., Daunt, A., Ashby, D., Riley, S., Atchison, C.J., Taylor, G.P., Satkunarajah, S., Naar, L., Klaber, R., Badhan, A., Rosadas, C., Khan, M., Fernandez, N., Sureda-Vives, M., Cheeseman, H., O'Hara, J., Fontana, G., Pallett, S.J.C., Rayment, M., Jones, R., Moore, L.S.P., McClure, M., Cherepanov, P., Tedder, R., Ashrafian, H., Shattock, R., Ward, H., Darzi, A., Elliott, P., Barclay, W., Cooke, G.S. (2020). Clinical and Laboratory Evaluation of SARS-CoV-2 Lateral Flow Assays for use in a national COVID-19 sero-prevalence survey. *Thorax*; 75: 1082-1088. DOI.

(4) Atchison, C., Pristerà, P., Cooper, E., Papageorgiou, V., Redd, R., Piggin, M., Flower, B., Fontana, G., Satkunarajah, S., Ashrafian, H., Lawrence-Jones, A., Naar, L., Chigwende, J., Gibbard, S., Riley, S., Darzi, A., Elliott, P., Ashby, D., Barclay, W., Cooke, G.S., Ward, H. (2020). Usability and Acceptability of Home-based Self-testing for Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Antibodies for Population Surveillance. *Clinical Infectious Diseases*; ciaa1178. DOI.

(5) Ward, H., Atchison, C.J., Whitaker, M., Ainslie, K.E.C., Elliott, J., Okell, L.C., Reed, R., Ashby, D., Donnelly, C.A., Barclay, W., Darzi, A., Cooke, G., Riley, S., & Elliott, P. (2020) Antibody prevalence for SARS-CoV-2 following the peak of the pandemic in England: REACT2 study in 100,000 adults. medRxiv; 2020.08.12.20173690. (*Nat Commun* 2021) DOI.

(6) Ward, H., Cooke, G., Atchison, C.J., Whitaker, M., Elliott, J., Moshe, M., Brown, J.C., Flower, B., Daunt, A., Ainslie, K., Ashby, D., Donnelly, C., Riley, S., Darzi, A., Barclay, W., Elliott, P. for the REACT study team. (2020). Declining prevalence of antibody positivity to SARS-CoV-2: a community study of 365,000 adults. medRxiv; 27 Oct 2020;10.26.20219725. (in press, The Lancet Regional Health - Europe). DOI.

4. Details of the impact (indicative maximum 750 words)

The REACT programme directly informed the government's response to the COVID-19 pandemic. Reports included weekly submissions to the government of both interim and final results from each round of surveys.

In a written answer on 21 October 2020 to a parliamentary question, Helen Whately MP, Minister of State for Social Care, responded that REACT-1 and the Office for National Statistics Coronavirus Infection Survey provide the "latest" and "most accurate" prevalence data [**B**].

The Royal Statistical Society in evidence to the Public Administration and Constitutional Affairs Committee Data Transparency and Accountability: COVID-19, noted that REACT-1: "*was designed in remarkably quick time*", "*has been particularly important … to inform the government response*" and that "*regional estimates are suitably precise*" [**C**].

REACT-1 reports its own estimates of R and the data help calibrate models generated by the Scientific Pandemic Influenza Group on Modelling (SPI-M) for the Scientific Advisory Group of Experts (SAGE). These contributions are cited in several government press releases [**D**]. On 15 July 2020 the Secretary of State for Health and Social Care said about REACT-1: "*This ambitious testing programme will help us better understand the spread of the virus to date, predict how it may spread in the future and inform our response to the pandemic*". The government press release went on to say that the REACT-1 programme "*is the largest, most significant piece of research looking at how the virus is spreading across the country*". On 11 September 2020, the DHSC stated that findings from the study "*reinforce the need for the 'rule of 6' for social gatherings*". On 9 October 2020 REACT-1 was described as "*… one of several studies that feed into government decision-making and policies on tackling the spread of COVID-19 in England*" [**D**].

Minutes of government committees give further evidence of impact. SAGE minutes from 1 October 2020 comment: "*Surveillance studies such as REACT-1 ... are likely to be more reliable indicators*

of changes in incidence and prevalence than testing system data" [**E**]. SAGE minutes from 17 December 2020 cite REACT-1 results of the high prevalence in school-age children (13 to 17 years) indicating the utility of REACT-1 data as part of a decision-making process about the impact of school closures and re-openings: "*Overall, evidence is consistent with transmission occurring amongst school children when schools are open, particularly in those of secondary school age (high confidence). Multiple data sources indicate that half-term led to a reduction in transmission in children and that transmission rates picked up again in many places when schools reopened following half-term (medium confidence)*" [**F**].

The Chief Medical Officer (CMO) and Chief Scientific Adviser both cited REACT-1 estimates of SARS-CoV-2 incidence in England during two press conferences in October 2020 (16th, 22nd) when the second wave was spreading rapidly and widely [**G**]. At the press conference on 31 October 2020, the Prime Minister announced a four-week national lockdown, backed by slides from the CMO that included the estimated daily incidence from REACT-1 of 86,300 – 105,800 infections [**H**].

The REACT-2 programme has had impact through its provision of data on variation in cumulative risk of exposure by age, ethnicity, occupation, household and region. Following the publication of findings from REACT-2 (5) Health Minister Edward Argar said: "*Large scale antibody surveillance studies are crucial to helping us understand how the virus has spread across the country and whether there are specific groups who are more vulnerable, as we continue our work to drive down the spread of the disease*" [**I**]. Following subsequent publication of findings on the fall of antibody response over time (6), Health Minister Lord Bethell said: "*This study led by Imperial and Ipsos MORI is a critical piece of research, helping us to understand the nature of COVID-19 antibodies over time, and improve our understanding about the virus itself. We rely on this kind of important research to inform our continued response to the disease, so we can continue to take the right action at the right time*" [**I**]. A report to SAGE in November 2020 cites REACT-2 among its key sources and proposes a series of interventions to reduce household transmission and protect those living in large households [**J**].

The REACT investigators have held regular Press briefings since June 2020 to present and explain their findings through the Science Media Centre, appeared on all the major news channels in the UK (and many overseas outlets), and their results have been widely disseminated across the national and world media.

5. Sources to corroborate the impact (indicative maximum of 10 references)

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[**B**] Written answer on 21 October 2020 by Helen Whately, Minister for Social Care, to parliamentary question by Marcus Fysh: https://questions-statements.parliament.uk/written-questions/detail/2020-10-21/107037. Archived here.

[**C**] Written evidence from the Royal Statistical Society (DTA 42) to the Public Administration and Constitutional Affairs Committee Data Transparency and Accountability: Covid 19 (November 2020): https://committees.parliament.uk/writtenevidence/14038/html/. Archived here.

[**D**] Government press releases.
- 15 July 2020. Largest testing programme for coronavirus publishes its initial findings. Archived here.
- 9 October 2020. Largest testing study for coronavirus publishes latest findings. Archived here.
- 11 September 2020. Largest testing programme for coronavirus reinforces need for vigilance. Archived here.

[**E**] Minutes of the sixtieth SAGE meeting on Covid-19. 1 Oct 2020: reference to data from REACT-1 in Point 12. Archived here.

[**F**] Minutes of the seventy-third SAGE meeting on Covid-19. 17 Dec 2020: reference to data from REACT-1 in points 32 and 33. Archived here.

[**G**] 16 October 2020 press conference, presented by Patrick Vallance, estimated daily incidence – REACT-1 (also quoted in Press Conference 22 October). Archived here.

[**H**] COBR slides for 31 October press conference Chief Scientific Advisor cites REACT-1 estimates of daily incidence (archived here) which was informed by the SAGE meeting of 29 October (archived here).

[**I**] Government press releases.
- 13 August 2020. Largest home antibody testing programme for COVID-19 publishes findings. Archived here.
- 27 October 2020. Largest COVID-19 antibody testing programme publishes findings on antibody response over time. Archived here.

[**J**] Housing, household transmission and ethnicity: For SAGE meeting 26th November 2020. Consensus statement. 24th November 2020.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943178/S0923_housing_household_transmission_and_ethnicity.pdf (archived here).