technopolis group

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Impact evaluation of UKRI's R&I funding response to COVID-19

Annex to the final report

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Table of Contents

This document

This document is part of the final reporting from the evaluation of UKRI's research and innovation (R&I) funding response to COVID-19. This study has been carried out by Technopolis (with bibliometric analysis carried out by Digital Science) and was commissioned by UKRI. The study ran from January to August 2022.

This document contains the annex material to the final report, which has been submitted to UKRI alongside it. This document contains the evidence materials on which the findings of the main report are based and we make reference to the annex materials in this document throughout the main report.

Appendix A UKRI's Covid-19 response: definitions and details

A.1. UKRI's COVID-19 response: investments in detail

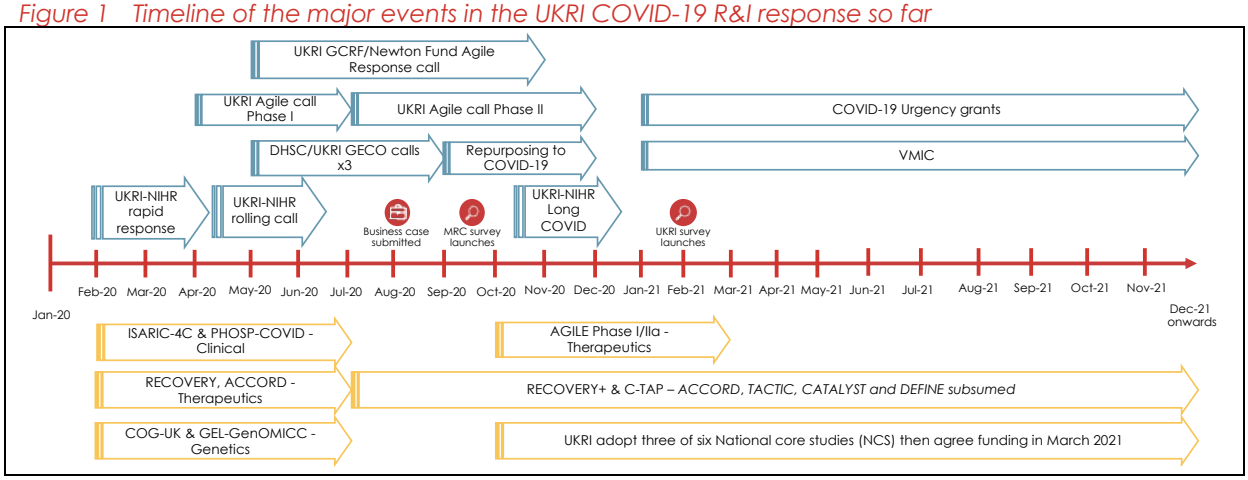
UKRI's R&I response to the COVID-19 pandemic involved responsive and directed funding components:

- Rapidly supporting several key centres and consortia at the start of the COVID-19 outbreak. These covered therapeutics (e.g. the RECOVERY trial into treatments for COVID-19 including the identification of Dexamethasone as a lifesaving treatment, and vaccine development projects (including an RNA based vaccine, traditional vaccine methodology and GMP manufacture to aid the development of the Oxford/AstraZeneca vaccine) which resulted in the development of the most widely used COVID-19 vaccine. The first half of 2020 saw the instigation of the UK COVID-19 Therapeutics Advisory Panel (UK-CTAP) , clinical studies (e.g. UKRI and NIHR funded: clinical studies ; the International Severe Acute Respiratory Infection Consortium, ISARIC, in setting up a UK-wide Coronavirus Clinical Characterisation Consortium, ISARIC-4C; and the Post-Hospitalisation COVID-19 study, PHOSP-COVID), and genetics (e.g. the COVID-19 Genomics UK, and the Genomics England COVID-19 study on the Genetics of Mortality in Critical Care, GEL-GenOMICC), COVID tool kit to provide standardised COVID-19 research reagents, and surveillance (transmission, health impact and behavioural) and modelling platforms (MRC GIDA, COG-UK consortium, EAVE II, MRC BSU, etc) that informed population health and movement policy.
- Setting up and running a joint Rapid Response initiative between UKRI and NIHR, launched in February 2020 with two specific calls (including vaccines, therapies and improving understanding of COVID-19), and then a rolling call from March 2020 to July 2020.
- Setting up and running the UKRI COVID-19 Agile Research and Innovation response call (hereafter 'Agile Call'). It launched 31st March 2020 and ran until December 2020. Projects could last up to 18 months to address the health, social, economic and environmental impacts of the COVID-19 pandemic. The funding was issued through an agile funding process managed by the nine UKRI councils with oversight from a research and innovation Taskforce. This call is split into two phases: the first was conducted off-system in order to enable rapid launch, while the second phase operated through UKRI's JeS/Siebel system for Research Councils and Innovate UK's Innovation Funding Service.
- Calls facilitating international cooperation on COVID-19, including the Global Effort on COVID-19 GECO call and the UK-India COVID-19 response call, awards to international co-investigators from seven countries on key topics and the UKRI COVID-19 GCRF/Newton Agile Response (closed on 31 July 2020); coordinating activity with other global funders, notably through the UK Collaborative on Development Research (UK CDR) and Global Research Collaboration for Infectious Disease Preparedness (GLOPID-R).
- UKRI also set up a process for repurposing existing UKRI-funded research projects (i.e. funded before the COVID-19 pandemic) to rapidly change scope and objectives. This did not constitute any additional investment as such, but allowed the usually lengthier process of mid-award change-requests to take place over just a few days or weeks, so that existing funded work in potentially important areas could become more directly relevant to challenges presented by the pandemic.
- HMG commissioned six National Core Studies (NCS) to address priority operational and policy research questions. These were initiated in September 2020. Three of these were adopted by UKRI and UKRI funds and oversees them, as they align with existing strategic objectives and COVID investments.

- Since closure of the Agile Call (December 2020), the Research Councils continue to accept COVID-19 related proposals through business-as-usual routes, as well as through tightly focused COVID-19 calls, notably a call on 'Long COVID', with NIHR, and the fast-track COVID-19 Urgency Grants for time sensitive and exceptional COVID-19 proposals, including for projects with a timeline of just three months (closed March 2022).

The timeline of events and list of interventions below further summarise the activities, with calls in blue and major platform and consortia studies in yellow (VMIC being a 'special case', which began long before COVID-19 but was accelerated in late 2020). The events above the timeline in blue indicate opening and closing dates of calls rather than when awards were active (except for VMIC which is still running), some of which extend as far as 2023.

Figure 1 Timeline of the major events in the UKRI COVID-19 R&I response so far



Source: Updated (December 2021) from: Kolarz et al (2021) Process evaluation of UKRI's R&I response.
Note: The Urgency Grants, VMIC, PHOSP-COVID, ISARIC-4C, COG-UK and GEL-GenOMICC are still active.

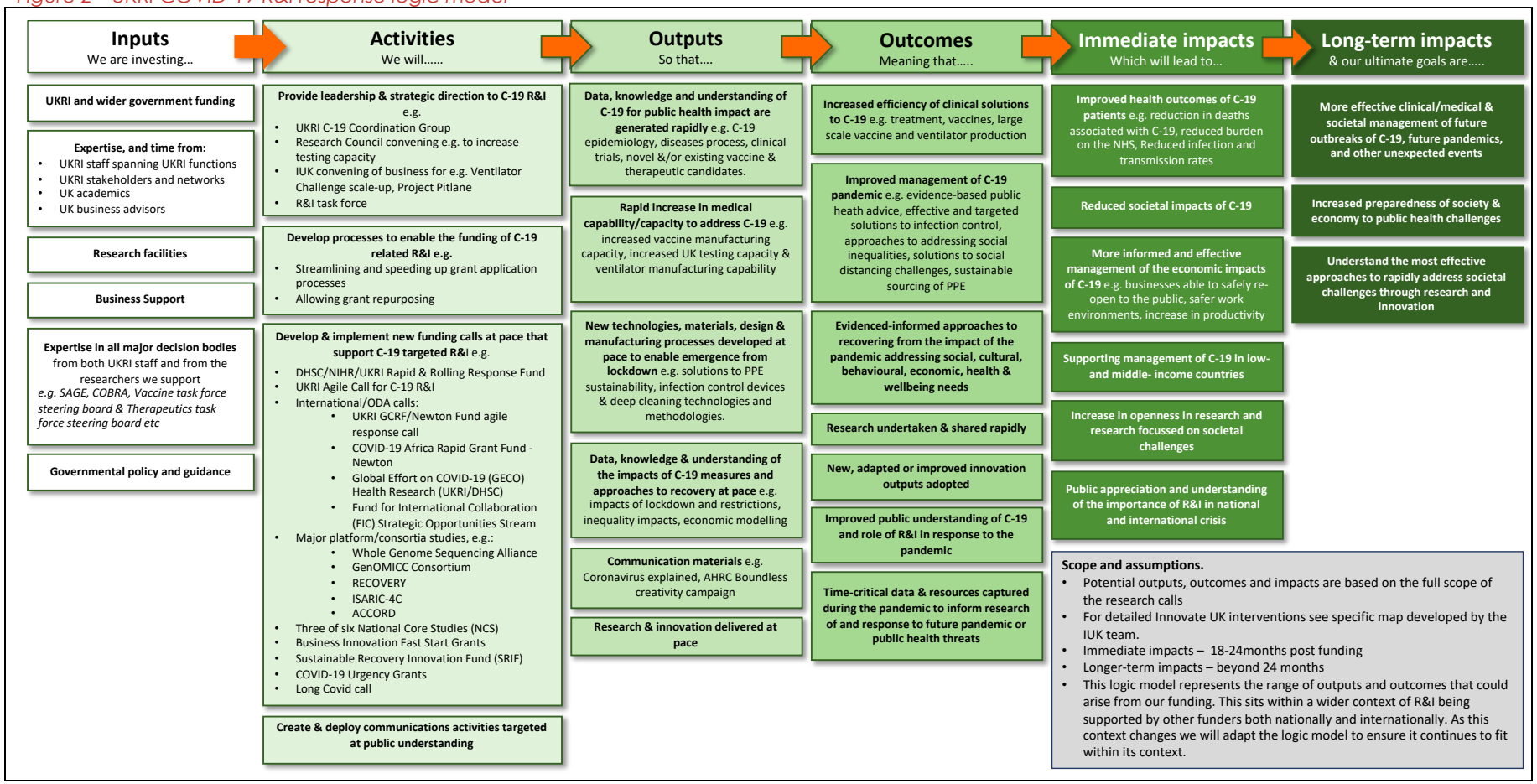
A.2. Logic model / Theory of change

UKRI developed a logic model as part of the business case for the second part of the Agile Call in July 2020, which was slightly revised in September 2020. We find that this logic model is fit for purpose and use it therefore to inform our evaluation.

We have only made one small change in the 'Activities' column, where not all UKRI investments were listed. The model now provides an accurate reflection of UKRI's interventions and intended results, including the influences of non-financial interventions.

This section takes the model one step further by describing the logic behind the pathways to impact, assumptions, risks and external factors affecting the response. We are mindful of the five types of impact that the evaluation should explore: knowledge, societal, economic, policy, capacity and capability.

Figure 2 UKRI COVID-19 R&I response logic model



Source: UKRI Full Business Case for UK R&I Agile Research & Innovation Response to COVID-19 (2020).

Critical throughout the intervention logic is UKRI's enabling role, in other words, the specific things UKRI did in order to facilitate impact pathways (beyond providing the funding itself). This most notably involves the following aspects:

- **Speed:** UKRI sought to allocate funding as rapidly as possible in order to ensure awards could deliver within the tight timeframes to mitigate the impact of the pandemic and its effects as rapidly as possible. Moreover, there was also the expectation that awards will produce results, at speed, to help inform the policy response to the pandemic, which was embedded in the design of the calls.
- **Convening and catalysing**: This includes foremost the design of the calls to address all aspects of the pandemic, facilitating international input and participation, advising on the shape of the platforms and partnerships, and streamlining/organising the direction of clinical trials. However, in terms of impact facilitation, the following are important functions to consider:
  - **Partnerships:** where portfolio managers and other UKRI staff were aware of separate awards that may benefit from partnership, they could facilitate such collaboration. This evaluation will seek to understand the extent to which such convening took place.
  - **Non-programmatic activity**: Some stakeholders suggested that the evaluation should also consider UKRI's participation in COVID-19 taskforces and working groups in the formulation of policy. This includes how UKRI staff fed into SAGE and vice-versa, and UKRI's convening role across government
  - **Communication of R&I findings to policymakers** to support the wider application of R&I knowledge and products coming out of UKRI's portfolio, and to the wider R&I community to contribute to the next steps of R&I in their disciplines, via direct communication from the project investigators in evidence to select committees and other means. UKRI staff convening award holders and potential research users (e.g. in the policy sphere) is also a critical component of this. Finally, another component is ensuring the PIs understand what is needed by policymakers in an evolving situation.
- **Prior investments:** Whilst the pandemic was an unprecedented event, UKRI had existing knowledge and prior funding relevant to responding effectively to a COVID-19 pandemic. Prior funding for research groups with critical expertise, as well as for centres and infrastructures may have played a part in the ability to make the right investments rapidly.

A.3. Scale of investment and number of awards

In the main report for this study, we state the award numbers and total UKRI investment (and co-funder investment where relevant). Across the various investments, those figures amount to 818 individual awards totalling £354m of UKRI funding. Additionally, at least 376 pre-existing UKRI awards worth in excess of £147m were repurposed for the COVID-19 response.

These figures represent the state-of-play shortly after the beginning of our study in February 2022. However, there are some important qualifications:

- These figures may exclude investments made by individual Research Councils and InnovateUK outside of UKRI's main COVID-19 response investments. For InnovateUK in particular, we include only the 155 awards made as part of the UKRI-wide Agile Call. These figures notably exclude the Vaccine Manufacturing and Innovation Centre (VMIC)
- Over the course of the study, several additional COVID-19 response awards have been made. In some cases, these are top-up payments for existing centres or awards. Several are also small 'Urgency grants' made through various systems. The 'true' current number of UKRI COVID-19 response awards (excluding repurposed ones) may therefore have risen to around 850 during the course of our evaluation. We have endeavoured to include some of

these as the evaluation progressed (e.g. by including those new award recipients in our survey), but it was not feasible to re-update all parts of our analysis on a continuous basis

- For some parts of our analysis, certain elements of the COVID-19 response are not included. For instance, the Newton Africa awards are managed by funders in South Africa, so there is limited data availability. InnovateUK hold a different format of awards data, so it is not always possible to fully compare 'like with like', leading to Innovate UK awards being omitted in some parts of data presentation
- For primary data collection there is a slight limitation in that around 30 awards did not have a valid email address in the data we received, and an additional 20 valid email addresses bounced, so these could not be contacted
- Occasionally, individual awards were missing other individual pieces of information in the data we received. Most often this applies to fewer than five out of the 818+ awards, but this issue counts for a small level of non-inclusion in some elements of our data presentation

A.4. UKRI COVID-19 Response Awards Data

Below we note some basic figures around the distribution of UKRI COVID-19 response awards, by institution. The figures exclude the 155 awards from Innovate UK for which data was not available. We find that UKRI COVID-response awards were generally made to the same institution at comparable concentration as in our comparator data of all UKRI awards of 2015-19.

Table 1 Top 10 ROs for projects to address COVID-19 (n = 635) and in 2015-19 (n = 10353) excluding projects funded by Innovate UK*

Rank	Top ROs for projects to address COVID-19	Share of projects to address COVID-19	Top ROs for projects 2015-19	Share of projects 2015-2019
1	Imperial College London	5.5%	University of Oxford	5.0%
2	University of Oxford	5.5%	University College London	4.4%
3	University College London	5.4%	University of Cambridge	4.2%
4	University of Birmingham	3.9%	University of Manchester	3.9%
5	King's College London	3.3%	University of Edinburgh	3.7%
6	University of Nottingham	3.1%	Imperial College London	3.5%
7	University of Liverpool	3.0%	University of Birmingham	3.1%
8	University of Cambridge	2.8%	University of Nottingham	3.1%
9	University of Edinburgh	2.8%	University of Leeds	2.9%
10	University of Leeds	2.8%	University of Bristol	2.7%

Data on COVID-19 response funding obtained directly from UKRI, comparator funding data obtained from GtR.

However, when we consider funding amounts, there is a higher-than-usual concentration of funding in especially research-intensive organisations. The top-5 institutions by amount

awarded under the COVID-19 response account for around 42% of total funding, significantly more than in our comparator sample representing business-as-usual funding.

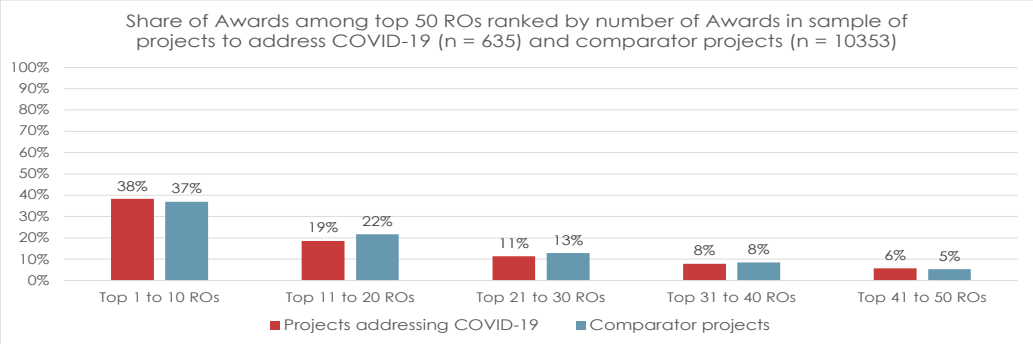
Table 2 Top 10 ROs for funding to address COVID-19 (n = £305 m) and in 2015-19 (n = £2.7 bn) excluding funding from Innovate UK*

Rank	Top ROs for funding to address COVID-19	Share of funding to address COVID-19	Top ROs for funding 2015-19	Share of ROs for funding 2015-19
1	University College London	13.2%	University of Cambridge	6.5%
2	University of Birmingham	8.3%	University College London	6.4%
3	Health Data Research UK	7.7%	University of Oxford	5.2%
4	Imperial College London	7.1%	University of Edinburgh	4.5%
5	University of Oxford	6.1%	Imperial College London	4.4%
6	University of Edinburgh	3.6%	University of Manchester	4.4%
7	London School of Hygiene & Tropical Medicine	3.2%	University of Southampton	3.7%
8	Public Health England	3.1%	University of Sheffield	3.5%
9	University of Cambridge	2.7%	University of Glasgow	3.1%
10	University of Leeds	2.6%	University of Bristol	2.6%

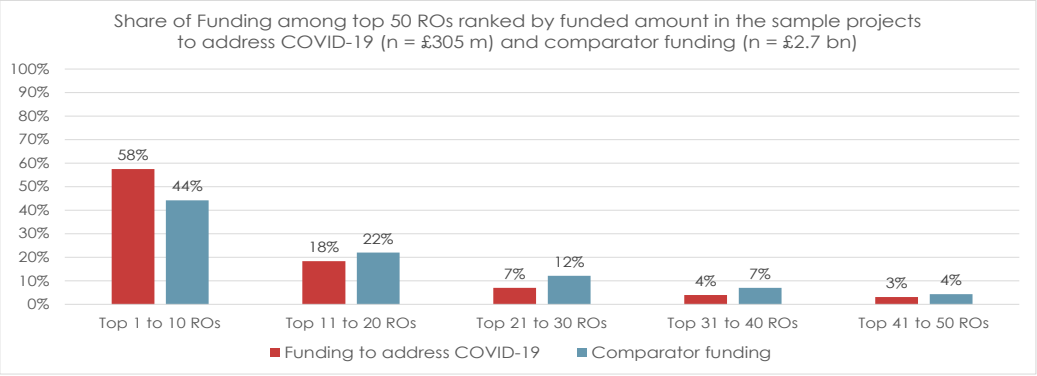
Data on COVID-19 response funding obtained directly from UKRI, comparator funding data obtained from GtR.

The two graphs below show the institutional concentration of both award numbers and funding amounts in broader perspective. Looking not just at the top-10 but the top-50 institutions (by number of awards or funding amount received), we find that COVID-19 response funding was in fact slightly less concentrated than business-as-usual funding in terms of number of awards, while in terms of financial value, the response was more concentrated than in business-as-usual funding.

Figure 3 Share of awards and funding by Top 50 ROs to address COVID-19 and projects in 2015-19 excluding those funded by Innovate UK*



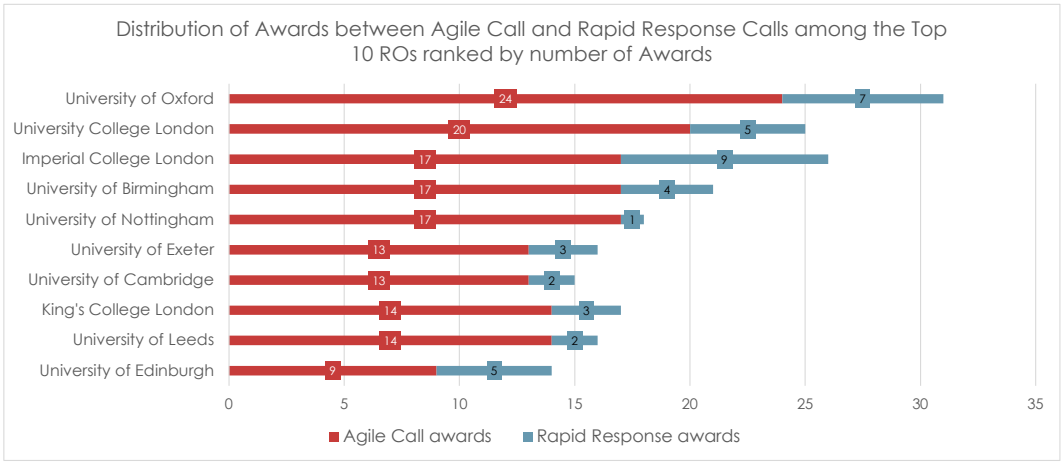
Source: Data on COVID-19 response funding obtained directly from UKRI, comparator funding data obtained from GtR. Figures exclude InnovateUK.



Source: Data on COVID-19 response funding obtained directly from UKRI, comparator funding data obtained from GtR. Figures exclude InnovateUK.

Finally, we note that different institutions have different profiles in terms of the kinds of awards they received: some feature prominently almost solely through the presence of many Agile Call awards, while others hosted several Rapid response awards. This is part due to the fact that those awards cover very different portfolios; Rapid response awards focus predominantly in population health and clinical while Agile awards cover the entire URKI spectrum with a small proportion of clinic-facing awards.

Figure 4 Research Offices by projects awarded in COVID-19 Rapid Response Calls 1, 2 and Open Calls, and in COVID-19 Agile Calls for R&I – Ten most awarded ROs in terms of count of awards granted to address COVID-19



Source: Data on COVID-19 response funding obtained directly from UKRI, comparator funding data obtained from GtR. Figures exclude InnovateUK.

A.5. Evaluation questions and sub-questions

In addition to the five headline questions specified in the introduction to our main report, each question also has several technical sub-questions, set out in the terms of reference for this study. These are listed in the table below.

Table 3 Evaluation questions and sub-questions

Evaluation question / Sub-questions
What was the impact of the R&I supported by UKRI and its main partners to respond to the COVID-19 pandemic?
a) What was the direct impact of R&I supported by UKRI to respond to COVID-19 on combatting the virus and ameliorating consequences of the virus in key priority areas?
b) To what extend did UKRI meet priorities in spite of the challenges outlined in the process review?
c) How (did) the immediate outputs and outcomes of the R&I supported by UKRI to respond to COVID-19 influence or inform policy decisions taken at national or sub-national level to address or respond to COVID-19?
d) How (did) the immediate outputs and outcomes of the R&I supported by UKRI to respond to COVID-19 lead to increased scientific, medical, commercial and/or other forms of capacity and capability to understand, treat or respond to COVID-19 and similar/related viruses? To what extent was long-term capacity for such research increased?
e) What was the indirect impact or contribution of R&I supported by UKRI to respond to COVID-19 to health outcomes, e.g. lives saved or extended, ill-health avoided, improved mental health and wellbeing?
f) In what other ways (did) R&I supported by UKRI to respond to COVID-19 affect people's lives?
g) What was the indirect impact or contribution of R&I supported by UKRI to respond to COVID-19 to economic outcomes, and how (did) it support the UK's economic recovery from the pandemic?
h) To what extent (and how) have projects fostered an equal, diverse and inclusive research and business environments, and how well do projects align with UKRI ED&I aims?
i) Did the UKRI COVID-19 R&I support result in any unintended outcomes?
How successful was UKRI's R&I response to COVID-19, and was it Value for Money?
What were the overall objectives of UKRI's R&I response to COVID-19, and to what extent were these met?
What expectations were set in terms of the measurable impact of UKRI's R&I response to COVID-19, and to what extent have these expectations been met?
Did UKRI's R&I response to COVID-19 have greater impact in certain areas?
How well did UKRI leverage external investment?
Overall, taking account of the evidence gathered through the evaluation, was UKRI's R&I response to COVID-19 value for money to taxpayers?
What were the key historical and real time drivers, barriers and enablers to impact of UKRI's R&I response to COVID-19?
• What historical research and innovation outputs were utilised by the researchers and innovators supported by UKRI to respond to COVID-19?
• What existing knowledge, partnerships or other factors did researchers and innovators use to respond to R&I needs and priorities during the COVID-19 pandemic by proposing impactful projects?

Evaluation question / Sub-questions
• How (were) researchers and innovators effectively incentivised to respond to the R&I needs and priorities to respond to COVID-19? Who or what provided these incentives?
• Where and how did researchers and innovators collaborate across disciplinary, sectoral, organisational, cultural and other boundaries? What incentivised or enabled them to do this? What prevented or deterred them from doing this?
• What key factors facilitated or inhibited making a difference in terms of R&I having impact on people's lives?
What are the key lessons for UKRI and, where applicable, the UK R&I System?
How effectively (did) UKRI direct the R&I community towards areas of R&I having (or with the potential to have) greatest impact on the COVID-19 pandemic?
Did UKRI strike the right balance between a top-down and bottom-up approach (what was requested by UKRI and what was strategically organised/directed by UKRI versus what arose spontaneously from the community)?
How (did) UKRI enable certain disciplines or sectors to respond more (or less) effectively to the need for COVID-19 focused R&I?
How (did) UKRI help to ensure the immediate outputs or outcomes of R&I were translated or led to impact on the pandemic?
Did UKRI duplicate R&I efforts and, if yes, to what extent?
Did UKRI strike the right balance between convening big consortia and funding individual research projects?
What can UKRI learn from the COVID-19 support and impact of international funders?
Would an alternative approach to peer review have enabled quicker and/or better funding decisions that would generate as great (or greater) impact on quicker timescales? Did UKRI strike the right balance between high risk and low risk R&I? What was the impact of duplications?
How can UKRI and the R&I System maximise or enhance its future impact in similar situations requiring a rapid, coordinated R&I response to an unforeseen event?
What specific features of UKRI's R&I response to COVID-19 contributed to the R&I having impact? Were there any features than contributed more than others?
What specific features of UKRI's R&I response to COVID-19 prevented the R&I having as much impact as it might have done?

Appendix B Case study 1: Responsive

Responsive

The RECOVERY trial and the Oxford/AstraZeneca vaccine programme were both funded through UKRI-NIHR Rapid Response Call to develop treatments and candidate vaccines against COVID-19.

RECOVERY is the world's largest clinical trial into treatments for COVID-19 and it identified the world's first effective COVID-19 treatment, dexamethasone - a cheap and readily available steroid. Data suggests that between May 2020 and March 2021 dexamethasone has saved tens of thousands of lives in the UK and an estimated 1 million globally. To date, the RECOVERY team has identified three further effective treatments for COVID-19 as well as several treatments that were being widely used with COVID-19 patients that the trial found to be ineffective. Guidance based on the results of RECOVERY has been adopted by the World Health Organisation, the UK NHS, the US National Institutes of Health, the European Medicines Agency, and many others.

Named the "vaccine of the world" due to its high global reach more than 2.5 billion out of 10 billion doses of the **Oxford/AstraZeneca COVID-19 vaccine have been** administered globally . While the funding that came through the UKRI-NIHR rapid response call was a small proportion of the total sum for the vaccine's development, the foundation for the breakthrough success was undoubtedly University of Oxford's ChAdOx vaccine development platform funded through long term investment including from UKRI and DHSC. The Oxford/AstraZeneca vaccine has demonstrated unprecedented speed of platform vaccine technology response moving through the development lifecycle, regulatory authorisation and scaling up for global production within 12 months where that would conventionally have taken up to 10 years.

B.1. Introduction and description of awards

B.1.1. In this case study, the achievements of the Randomised Evaluation of COVID-19 Therapy (RECOVERY) Trial and the development of the oxford/AstraZeneca vaccine programme are presented. These two projects were launched as a result of the COVID-19 Rapid Response call.

B.1.2. The Randomised Evaluation of COVID-19 Therapy (RECOVERY) Trial

The RECOVERY trial is the world's largest clinical trial into treatments for COVID-19, with **more than 47,000 participants across 195 trial sites in the UK**.

RECOVERY was and is a phase II and III clinical trial, providing data sufficient for emergency market authorisation[i]. Patients hospitalised in the UK with a confirmed coronavirus infection were invited to join the trial, where the safety and efficacy of the repurposed medicines were assessed.[i] The aim was to discover existing medicines that could be repurposed to prevent and effectively treat COVID-19 in order to save lives and reduce pressure on healthcare systems. RECOVERY focused especially on patients suffering from severe lower respiratory tract (LRT) illness. There were several promising treatments and The RECOVERY trial set out to test up to six medicines: two of the most promising ones that were already the subject of studies in China plus up to four additional medicines. UKRI had a convening role in ensuring that the trial of these drugs became primarily UK based.

The project was jointly funded by UKRI and NIHR for a total of £2.1 million in March 2020 (with an additional £19m provided later in 2020). It was awarded to **Professor Peter Horby** and his team at the University of Oxford. Other core funders of the RECOVERY trial international work

included Wellcome, the Bill & Melinda Gates Foundation, and the Foreign, Commonwealth & Development Office. Further infrastructure support were provided by Health Data Research UK, the Medical Research Council Population Health Research Unit, the NIHR Oxford Biomedical Research Centre and NIHR Clinical Trials Unit Support Funding.[2]

B.1.3. The development Oxford/AstraZeneca vaccine

The development of what came to be known as the Oxford/AstraZeneca vaccine was based on many years of in-depth research, supported by UKRI and others, including DHSC.

The Oxford COVID-19 vaccine team is led by **Professor Sarah Gilbert, Professor Andrew Pollard, Professor Teresa Lambe, Dr Sandy Douglas, Professor Catherine Green and Professor Adrian Hill.** Their team includes scientists from both the Jenner Institute and the Oxford Vaccine Group, who brought together decades of internationally recognised experience in vaccine research, including responding to the Ebola outbreak of 2014.[3]

The team had already begun work on pandemic preparedness in preparation for 'Disease X' using the technology behind the **ChAdOx1** platform. The ChAdOx1 platform was developed at Oxford in 2010, with the support of UKRI,[5] and had been used to develop candidate vaccines for several pathogens including flu, Zika and Middle East Respiratory Syndrome (MERS), another coronavirus, the latter funded by DHSC with MRC support as part of the UK Vaccines Network. When the disease emerged in China, the team moved quickly, and as soon as the genetic sequence was available, work on a clinical trial was initiated.

The £2.2m award of March 2020 was jointly funded (50:50) by the UKRI, through the Medical Research Council (MRC), and the National Institute for Health Research (NIHR) via the UKRI-NIHR Rapid Response call (Table 1).[3]

The UKRI award allowed the team to manufacture the Oxford/AstraZeneca vaccine in-line with international standards (cGMP) and to conduct a Phase 1 clinical trial in the UK (in June 2020). They worked with partners to demonstrate protective efficacy of ChAdOx1 nCoV in two different animal models, which provided information to support further clinical trials of this vaccine to demonstrate efficacy in humans. The UKRI-funded project aimed to complete all the required testing of the vaccine and to obtain regulatory approval in a shorter period than usual.[1] In addition to their commitment to develop an effective medicine, the Oxford team wanted to find a way to produce a vaccine that could be made available globally and would be affordable to countries throughout the global south. The team included consideration of both the logistics and the pricing of the vaccine (it was to be supplied on a cost basis) as part of the development plan.[4,25]

Further funders for the Oxford/AstraZeneca vaccine project included the UK's Vaccines Taskforce (~ £20million, which later expanded to £31million) and CEPI ($350,000, which later funded AstraZeneca $383 million to manufacture 300million doses for Covax).[4]

Table 4 Overview of awards covered in the case study

Award title	**Lead organisation**	**Principal investigator**	**Total funding awarded UKRI/NIHR**	**UKRI (MRC) funding awarded**
COVID-19 multi-arm, multistage adaptive clinical trial (CoV-MAMS)	University of Oxford	Professor Peter Horby	£2,106,034	£1,053,017

nCoV: Rapid Clinical Development of ChAdOx1 nCoV-19	University of Oxford	Professor Sarah Gilbert	£2,174,848	£1,087,424

Source: Gateway to Research and consultation with UKRI.

B.2. Main results (outputs, outcomes, impacts)

The Recovery trial and the Oxford/AstraZeneca vaccine project have produced twelve and nine key scientific publications respectively, as well as numerous reports and media coverage (Section A.6) and fed into a scientific advice committee for helping policy makers tackling COVID-19. The treatments and vaccine developed as the outcome of these two awards have been shown to save many lives and reduced societal impacts such as economic disruption and diminished quality of life caused by lockdown.

B.2.1. A clinical trial that changed global treatment of COVID-19 and health policy

In June 2020 **Dexamethasone**, a **cheap and readily available** steroid, was identified by the **RECOVERY trial** as one of the **world's first treatments for patients hospitalised with COVID-19.** Dexamethasone was found to **reduce deaths** of hospitalised COVID-19 patients with severe respiratory complications **by up to one third**. The trial expanded to Indonesia and Nepal in early 2021.[7] To date, three other treatments for COVID-19 have been identified by RECOVERY: these include the rheumatoid arthritis treatment, **tocilizumab** (February 2021); **Ronapreve** (June 2021), a combination of monoclonal antibodies (casirivimab plus imdevimab) targeting the viral spike protein; and **baricitinib**, another anti-inflammatory used to treat arthritis, which showed a **reduction of 13%** of deaths compared to patients receiving the usual standard of care.[8]

A report from Professor Horby's group suggested the roll out of dexamethasone treatment for COVID-19 would have saved **hundreds of thousands of lives globally** in under 6 months.[11] Figures published by the NHS in March 2021 confirmed that dexamethasone had **saved the lives of around 22,000 patients in the UK** and an estimated **one million lives globally** since June 2020.[12] The economic consequence of the UK NHS endorsing dexamethasone as a default choice for treating patients with COVID-19 was estimated to have had a **total incremental cost of £85m from July to December 2020**. This equates to **approximately £8,200 per life saved and £940 per life-year gained.**[11] Considering the National Institute for Health and Clinical Excellence (NICE) cost-effectiveness threshold value of £70,000/QALY gained, the dexamethasone treatment is a **cost-effective option.**[13,14]

The RECOVERY trial has utilised currently available and affordable treatments to find the solution to treat hospitalised COVID-19 cases, as well as determining the ineffectiveness of several widely used and repurposed treatments, such as hydroxychloroquine, lopinavir-ritonavir, or convalescent plasma.

The outcome of the trial has led to the creation of the **clinical treatment guideline** adopted by multiple countries and organisations such as the World Health Organisation (WHO), UK NHS, US National Institutes of Health, European Medicines Agency (EMA), and many others.[1] The WHO has also adopted the results from the trial to produce an **international guideline** for treatment. The guidelines are constantly updated depending on the latest findings from the trial.[1] This has allowed clinicians to focus on using treatments that work, along with the money saved from not prescribing ineffective treatments.[6]

B.2.2. A changed future to vaccine development and production

Professor Gilbert's team has proven the **Oxford/AstraZeneca vaccine** to be **safe and induce a strong response** to COVID-19 in young healthy adults; A single dose of the vaccine was 76% effective from 22 to 90 days post vaccination. In September 2020, the team reported that the vaccine also induced a **strong response** in older adults-the group with increased risk of severe COVID-19. With further investigation in response to emerging variants of the virus, the team has found the vaccine to be effective against all COVID-19 variants as of February 2021. The **average efficacy of 70.4%** provided a good protection against COVID-19 with two different dose regimens. In **less than a year**, a **safe and highly effective** vaccine was developed, which **prevented deaths or hospitalisation after one dose and reduced transmission.**[4,6]

In the UK, real-world data has demonstrated:[17]

- A first dose of the Oxford/AstraZeneca vaccine **reduced the likelihood of hospitalisation by 94%**. The majority of vaccine recipients were aged over 65 years and the effects were comparable across all age groups
- A first dose of the Oxford/AstraZeneca vaccine was **80% effective at preventing mortality in people over 70 years old** compared to unvaccinated individuals
- A first dose of the Oxford/AstraZeneca vaccine was **80% effective at preventing hospitalisation in elderly** and frail adults aged 80 years with extensive comorbid disease
- Two doses of the Oxford/AstraZeneca vaccine have demonstrated to be **very effective against hospitalisation (92% against Delta and 86% against Alpha variant)**. However, the vaccine effectiveness against hospitalisation is reduced to 75-90% at 15-20 weeks after the second dose[27]

Not only has the Oxford/AstraZeneca vaccine prevented death in individuals who may otherwise have contracted COVID-19, it has also reduced transmission. A study has found vaccinated individuals were between **38% and 47% less likely to pass the virus to others in their household** compared to those who were unvaccinated (based on data collected 21 says after vaccination).[18] However, the study did not specify the positive COVID-19 variant of the participants.

Other factors such as supply, delivery and acceptance are important aspects of the impacts of this and all vaccines.[4]

Due to the production of large quantities of the vaccine at a low cost and being a vaccine that could be stored and transported easily, low-income countries were able to afford and manage the logistics of the vaccine much better compared to other vaccines on the market, making this the "**vaccine of the world**".

The **Oxford/AstraZeneca vaccine** has demonstrated unprecedented speed of platform vaccine technology response, where the length of vaccine development was reduced from ten to one year. The vaccine was made **accessible and affordable globally,** with a global reach of **178 countries** using the Oxford/AstraZeneca vaccine. As of January 2022, more than **2.5 billion out of 10 billion doses** of the COVID-19 vaccines administered globally have been the Oxford/AstraZeneca vaccine.[15] An economic evaluation found that $1 invested in the AstraZeneca vaccine have $28 in return when health and education loss are considered. If the value of life is taken into account, this return increases to $443.[16]

The Oxford/AstraZeneca vaccine was offered at the lowest price of $5 per course, which made it one of the most affordable vaccines available against COVID-19. The reason for the low price of the Oxford/AstraZeneca vaccine was mainly due to the pledge made by AstraZeneca, after an exclusive licensing agreement with University of Oxford, to sell the vaccine globally without making a profit during the pandemic. Even though the Oxford/AstraZeneca vaccine was one

of the most affordable and easily transported vaccine, only 14% of the originally promised vaccine doses were delivered to COVAX22. This was partly caused by the Indian export restrictions on the Oxford/AstraZeneca vaccine due to its growing epidemic.[28] The global equal access to the Oxford/AstraZeneca vaccine was further hindered by bilateral purchasing agreements made between AstraZeneca and countries outside of COVAX.[22]

Up to the end of October 2021, 1.9 million doses of the Oxford/AstraZeneca vaccines were unused/written-off after changes to clinical advice about the vaccine in the UK, where the Joint Committee on Vaccination and Immunisation's (JCVI's) recommended not to offer the Oxford/AstraZeneca vaccine to people under 40 years old. Although to avoid some wastage, 4.5 million Oxford/AstraZeneca vaccine doses were redirected to other countries, vaccines already at local sites had to be destroyed in line with regulations.[20] This was partly a consequence of the findings of the very rare blood clotting events and misinformation circulating via social media.

The acceptance and uptake of vaccine has been affected by the news of the rare blood disorder, anti-vaccine protestors, fake news, miscommunications by the media, and political disagreement between the UK and the EU. For example, incidents of an extremely rare blood disorder called thrombosis with thrombocytopenia (TTS) were reported in a small number of people who had received the Oxford/AstraZeneca vaccine, which was picked up heavily by the media. This led to changes to the regulation but was later shown to be within the acceptable risk threshold expected with all medicines that have accompanying side effect in some populations. How these barriers impacted the uptake and acceptance of the vaccine will be explored in more detail in the section A.4, where the barriers affecting the project outcome and impact will be discussed.

B.2.3. Lessons learnt and preparation for the future

B.2.3.1 Lesson 1: Preparedness

The time reduction in the vaccine production from ten to one year is unprecedented but has raised questions as to why it has not been achieved before. This achievement was greatly influenced by previous work, the UK investment in vaccines research and global clinical research networks over the past decade, in preparation for a pandemic. An example is the support for the ISARIC federation of 55 clinical research networks around the world, which has aided the RECOVERY trial through established protocols for the rapid coordination of the clinical investigation of treatments for COVID-19. The ISARIC study with other organisations, such as the WHO, have created protocols for rapid trial recruitment plans that can be implemented immediately in the event of a pandemic. The efficient implementation of such clinical trial recruitment plan, and the infrastructure put in place by the NIHR Clinical Research Network (CRN), particularly the register of hospitalised patients, has contributed greatly to the unprecedented recruitment and repurposing of existing drugs that underpin the success of the RECOVERY trial.[6] This demonstrates the importance of long-term investments in underpinning research and global networks, suggests that UKRI should continue to invest in area relating to various major health risks.

Furthermore, previous work and investment made into vaccine platform technology development over the past decade, has allowed a novel vaccine to be made based on a pre-existing vaccine. A study has found that 97% to 99% of the funding that went into the two-decade long research of the ChAdOx vaccine technology at the University of Oxford were by public and charitable bodies, including the UK government, the European Commission, Wellcome, the Coalition for Epidemic Preparedness Innovations (CEPI) and UKRI. However, since the start of the COVID-19 pandemic, the UK government has been the main contributor (95.5%) of identifiable R&D funding for this project, until October 2020. The high percentage of

contribution by public funding for the R&D of the ChAdOx vaccine technology, which underlies the Oxford/AstraZeneca vaccine, and its potential application in many more global health challenges beyond COVID-19, which may have potential impact for equal access and affordability of vaccines for other diseases compels advocacy for the benefit of this research to be shared fairly and equally to the global population, beyond the favourable price tag.[22]

Infrastructure (research and manufacturing), system (surveillance, stockpiling, and travel bans), and global cooperation and collaboration are all elements that would have benefitted from further preparedness.[4] Relatedly, there was an issue of surpluses and wastage of the Oxford/AstraZeneca vaccine highlighted in the previous subsection. The National Audit Office (NAO) has suggested that the Vaccine Taskforce, NHSE&I and UKHSA, working with local partners, should set out a clear strategy to manage this issue in the future and review the overall expected wastage to ensure lessons have been learnt from the write-offs required for the Oxford/AstraZeneca vaccine.[20]

B.2.3.2 Lesson 2: More support for academics in vaccine production and clinical trials

Changes to the way funding was given out to the awardees via a rapid mechanism, based on existing processes and forms, but eliminating any non-vital procedures, **reduced a lot of waiting time** before work could be started. The Oxford team has also adopted a new approach to the way research works by taking a risk on starting all the necessary preparatory work for vaccine development before the funding arrived and by **doing things in parallel that were usually done sequentially**. The infrastructure, process, and capabilities of vaccine development at Oxford has been challenged, which led to development of a better method that allowed a scaled-up vaccine production capability. For example, a rapid method to make the starting material and new purification method that allowed mass production were not finalised or fully mapped out at the start. However, through the partnership with AstraZeneca, the Oxford team learnt the way things could be scaled-up. This partnership where **the Oxford team provided the recipe for making the vaccine and AstraZeneca provided the ability to mass produce the vaccine has proven to be a very successful one.**[4]

The Oxford/AstraZeneca vaccine story exemplifies success and impact of research at universities and small companies disproving the misconception that vaccine research can only be achieved by big pharmaceutical companies.[21] The opportunity for academics to form partnerships with pharmaceutical companies rather than race them has promoted sharing of scientific knowledge, making scientific discovery open access, and scientists, from universities or industry and led to co-creating in record time. The set-up of international vaccine trials was made possible due to the networking and relationship building via international conferences.[4] This has suggested that fundings for universities and small businesses are just as important and impactful as funding for big pharmaceutical companies

B.3. Contribution analysis: UKRI's role

The Medical Research Council (MRC) has a history of supporting clinical trials, from supporting innovative development of methodologies to direct funding for ground-breaking new trials. The Clinical Trials Service Unit (CTSU) at the University of Oxford established in 1975 was one of the investments made by MRC, which is now a world leader in the conduct of large-scale Randomised Controlled Trials (RCTs) and analyses from the trials have provided reliable evidence regarding safety and efficacy of many treatments. The prior experience of the CTSU placed Professor Horby's team in a good position in leading the RECOVERY trial. Furthermore, in response to the start of the pandemic threat back in January 2020, UKRI in collaboration with other funders and the government responded by immediately implementing emergency planning and support the rapid roll out of the RECOVERY trial. The main focus was on repurposing existing drugs that were affordable and readily accessible to identify effective

treatments for immediate introduction into clinical care globally.[6] Furthermore, repurposing of existing drugs that have already been tested for safety greatly speed up the approval process and reduced the cost by around 10% compared to developing new drugs.[26]

Prior to the pandemic, in 2016, the UK government had committed to invest £120 million until 2021 for the development of new vaccines with the advice provided by the UK Vaccine Network (UKVN), which is made up of leading experts from academia, industry and policy. Over the past few decades, UKRI has supported vaccine developments, which have led to the formation of extensive networks of expertise and strong knowledgebase in vaccine development for infectious diseases. In 2016, the UKVN, with DHSC funding and UKRI support, made an award to Professor Gilbert for the development and testing of ChAdOx1 vector in a Phase I trial against MERS coronavirus. This work was vital during the development of the Oxford/AstraZeneca COVID-19 vaccine.[6] Furthermore, Professor Gilbert has highlighted her role as co-director of the multidisplinary Future Vaccine Manufacturing Research Hub (Vax-Hub), supported by the Department of Health and Social Care, and managed by EPSRC with funding of £8 million, was critical for getting the project off the ground quickly. This has highlighted the importance of funding large-scale, collaborative vaccine manufacturing research.[29,30]

The UKRI-NIHR Rapid Response also funded the development of other treatments and candidate vaccines. This includes a project led by Professor Robin Shattock at Imperial College London, which used a self-amplifying RNA technology to develop a novel vaccine technology to tackle COVID-19 pandemic. However, after poor results in the efficacy, the trial was discontinued.[6]

Both UKRI and NIHR have been influential in supporting the launch of the RECOVERY trial nationally and internationally to facilitate data sharing, best practice, and results comparison. The infrastructure support provided by UKRI and NIHR prior to and during the RECOVERY trial, and the prioritisation of COVID-19 trials studies, including the RECOVERY trial, by NIHR have proven to be instrumental in facilitating recruitment at unprecedented speed[6]. This has changed the landscape for future clinical trials and the lessons learnt from the preparedness and the implementation of the RECOVERY trial will hopefully be reviewed and adopted into future clinical trial practices. Furthermore, the UKRI-NIHR funding has allowed the initial effort of the making and testing of the vaccine possible, which then allowed the researchers to secure further fundings and eventually partnering with a large pharmaceutical company, AstraZeneca, that allowed the scaling up and mass production of the vaccines within 7 months. This has been an unprecedented achievement[4].

It has been acknowledged by the awardees that UKRI took a very successful approach to funding COVID-19 research via a rapid mechanism, which was based on existing processes and forms but eliminated non-vital procedures. A committee of experts reviewed and approved applications, and the details of awards were made public, to maintain oversight and transparency without causing delay. While other funders were still maintaining their complex and slow application processes. A review of the funding process must be reviewed and learn from the experience of the pandemic[4].

B.4. Barriers and Challenges

The world media had a significant negative effect on the timing, extent of use, and uptake of the Oxford/AstraZeneca vaccine. There were substantial misinformation campaigns regarding vaccines, many of which were especially highlighting the Oxford/AstraZeneca vaccine, which has been one of the barriers to impact.

Furthermore, the scientific research findings about the Oxford/AstraZeneca vaccine were released via an irregular pathway. Instead of publishing peer-reviewed papers containing detailed methodology and results, a press release was legally required straight away to prevent

insider trading, due to the fact that a publicly listed company (AstraZeneca) was involved in the development of the vaccine, where the share price could be affected. Therefore, the initial release of the data on the vaccine would not have contained the level of details required in a peer-reviewed paper. This has led to further misinformation being released by the media[4,23].

Between January to March 2021, there was tension between the UK and the EU due to the perceived preferential treatment of the UK by AstraZeneca for vaccine deliveries, which led to the threat by the EU to block vaccine exports (from EU to the UK) and the threat of legal action against AstraZeneca for not respecting its contract for the supply of vaccines to member states. Moreover, between March to April 2021, the Indian government stopped all exports of the vaccine from its Serum Institute, and instead diverting the supplies for domestic use has further led to bad press for the Oxford/AstraZeneca vaccine[20].

For various reasons, there was some side-lining of the Oxford/AstraZeneca vaccine by the EU, and the US FDA had still not authorised the vaccine for use in the US.[15,24] This has impeded the vaccine's global reach and led to the reduction in the use of Oxford/AstraZeneca vaccines in general, and an increase in vaccine wastage.

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B.6. Annex: Key Outputs

Award	Key outputs
RECOVERY Trial: COVID-19 multi-arm, multistage adaptive clinical trial (CoV-MAMS)	Cao B (2020) A Trial of Lopinavir-Ritonavir in Adults Hospitalized with Severe Covid-19. in The New England journal of medicine Horby P (2022) Baricitinib in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial and updated meta-analysis Horby P (2020) Effect of Hydroxychloroquine in Hospitalized Patients with COVID-19: Preliminary results from a multi-centre, randomized, controlled trial Horby P (2020) Evaluation of the Efficacy and Safety of Intravenous Remdesivir in Adult Patients with Severe Pneumonia caused by COVID-19 virus Infection: study protocol for a Phase 3 Randomized, Double-blind, Placebo-controlled, Multicentre trial Horby P (2021) Hydroxychloroquine in Hospitalized Patients with Covid-19. Reply. in The New England journal of medicine Horby P (2020) Azithromycin in Hospitalised Patients with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial Horby P (2020) Effect of Dexamethasone in Hospitalized Patients with COVID-19 - Preliminary Report Horby P (2020) Lopinavir-ritonavir in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial in The Lancet Horby PW (2020) Hydroxychloroquine for COVID-19: Balancing contrasting claims. in European journal of internal medicine RECOVERY Collaborative Group (2020) Effect of Hydroxychloroquine in Hospitalized Patients with Covid-19. in The New England journal of medicine Wang Y (2020) Remdesivir in adults with severe COVID-19: a randomised, double-blind, placebo-controlled, multicentre trial in The Lancet WHO Rapid Evidence Appraisal For COVID-19 Therapies (REACT) Working Group (2020) Association Between Administration of Systemic Corticosteroids and Mortality Among Critically Ill Patients With COVID-19: A Meta-analysis. in JAMA https://www.sps.nhs.uk/articles/summary-of-covid-19-medicines-guidance-critical-care/ https://www.who.int/news-room/feature-stories/detail/who-updates-clinical-care-guidance-with-corticosteroid-recommendations

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Source: Gateway to Research

Appendix C Case study 2: Predictive

Case study 'Predictive' summary

The 'predictive' case study relates to seven awards in the area of surveillance and disease modelling. Three of these are long established centres or units, two are newly formed consortia and two are awards that repurposed existing platforms or ongoing awards. The awards resulted in over 400 published papers and many more technical reports and briefings to the Scientific Advisory Group for Emergencies (SAGE) and its' subgroups as well as tools such as COV-GLUE and the CoV toolkit. Outputs from these seven awards influenced national decisions with wide ranging health and socioeconomic impacts. A few examples include the decision to lockdown in March 2020, an age prioritised vaccine roll out strategy and the gradual timed removal of restrictions from the final lockdown. Reagents from the CoV toolkit have been distributed worldwide and have facilitated research into clinical pathologies, variants of concern and drug screening. Many of these awards' achievements and the speed with which they were delivered was facilitated by world leading expertise, research infrastructure and collaborations born of sustained and strategic prior investment by UKRI.

C.1. Description of the awards

This case study relates to seven awards in the area of surveillance and disease modelling.

- Three of the recipients are established, international centres of excellence with core funding (The MRC Centre for Global Infectious Disease Analysis (MRC GIDA), The Biostatistics Unit at the University of Cambridge (MRC BSU) and The MRC/University of Glasgow Centre for Virus Research (CVR)).
- Two are newly formed consortia (COVID-19 Genomics UK Consortium (COG-UK) and the Joint UNIversities Pandemic and Epidemiological Research consortium (JUNIPER)). Both consortia include at least 2 of the three Centres/Units among their members.
- Two awards repurposed existing platforms (i-sense: early warning system for infectious diseases) was an ongoing EPSRC-funded project on outbreak detection and surveillance to which UKRI added supplementary funding for the repurposing of tools for COVID19. EAVE II: funded through the RRI call revived the dormant EAVE cohort -an NIHR funded project on pandemic influenza).

These were larger awards in the main, ranging from a £20m grant to COG-UK at one end of the spectrum through to £0.5m for i-sense at the other. With the exception of JUNIPER, all awards were made early in the pandemic.

At the outset of 2020, the WHO surveillance data (1) was suggesting a case fatality risk[1] of 3-5% (2) and it was anticipated that a vaccine was unlikely to be available for two years. As an illustration of the changing context, the first vaccinations in the UK in fact took place in December 2020 (9 months later) and the current case-fatality risk in the UK is estimated at 0.8% on 19th July 2022 (3).

MRC GIDA is an internationally renowned centre of excellence for research and capacity building on the epidemiological analysis and modelling of infectious diseases. In addition to 'pivoting' activities with core funding MRC GIDA was awarded ~£500,000 in 2020 (4) and in 2021 a further ~£1,200,000 for equipment (5). The work of MRC GIDA on COVID-19 was led by

[1] Deaths from Covid19/confirmed cases of Covid19

Professor Neil Ferguson and was funded not only by UKRI but a number of additional funding sources including Wellcome, The National Institute for Healthcare Research and the Foreign, Commonwealth and Development Office (FCDO).

MRC BSU is one of the largest groups of biostatisticians in Europe, and a major centre for research, training and knowledge transfer in biostatistics and receives core funding from UKRI (7). Early in the pandemic, the group pivoted ongoing funds on a ~£3,783,000 award running from December 2016 through to March 2023(8).

CVR is the UK's largest grouping of human and veterinary virologists. In addition to 'pivoting' activities with core funding CVR was awarded ~£500,000 in 2020 (5) and in 2021 a further ~£1,400,000 for equipment(6). The work of CVR on COVID-19 was led by Professor Massimo Palmarini and was funded not only by UKRI but a number of additional funding sources including Lifearc(9) Bill and Melinda Gates Foundation, Wellcome and Mastercard(10).

COG-UK was conceptualised, proposed and funded during the very early stages of the pandemic. It brought together academic partners with public health agencies, NHS trusts and external research bodies across the UK to provide genome data, associated sequencing methods and analysis tools that could be used to inform public health actions and policy decisions(11). COG-UK was led by Professor Sharon Peacock and was awarded ~£20,000,000 from UKRI (~£6,000,000), DHSC and the Wellcome Sanger Institute in 2020 plus an additional ~£1,200,000 for equipment(5).

JUNIPER brings together leading mathematical and statistical modelers from seven UK universities. JUNIPER was awarded ~£3,000,000 in November 2020 through the UKRI Agile call and was led by Professor Matthew Keeling.

The i-sense Agile Early Warning Sensing System for Infectious Disease and Antimicrobial Resistance has been funded since 2013 by the Engineering and Physical Sciences Research Council (EPSRC) most recently receiving a 4 year award of ~£4,300,619 (5) in 2018. In 2020 the focus of the i-sense team switched heavily to COVID-19 and adapting their tools and technologies to support development of emergency diagnostics and surveillance to assess prevalence of the virus(12). I-sense is an multidisciplinary team under the directorship of Professor Rachel McKendry and received an additional funding amount of ~£500,000 from UKRI in April 2020 alongside a ~$200,000 grant from Google and industry in-kind support from "Carto Grants for Good"(13).

EAVE II: Early Pandemic Evaluation and Enhanced Surveillance of COIVD-19. EAVE II is a nationally scaled data set in Scotland containing near real time real-world data such as GP consultations, prescriptions, deaths, and COVID19 test results. EAVE II was led by the principal investigator Professor Aziz Sheikh and received a UKRI-NIHR award of c. £450k in March 2020 (5,6,14).

These awards are often interconnected and all draw heavily in one way or another on previous UKRI investment as well as contribute to others. In the case of the three units and centres they represent long term investments of UKRI with a substantial amount of core funding. Centre directors have the facility to pivot activities at their discretion providing a platform for very rapid mobilising of world class expertise. MRC GIDA was engaged from January 2020 and by March had 70 disease outbreak experienced staff full time on COVID-19. Similarly, CVR with a considerable number of the world's leading virologists were able to pivot all their staff (over 240) shortly after the emergence of COVID-19. MRC BSU researchers with adaptive clinical trial

expertise have been engaged in coordinating treatment trials including RECOVERY[2] and PROTECT[3] while CVR were engaged in the ISARIC4C (coronavirus clinical characterisation consortium) funded by UKRI. (15). The centres are also involved in both of the consortia in this case study. In each case previous work and collaboration heavily influenced consortium readiness to form, purpose and activities. This is exemplified by COG-UK that: engaged all three centres, drew much of its inspiration for purpose and potential from previously funded work of CVR on Zika and Ebola, and was heavily supported by connection with CLIMB[4] (UKRI funded since 2014) at its conception. While the initial connection was forged by the researchers themselves, it is acknowledged that very few, if any, countries had an equivalent to CLIMB. Without CLIMB COG-UKs genomic surveillance efforts for SARS-Cov-2 would not have been possible (16).

JUNIPER in November 2020 drew together and formalised a network of modellers that had been collaborating extensively up to that point throughout the pandemic and prior to it including on several UKRI funded projects.

Finally, both repurposed awards by definition relied on prior investment and facility to reignite or redirect funding.

C.2. Main results (outputs, outcomes, impacts)

The awards resulted in over 400 published papers and many more technical reports and briefings to the Scientific Advisory Group for Emergencies (SAGE) and as well as membership of various SAGE subgroups (e.g. the Scientific Pandemic Influenza Group on Modelling (SPI-M)). Published papers are shown in the table below, technical reports and briefings are harder to capture. JUNIPER report over 120 documents provided to SPI-M and 24 to SAGE(17) GIDA reports 35 papers that have been considered by SAGE(18) and eight reports from early in the pandemic are listed on the SAGE website(19). BSU have produced weekly 'Nowcasting and Forecasting' reports for SAGE and SPI-M since 10th May 2020(19). COG-UK report 18 technical briefings to SAGE and the four Public Health Agencies between March 2020 and May 2021 and the EAVE II team report their data featuring in 19 Scottish Government reports on the modelling of the pandemic between October 2020 and January 2022.

Table 5 Publications from the awards

Focus	**Award**	**ResearchFish (20)**	**Estimates provided by awardees (reference)**
Modeling	MRC GIDA (MC_PC_19012)	146	145 (18)
	MRC BSU (MC_UU_00002)	62	70 (21)
	JUNIPER (MR/V038613/1)	18	52 (22)
Primary surveillance data provision	EAVE2 (MC_PC_19075)	4	30' key papers' (23)
	i-sense (EP/R00529X/1)	10[1]	6 C-19 specific (24)

[2] Randomised Evaluation of COVid-19 thERapY

[3] Two community trials for testing treatments for post exposure prophylaxis in care homes (CH and identifying treatments for post exposure prophylaxis in immunocompromised vulnerable patients (V).

[4] Cloud Infrastructure for Microbial Bioinformatics: an open, cloud-based computing infrastructure for developing and sharing datasets and bioinformatics software, tools and methods to interpret big data

	CVR (MC_PC_19026)	42	51 (15)
	COG-UK (MC_PC_19027)	33	86 (25)

The awardees built on pre-existing relationships and prior projects not only to begin generating surveillance data and models at a rapid pace but also to forge required links and memberships with key advisory and policy making groups.

I-sense had previously developed and Public Health England (PHE) had adopted an online 'Flu Detector'. On request from PHE they rapidly repurposed this machine learning based tool for COVID-19 (26) and by March 2020 were producing and submitting weekly COVID-19 surveillance reports focussed on regional anomalies and early detection of local clusters.

While i-sense was focussed on England, the EAVE ii cohort was being rapidly established in Scotland. The original EAVE[5] platform was retained 'dormant' as part of NIHR Pandemic Preparedness Research Portfolio and was expanded and augmented to track COVID-19 across Scotland. By 23rd February 2020 it had been expanded to include some 5.4 million individuals registered with a general practice (almost 99% of Scotland's population) and went on to track the pandemic in Scotland in near real time (14).

In March 2020 COG-UK began sequencing virus samples from people who had been infected and by February 2022 over 2 million SARS-CoV-2 genomes have been sequenced and uploaded to the international GISAID database, this is a quarter of all SARS-CoV-2 genomes sequenced and shared globally (27). CVR were a key partner in COG UK and also began sequencing in March 2020 initially taking on the sequencing for all Scotland samples until the broader infrastructure of COG-UK was established.

On the modelling rather than surveillance side Neil Ferguson (MRC GIDA) was present at the first 'precautionary' SAGE meeting related to COVID-19. At the second meeting it was confirmed that SPI-M, whose members would include individuals from JUNIPER, MRC BSU and MRC GIDA, would be a SAGE subgroup for the duration of the pandemic (28).

SPI-M produced their first of the regular consensus statements on COVID-19 that included estimates of key parameters by third February 2020. The first models to be considered by SAGE included the potential effects of non-pharmaceutical interventions on a COVID-19 epidemic (25th February 2020) led by MRC GIDA and early models of transmission reducing interventions effect on attack rate and incidence prepared by Julia Gog a founding member of JUNIPER. Following this, SPI-M and so by definition MRC GIDA, MRC BSU and JUNIPER researchers continued to support SAGE with modelling of the available surveillance data throughout the pandemic stretching from these early stages and the first lock down (announced 23rd March 2020) (29) through to the roadmap to recovery and gradual easing of restrictions after the third lockdown a year later.

The data, models and expert advice from all seven awards has influenced many policy decisions across UK government, and globally in several cases, with wide ranging health and socio-economic benefits for the UK and the rest of the world. A selection of examples of such impacts on different aspects of the pandemic include:

[5] Estimation of vaccine and Anti-Viral Effectiveness: a Scotland-wide cohort of 227,000 individuals recruited from 40 general practices, funded by NIHR and was set up in 2009 related to pandemic Swine Flu(14).

C.2.1.Decision to Lockdown

The decision to 'lockdown' in the UK in March 2020 is arguably one of the most impactful moments of policy decision making throughout the pandemic. The modelling evidence underpinning that decision was wide ranging and produced by a number of groups feeding into SPI-M.

Neil Ferguson's report (30) showing that the UK health system would be overwhelmed without interrupting transmission, and that to block transmission required implementing of social distancing was one of the most influential in the UK and globally. Results contained in this report were shared with SAGE, the CSA, CMO, the NHS executive and Downing Street in the days preceding the first announcement from the UK government of a move to a suppression strategy on 16 March 2020 that subsequently led to the first UK lockdown on 23 March 2020.

Widespread global media coverage of the report generated considerable global impact as evidenced by a drop in mobility from 17th March (31). Evidence pooled from across Europe suggests that lockdowns reduced transmission by around 80% (32) and based on modelling the decision to lockdown would have prevented somewhere in the region of 470,000 deaths and reduced case numbers to a level where demand did not exceed intensive care unit capacity(33,34).

While the effects of lockdown on COVID-19 transmission were highly positive, there were immediate and lasting negative impacts on the economy which shrank by a fifth during the period April 2020-June 2020; mental health which worsened with particular concerns for young people, women and over 70s(35); and education with children being home schooled and existing attainment gaps exacerbated(36).

C.2.2.Influencing Testing Strategies

As testing capacity increased in the UK and NHS Test and Trace was established, MRC GIDA modelling (37) investigated the feasibility and impacts of several mass testing strategies. Results included demonstrating weekly screening of health care workers using PCR tests would reduce their contribution to transmission by approximately a quarter as well as test and trace for symptomatic cases reducing transmission by 26% compared to self isolation alone. This directly informed the policy and UK Government Consensus Statement on Mass Testing (August 2020) (38).

The COVID-RED dashboard from i-sense launched in October 28th 2020 and almost immediately data on the dashboard and in particular the low testing rates highlighted were picked up in the media including The Conversation, The Guardian, The Telegraph, Evening Standard, Sky news, PA via Express and Star, Mail Online and the Daily Mail (39-42). A rapid increase in testing capacity can be observed on the Governments COVID dashboard around this same period (<370,000 on 23rd October to >526,000 on the 2nd November)(43)

C.2.3.Informing Vaccination Roll Out

Vaccination in the UK launched in December 2020, and proved to be a cornerstone of the pandemic response, preventing deaths and reducing hospital admissions. NHS England and NHS Improvement has led on operational delivery while the implementation strategy has followed the advice of the Joint Committee on Vaccination and Immunisation (JCVI)(44).

In development of that strategy JUNIPER models were used. These showed that targeting vaccination to the oldest and most vulnerable individuals first could substantially reduce the number of deaths from SARS-CoV-2 compared to random vaccination-potentially halving the number of deaths for a fixed deployment of vaccine(45). Based on this work, JCVI advised and the government adopted this strategy with the first cohort being residents living in care homes for older adults and their carers (44).

The EAVE II cohort gave an early assessment of COVID19 epidemiology and vaccine/anti-viral effectiveness and provided data on the 'real world' impact of the UK's vaccination programme showing that hospital admissions were reduced in Scotland by 85% and 94% for the Pfizer and Oxford/AstraZeneca vaccines respectively (46).

During phase two of the vaccine roll out, again JUNIPER modelling informed JCVI advice and was taken up by the government. This time the models compare whether giving as many people as possible 2 doses within a short time-interval, or achieving a high coverage of a single dose would be more impactful. The results strongly suggested that more deaths would be averted by prioritising single doses (47) which was what was rolled out.

C.2.4. Contributing to Surveillance and Responding to Variants of Concern

Surveillance of the virus evolved over the pandemic reflecting the changing testing capacity and strategies. Initially focussed on identifying individual cases and understanding basic transmission characteristics surveillance capabilities progressed to identification and monitoring of different variants at high scale.

During the first stages of the pandemic the machine-learning based surveillance approach developed by i-sense predicted regional surges in infection 7-10 days before they were identified by case counts (48). These predictions were used by Public Health England in their decision making very early in the pandemic, and were particularly useful in the period before community testing was rolled out. Asked about the impacts of this data a former Public Health England representative said "[the reports were] used by policy makers at the national level to make decisions on outbreak management policy…the data is presented and discussed in a range of national level situational reports and meetings attended by senior staff from Public Health England and the Department of Health and has undoubtedly informed the decision-making process with regards to COVID19 national policy".

EAVE II provided data on the co-morbidities and serious covid-19 outcomes supporting identification of individuals at particularly high risk of serious outcomes and ultimately became the UKs main prediction algorithm for identifying these risk factors (49).

As the pandemic progressed genomic surveillance data and its analysis fed into wide reaching policy decisions on transmission reduction strategies, travel restrictions, lockdowns and the need for vaccine updates for emerging variants. Due to COG-UK, the number of SARS-CoV-2 genomes sequenced in the UK was among the highest in the world both in terms of overall number and % of positive cases sequenced (50). One example of a related impact is the quick identification and characterisation of Alpha when cases surged in November 2020. Understanding Alphas faster rate of spreading in combination with epidemiological modelling by MRC GIDA provided the first estimates of increased transmissibility of up to 70% alerting the UK and the world to the dangers of this variant (51). The 70% figure was cited by the Prime Minister in his statement on 19th December (52) that led to the decision to put more regions of the UK into Tier 4 restriction and eventually the 3rd UK national lockdown in January 2021.

COG-UK having supported the provision of UK-wide COVID-19 sequencing and analysis have enabled the 4 public health agencies to create a long-term national pathogen genomics service. As a measure of the nationwide increase in capacity prior to the pandemic Public Health England sequenced around 50,000 genomes annually in the tracking of outbreaks such as TB or foot and mouth. In a single week in April 2022 around 70,000 SARS-Cov-2 genomes were generated across the UK (53) representing a 70 fold increase.

JUNIPER was also instrumental in helping to shape scientific opinion on newly emerging variants (Alpha, Delta and Omicron). In each case their results provided rapid and robust estimates enabling policy decisions to be made quickly. In an epidemic, such prompt decision making is key and provides substantial gains in terms of hospital admission and deaths, and provides

socio-economic benefits in terms of requiring shorter duration restrictions. Quantification of these benefits is impossible, but it is clear that the controls that were implemented after Alpha and the public-health advice that was issued after Omicron substantially reduced the scale of the epidemic (49).

C.2.5.Navigating the Roadmap to Recovery

The first Roadmap document (February 2021) set the basic timescale for the steps out of lockdown. The roadmap was based on evidence presented at SAGE 81 where independent modelling by the different groups all supported a careful and gradual reopening of society. JUNIPER and MRC GIDA were two of three groups that provided projections for the likely impact of the relaxation steps throughout 2021 (from February 2021 to November 2021).

The MRC GIDA models suggest the incremental roadmap out of lockdown in 2021 saved up to 100,000 lives (and up to 300,000 hospital admissions) compared with what a very rapid lifting of all measures in March 2021 might have resulted in(55). JUNIPER models projected vaccination would not be able to control the outbreak without non-pharmaceutical intervention (NPI) and that should all restrictions be lifted an additional 21,400 deaths would result. This increased to 96,700 deaths with less optimistic vaccination rates. The paper argued that the UK could not remove all social mixing restrictions simply because vaccination was underway, this supported controls being relaxed gradually suggesting that a slow release of NPI controls approximately halved the number of deaths compared with a more rapid release. (56).

Roadmaps 2 and 3 supported the gradual reopening of society - with the associated socio-economic benefits. Roadmap 4 (June 2021) coincided with the arrival of Delta, and the models of both groups helped to inform the government decision that there was too much uncertainty for Step 4 to occur at that time. Following a delay of four weeks Roadmaps 4b and 5, supported the gradual reopening of society and projections suggest that the delay reduced peak hospitalisations by around 30%(57). One respondent to the Technopolis survey named the modelling for the exit strategy from the third lockdown as the single most impactful output of MRC GIDA's work(58).

C.2.6.Supporting longer term and more global pandemic responses

These awards have also included membership of a number of international committees and the development of various open access, online data analytics tools. This has facilitated the impacts of the awards in many cases to stretch beyond the UK and include supporting low and middle income countries with their response

CVR produced several tools that continue to contribute substantially to knowledge and understanding of COVID-19 and measures to facilitate recovery at pace. In particular CoV-GLUE: a database of the mutations observed during the pandemic allows researchers globally to search for and track the occurrence of specific mutations world-wide helping to understand evolution and spread of the virus at a global level(59). For example when Remdesivir resistance was flagged as a potential concern, CVR researchers were able to first identify in vitro what mutations would confer resistance and then use COV-Glue to determine that the mutation is not one that appears naturally in currently circulating variants(60).

The CoV toolkit - a CVR collaboration with the University of Dundee launched in May 2020(61). generated plasmids proteins and antibodies essential to research such as vaccine or drug development (62). and critically also shared them on an open-source basis. The CoV toolkit contains 4 primary types of reagents, 3 of which were produced by CVR that have been shared with and further distributed by the National Institute for Biological Standards and Control, Public Health England as well as over 300 labs and several public health agencies, UKHSA other international agencies like BEI Resources (63).

The provided reagents and antibodies have facilitated a range of research world-wide and have underpinned several high profile fundamental biology studies (64-67). Outcomes have largely been to better understand how the virus works which has had both clinical and policy implications. Permissive cell lines were used by many of the agencies to identify and characterise new variants including predicting or demonstrating compromised vaccine or treatment efficacy (64, 66) or immune response (65) with implications for surveillance; identifying mechanisms of pathology (68), demonstration of the link between OAS1gene expression and severe COVID (69,70) as well as to establish a variety of assays for drug screening and identify potential treatments (71).

I-sense also had a significant output as regards a communication tool. They developed a new public health data visualisation dashboard for COVID-19 to create the first complete picture of the COVID-19 response, transmission and impact in England. I-sense response evaluation dashboard (COVID-RED) was launched October 28th 2020. The key aim of this funding was to develop a dashboard that brought together COVID-19 data from a wide range of sources into one programme and explored the UK's "find-test-trace-isolate-support" system as a whole. The dashboard aimed to contribute to the public understanding of COVID-19's spread and support policy makers in identifying which areas of the system needed strengthening(72). and received more than 25,000 hits in the first 24 hours. The research team developing it received 20 + emails in the first days plus many tweets thanking them for the dashboard which was perceived to be a data driven approach and a clear evaluation of the situation and a good way to get a picture of the related policies and approaches and make sense of the data. More than one mentioned they shared this dashboard or figures in the dashboard with family/friends or in forums/chat groups(39).

MRC GIDA staff are members or contributors to a wide-ranging set of committees internationally including: WHO SAGE COVID-19 vaccine working group, the Pandemic Preparedness Committee of the National Science Foundation, Special Advisor to Governor of NYC, Chair of the Covid19 modelling group for the global fund, the SET-C committee, WHO strategic and TAG for TB. They have provided advice to the governments of Colombia, Malawi, Italy, the Philippines, Zimbabwe, India, the US, Senegal, Sudan and Indonesia in their design and implementation of COVID-19 control measures. They have advised WHO on P1 variant and through their modelling allocation and impact of the vaccine contributed to the WHO SAGE roadmap for prioritising uses of COVID-19 vaccines in the context of limited supply. The have assisted the Global Fund in quantifying impact of COVID 19 on HIV, TB and Malaria(4). The protocols of the Recovery Trial developed with the inputs of BSU have underpinned the 'Solidarity'6 therapeutics trial.

To extend global sequencing capability, COG-UK members have been supporting sequencing efforts in 28 countries, including 18 low- and middle-income countries and have contributed to the WHO's global guidance document for sequencing of SARS-CoV-2 and subsequent virus genomic analyses. They have a role in the Global Early Warning System Action Collaborative Advisory Council.

The capacity tools and resources built through these awards has the potential to contribute substantially to longer term pandemic preparedness worldwide. Global surveillance tools such as COV-GLUE remain in place while the i-sense search-based surveillance has demonstrated transfer of learning -i.e. that machine learning from one country can be successfully transferred to another country that is earlier in the pandemic and that predictions precede case and

[6] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov/solidarity-clinical-trial-for-covid-19-treatments

death counts by 16 days and 22 days respectively. The CoV toolkit could easily be directly adapted to aid the research response for other possible future coronavirus epidemics or pandemics (which are likely to occur, as there have been 3 in the last 20 years alone). In particular, COG-UK and by extension the global community engaged in outbreak response are now prepared to establish new reverse genetics systems for other coronaviruses.

There has also been a significant increase in capacity the most notable being the sequencing capacity as described above. JUNIPER also report that the award enabled the training of a new generation of modellers giving them experience of pandemic management while simultaneously broadening the skill base and topic depth of those engaged in development of advice. Based on their experiences during this pandemic CVR has established the COVID-19 Drug-screening and Resistance Hub (CRUSH) that will use their state-of-the-art containment facilities, drug screening pipelines, and technological platforms such as real time genomic sequencing and cryo-electron microscopy(73).

Finally, COG-UK are taking forward data linkage (including with other UKRI projects) in order to reach the full potential of how genomic sequencing can support future pandemic preparedness and management. They have launched COG- TRAIN an international educational initiative providing open-access learning in SARS-CoV-2 genomics. It aims to facilitate an increase in global genome sequencing and analysis capacity, reduce sequencing inequality and enhance pathogen surveillance. (74).

C.3. Contribution analysis: UKRI's role

A key impact pathway for many of the awards in this case study was the uptake of both modelled and primary data into decision making throughout the pandemic and the effect this had on health outcomes and other societal impacts. It is clear that data rapidly reached advisory committees and subsequently policy makers. It is key however, to keep in mind that policy makers considered in their decisions more than the data and resultant advice from these specific awards or indeed the advisory committees. Thus advice and decisions are not necessarily immediately concordant.

A collection of twenty papers of modelling that underpinned policy decisions in the UK have been published in Philosophical Transactions of the Royal Society. In these papers the authors have drawn concrete links between the data and a number of key decisions including the stay at home order March 23rd 2020, reopening of Schools in May 2020, introduction of support bubbles, the 'rule of six' in September 2020 as well as localised policy changes in response to heterogenous local transmission(71). This does indicate a level of endorsement by many in the modelling community of the links between their outputs and the resultant decisions where they are in line with the data. Analysis undertaken into the relationships between the advice of SAGE and decision making does suggest that (earl`y in the pandemic at least) policy decisions were largely in line with and connected to SAGE evidence and advice (76–78). Lastly, it is also worth noting that a further distance between research output and impact is added since the effects of decisions were dependent also on the management, timing and success of their implementation.

Awards in this case study were highly interlinked with each other, with previous platforms, core Centres and other ongoing projects. It is clear that the sustained prior investment of UKRI particularly in Centres and Units played a critical role in fast mobilisation of world leading expertise through the discretion of the directors to redirect core funding and respond quickly and independently. There was rapid identification (mainly by researchers themselves) of opportunities for repurposing of previous work and immediate redirection of staff time in the Centres and Units which was also facilitated by the core grants at the discretion of the Centre or Unit Directors. Researcher networks were important in the impact pathways in that they

facilitated key collaborations with other research groups as well as pre-existing links to a number of advisory groups and policy makers both nationally and internationally. Both of these aspects being fundamental to impacts being achieved by way of surveillance data being highly leveraged in the modelling as well as reaching decision makers quickly. Some researchers were also able to use established links to Industry and private partners to open up new avenues of data sharing and access as well as 'in kind' resourcing. There were many references made by researchers to high levels of support from UKRI, openness to a direct approach and a collaborative process in the onward development of the ideas and progressing them towards funding. In at least one case of a supplementary award to a centre/unit, they did not apply and were unaware of it almost until actual receipt of funds.

The fast dissemination of data, sharing data in an unprecedented way setting aside the usual issues of authorship and credit was also important – both in getting data to policy makers as well as forming data linkages that allowed different projects to interact and leverage each other. This sharing of data, protocols and open research not only promoted recognition of the significant contribution of UK research but in combination with researcher networks has led to impacts in low- and middle-income countries. Many of the tools are open access supporting global use and a number of research outputs and processes underpin various of WHO's advice and global guidance.

The very substantial number of prior investments and variety of other influencers mean it has not been possible to quantify and attribute impacts to the specific UKRI investments. However, it is clear that the scale of the health benefits these activities have contributed to run into the many hundreds of thousands of lives saved, and that the development of tools and technology, research infrastructure, training and new facilities as a result of these projects are set to have a long-term legacy in pandemic preparedness.

C.4. Barriers and challenges

This section of the case study focusses on elaborating challenges and barriers and how they affected delivering impacts. Barriers identified were drawn from interviews and many derive from overarching contextual challenges such as epistemic uncertainty in an evolving emergency and the complex nature of advising any government in that environment.

Rapid and sustained connection of awardees with each other as well as advisory groups and in particular SPI-M and SAGE was critical to the impacts in this award. In most cases this happened both naturally and effectively as a result or previous partnerships or existing researcher connections. Researchers who were less naturally engaged with SAGE and SPI-M– for example i-sense who primarily occupy a digital technology space as opposed to epidemiological– would have benefitted from further assistance to make these connections promoting higher impact. This could have occurred through: the increased utilisation of some awards outputs in policy; incorporation of diverse data sources and modelling techniques into advice; or fostering of new collaborations and combinations of skills. An awareness from UKRI that many of these critical connections form organically rather than systematically should prompt additional facilitation by UKRI in the future wherever possible. This in turn could promote wider inclusion and recognition of more innovation within the advisory groups.

Impacts of the modelling that was so effective later in the pandemic were reduced early on through lack of data. Without sufficient data to confidently model there was a delay in decision making; as surveillance became more established the scale of the UK outbreaks were confirmed to be much higher than previously understood. It has been estimated and testified to the Houses of Commons that should lockdown have happened a week earlier the resultant deaths in the UK (as of June 2020) would have been halved(79). Supporting development and integration of the advances in surveillance capacity, novel surveillance techniques and ability

to scale that have come to the fore through the pandemic could help overcome similar challenges in the future.

One desirable impact highlighted in the logic model is "public appreciation and understanding of the importance of R&I in national and international crises". The evidence presented in this case study supports the contribution of these awards highlighting a tangible impact of research and innovation. While valuing the high profile of research throughout the pandemic interviewees also recognised the potential for research to be scapegoated where policy decisions or their implementation were unpopular, delayed or did not result in the desired impacts. This was especially a concern in the context of the neglect of research around some of the wider and keenly felt societal impacts of the pandemic. Though this is a well-documented aspect of the nature of the relationship between governments and the provision of scientific or technical advice particularly in a crisis (76-78, 80) there was no immediate evidence to support it having occurred, To the contrary data suggested public trust in scientists or science had not been eroded (81-82) and a 2020 survey suggested 82% of adults in the UK thought government investments in scientific research were worthwhile (83).

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C.6. Interviews

- Emily Gale, Programme Manager for Evaluation, MRC UKRI, Interviewed 16th March 2022
- Anna Kinsey, Head of Epidemic Preparedness, MRC UKRI and David Pan, Interim Head of Programme, COVID-19 response, MRC UKRI interviewed together 17th March 2022.
- Katherine Freeman, Senior Portfolio Manager, Healthcare Technologies, EPSRC UKRI, interviewed 4th May 2022.
- James Carter, Evaluation Officer (Corporate Reporting and Projects), MRC, UKRI, interviewed 3rd May 2022.
- Neil Ferguson, Director MRC-GIDA, Imperial, interviewed 11th May 2022
- Massimo Palmarini, Director CVR, University of Glasgow, interviewed 13th May 2022
- Patrick Chinnery, Clinical Director MRC, Chair C-TAP, interviewed 6th May 2022
- Ingemar Cox, Deputy Director i-sense, UCL and Mengdie Zhuang, (formerly) lead COVID-RED, UCL, interviewed together 12th May 2022
- Matt Keeling, PI JUNIPER, Warwick University, interviewed 11th May 2022
- Andy Jermy, External Communications Lead COG-UK, Questions answered by email 30th May 2022
- Suzannah Rihn, Research Fellow, Centre for Virus Research, Questions answered by email 08/06/2022

Appendix D Case study 3: Transmission

Case study 'Transmission' summary

The case study showcases the outcomes and impacts achieved by four UKRI-funded awards focusing on virus transmission in public transport and the built environment. UKRI funded research supported the Department for Transport and various transport operators' understanding of virus transmission on public transport and decisions regulating the environment. For example, Transport for London (TfL) introduced modifications to the whole London bus fleet based on the research findings. Researchers looking at transmission in school classrooms informed the Department for Education's (DfE) decision to buy CO2 monitors for UK schools and provided guidance for the use of the monitors. UKRI funded research and findings also contributed to the decisions on re-opening the events industry, allowing the industry to produce value and the employees to leave furlough. UKRI's coordinating role, demand and support from other government departments and public bodies facilitated the achievement of impact by supporting strong partnerships with research users.

D.1. Introduction and description of awards

Understanding virus transmission risks in different environments was crucial for providing evidence-based guidance and measures for safe social interaction and managing the pandemic and providing guidance for life after it.

This case study covers four awards contributing to understanding transmission of COVID-19 in different environments and providing evidence-based guidance to policymakers and others. The awards focus on transmission in public transport, non-domestic buildings (healthcare, theatres, offices and retail spaces) and schools. The Annex below summarises the partners involved (incl. award size). The following sections briefly introduce each project.

Public transport is an environment where it is hard to follow social distancing, and thus passengers and staff face infection risks. Two awards covered in this case study focused on transmission in public transport vehicles. Both are multidisciplinary collaborations, including engineering to understand ventilation systems, microbiology to detect the virus, infection control, air quality, fluid dynamics and behaviour insights.

- A team at University College London (UCL) and its partners conducted research to understand the **Risk of Transmission on London's transport vehicles (VIRAL)**. The project combined staff and passenger surveys, microbiological sampling, airflow computer simulations, passenger crowding and ventilation models and air quality measurements to understand how the risk of transmission can be minimised in London's transport systems (UKRI award: EP/V026895/1).
- The University of Leeds led **the Transport Risk Assessment for COVID Knowledge (TRACK) project** to develop a novel risk model to simulate infection risk through three transmission mechanisms (droplet, aerosol, surface contact) within different transport vehicles and operating scenarios. Led by Professor Noakes, several academic and government partners worked closely to complete different project tasks. Project partners collected air and surface samples, conducted user and staff surveys, analysed CCTV data and evaluated infection control strategies on public transport in Leeds, Newcastle and London. The ongoing project aims to provide targeted guidance and risk planning tools to the Department for Transport (DfT) to better assess infection risks for passengers and staff and design interventions to mitigate transmission (Track, 2022).

Returning to work, education or entertainment in non-domestic buildings requires evidence-based consideration of how virus transmission can be reduced in the built environment. Two awards covered in this study focus on how to limit virus transmission in schools and other non-domestic buildings.

- The University of Cambridge led the **COVID-19 Transmission Risk Assessment Case studies – education establishments (Co-Trace)** project aimed to reduce the uncertainties associated with airborne transmission routes. When re-opening, schools had to monitor the air quality to reduce virus transmission and required evidence-based guidance on best practices for ventilation. The project quantified the risk of airborne COVID-19 transmission in schools and evaluated the effectiveness of mitigation measures: changes to ventilation, use of screens, classroom layout and occupancy. Led by Professor Linden, the research team conducted field studies in primary and secondary schools and laboratory experiments.
- Like schools, other non-domestic buildings where people gather for work or leisure required evidence-based guidance and solutions to practice a safe return to the social gathering. Loughborough University implements the project **Airborne Infection Reduction through Building Operation and Design for SARS-CoV-2 (AIRBODS).** The project delivered guidance on ventilation operation and future building design to reduce the virus transmission in non-domestic buildings: primary healthcare settings, theatres, open-plan offices and retail spaces. Professor Cook leads a team of scientists and engineers that used experimental methods, mathematical modelling and fieldwork to investigate the transport of aerosols carrying virus particles.

D.2. Main results (outputs, outcomes, impacts)

D.2.1. Evidence for transport policy and safe transport operation

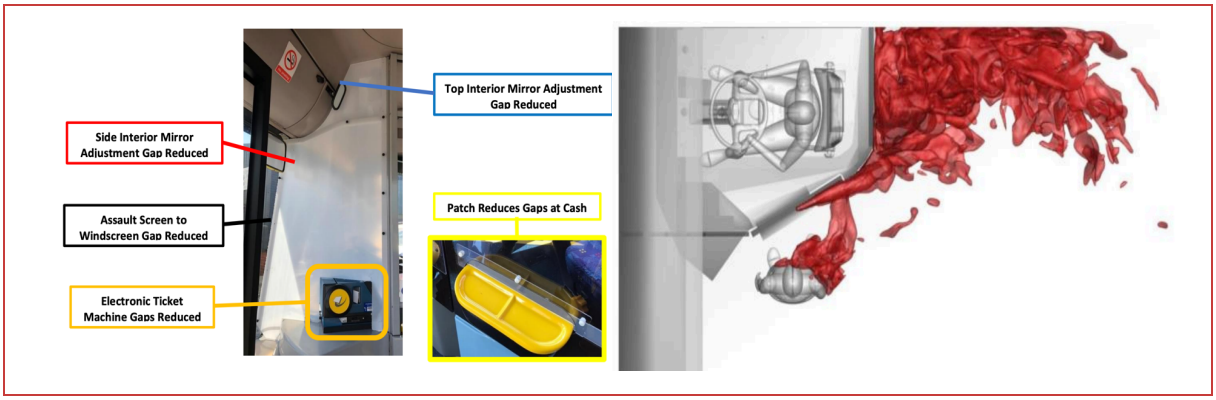
Two transport awards – VIRAL and TRACK – were **crucial in providing an overall understanding of virus transmission in public transport and supporting decisions and guidance to transport operators and for the Department for Transport**.

The **VIRAL** project evidence fed into the Transport for London (TfL) virus transmission risk assessment framework and recommendations for interventions (UCL Department of Civil, Environmental and Geomatic Engineering, 2022). TfL asked UCL to explore the nature of occupational risk concerning the interaction between passengers and the bus driver and how the design of the bus affects that. The research showed that modifications to the driver assault screen lower drivers' exposure to the air in the passenger saloon (Malki-Epsthein et al, 2020). By autumn 2020, researchers summarised the evidence and recommendations in the report on scientific advice to TfL, which is one of the core outputs of this project.

Researchers looked at what mitigation measures could reduce air from the passenger saloon entering the drivers' cabin and how virus transmission could be reduced in the passenger saloon. When selecting samples, conducting simulations, and modelling transmission, researchers found that adjustments to the drivers' cabin assault screen can reduce air exchange with the passengers' cabin. Adjusted ventilation and open windows in the passenger saloon can reduce virus transmission on buses. **Based on these findings, TfL introduced modifications to the drivers' cabin assault screen** (see figure below) for the whole London bus fleet. In a smaller number of buses, they also **modified the ventilation systems** so that the drivers' cabins would not receive air from the rest of the bus. Finally, TfL also **introduced blocks to prevent passengers from shutting the windows and added stickers asking not to close the windows**.

Based on findings from the VIRAL project, TfL modified the assault screens in the whole London bus fleet and changed the ventilation system in 1,200 busses. Around 55% of bus drivers reported feeling their safety had improved after these modifications. Public transport operators elsewhere in the world also introduced similar mitigation measures. For example, certain states in the USA and Canada introduced shields to protect bus drivers.

Figure 5 Illustration of modifications to the drivers assault screen and simulated airflows of exhaled aerosols



Source: Malki-Epsthein, L., Stoesser T., Ciric, L., Stubbs, A., Tyler, N. (2020). Report on Scientific advice to TfL on bus driver assault screen modifications due to the Covid-19 pandemic. Available: https://www.ucl.ac.uk/civil-environmental-geomatic-engineering/sites/civil_environmental_geomatic_engineering/files/tfl_drivers_cab_modifications_ucl_full_report_2020-10-28_0.pdf

The **TRACK** project analysed the relative importance of factors that affect the transmission of COVID-19 on public transport and the impact of mitigations. The project first developed virus transmission risk models simulating transmission for hand contact, close-range exposure and aerosol contact in London Underground. Models included mitigation measures. After modelling transmission in underground tubes, researchers conducted similar modelling for bus travel. Researchers also completed data collection on passenger demographics by conducting passenger surveys, analysis of ticketing data and CCTV analysis. The research provides insights into which surfaces are most likely to test positive for the virus, the impact of ventilation and other parameters. Behavioural insights showed variations in travel preferences and attitudes towards hand hygiene. All factors fed into the transport transmission risk model. The findings are summarised in two policy reports and, in autumn 2020, were circulated to government and transport operators. Researchers also communicated their findings in regular informal discussions with policy teams. The team has published several scientific articles and is working on more.

The Department for Transport (DfT) received research findings and information from the TRACK project through the pandemic and routinely used it to inform their strategic thinking and guidance on COVID-19. For example, the research fed into the government Plan B, its suggested measures, and the roadmap for re-opening in 2021. The DfT took the information from the project and used it to formulate internal papers that then fed into the decisions described above. Importantly, the research and the process through which research was shared in the regular meetings allowed the DfT and the transport operators to understand the complexity of virus transmission in public transport. The meeting format allowed the stakeholders to ask questions and receive immediate answers to their concerns. The TRACK project's risk factor modelling has shaped guidance relating to public transport, such as encouraging good ventilation and maintaining mask-wearing. Research ensured that the DfT guidance is underpinned by a specific understanding of virus transmission in the public transport environment. For example, at the beginning of the pandemic, there was a lot of focus on cleaning the surfaces in public transport. However, due to the TRACK and VIRAL projects, transport operators slowed the emphasis on cleaning and put more effort into ventilation and face coverings because of the new evidence on airborne transmission routes. The two projects also helped bring about the realisation that there is a lack of knowledge about ventilation on trains. The public transport standards are more about energy savings than air quality. The transport operators are now revisiting their strategies to address this.

According to the DfT representative, the TRACK project was a game-changer in terms of transport-specific advice. TRACK project provided evidence in a fast-moving pandemic context and was a trusted source of understanding about how transmission can happen in public transport. The evidence helped the DfT persuade transport operators who, because of commercial motivations, were hesitant to run the risk of being excessively cautious. Since September 2020, when the TRACK project started, the DfT consulted the research findings daily. Transport policy makers' understanding of the virus and virus transmission in public transport was minimal. They needed a trusted source of evidence to inform everyday work, decisions and guidance the department provides to the sector.

TRACK project outcomes and impact cannot be quantitatively measured. However, it is probably the most impactful award covered in this case study: **its findings were the most significant evidence the Department for Transport used to inform its overall departmental COVID-19 strategy**. The research improved understanding, clarified misperceptions, and provided recommendations for various potential actions to mitigate transmission in public transport. It also fed into key government decisions beyond transport: government Plan B and re-opening roadmap in 2021.

D.2.2. Evidence for safe operation of indoor spaces

The other two awards (Co-Trace and AIRBODS) focused on **indoor transmission in buildings**. Researchers produced new knowledge on virus transmission in school classrooms and other indoor spaces where many people gather.

The most notable and impactful output of the **AIRBODS** project is the research conducted before, during and after pilot events organised in the framework of the Events Research Programme (ERP)7 during the summer of 2021 and contribution to the Phase 1 report of the programme. The research supporting the pilot events focused on and found evidence on the risk factors of transmission, such as CO2 levels, crowd density, bacterial amounts on surfaces and in the air and compliance with face coverings and distancing as well as how to manage these risks. Some of the key findings were that outdoor events are safer, but some factors increase risk, such as indoor support spaces (food/drink concessions, toilets, etc.). Large unstructured gatherings indoors pose a high risk; mitigations measures such as communications, crowd management, face coverings, ventilation, testing, restrictions on food/drink, etc., reduce transmission risk (Department for Digital, Culture, Media & Sport, 2021).

ERP findings helped to inform decisions on the re-opening of events in Step 4 of the Roadmap to re-opening events. The **findings fed into government decisions allowing the reopening of public events in the summer of 2021 and bringing the events industry, which contributes £11.5bn Gross Value Added per year, back to business**. This included events with large crowd sizes, for example, sports championships, business conferences, music festivals, nightclubs, etc. The post-processing of the data gathered at the pilot events enabled the team to offer advice on the types of buildings, events and occupant behaviour that present the greatest risk of transmission and, conversely, those where risk was relatively low. Researchers held weekly meetings with the Events Research Programme scientific advisory board, which then advised the government on the safe reopening of society, what capacity to run spaces at, what kind of seating

7 DCMS, BEIS and HSC organised Events Research Programme aimed to examine the risk of transmission of COVID-19 from attendance at events and explore ways to enable people to attend a range of events safely. To achieve this, the programme explored how a combination of testing and non-pharmaceutical interventions can inform decisions on safely lifting restrictions at events. Numerous research groups across the UK contributed to the programme.

configurations were safe to get back to and what was not safe. For example, nightclubs were the last type of venue to reopen in July 2021, because the research showed that ventilation was poor in those spaces compared to shops, retail spaces or sports venues, which reopened sooner.

Another example of the research providing evidence-based solutions and guidance is the **guidance to the building designers and operators** through the Chartered Institution of Building Services Engineers (CIBSE), a partner in the AIRBODS project. CIBSE is a professional organisation guiding services engineers and facilities managers on how to operate buildings. It is the primary source of expertise for the building services industry in the UK. The findings on transmission in the built environment might be difficult to interpret and partnership with the CIBSE helps to disseminate the findings appropriately. In 2022, the project will finalise, with CIBSE and DCMS, identified as the best dissemination channels. At the time of writing, researchers are developing a guidance tool that building owners could use to insert building characteristics (number of windows, ventilation rates, occupancy, etc.) and calculate transmission risk. The tool and dissemination through appropriate dissemination channels are likely to significantly improve understanding of transmission rates and their reduction among UK building operators.

The **Co-Trace** project quantified the risk of airborne COVID-19 transmission in schools and evaluated the mitigation measures. Researchers conducted both laboratory-based experiments and field studies in schools to understand the flow patterns responsible for airborne transmission. They also investigated the changes to ventilation, use of screens, classroom layout and occupancy patterns and their impact on transmission. In the lead up to winter 2020/2021, researchers used historical data on the carbon dioxide levels provided by one of the companies included in the partnership. They found significant seasonal variation, with January being nearly twice as risky as July. Seasonal variations in risk are due to changes in ventilation rates. Findings had significant implications for policy guiding school operations during the upcoming school year. The team summarised findings in several academic papers, and researchers had regular meetings with the Department for Education (DfE) to explain their findings.

Evidence from the Co-Trace project looking at the virus transmission in classrooms supported the Department for Education decision to **buy 386,000 CO2 monitors for the England schools to monitor the air quality in the classrooms**. Researchers used CO2 levels as a proxy for transmission risk, and the findings showed that CO2 levels are higher in winter. Researchers found that airborne infection risks can be reduced by increasing outdoor air supply through increased ventilation and assessed adequate ventilation levels. The findings implied the need to monitor the CO2 levels and adjust ventilation in case of too high CO2 concentration. Similarly, as in the case of the AIRBODS project, researchers held weekly meetings with the people at the Department for Education responsible for providing advice to the DfE Chief Scientific Adviser (CSA). They discussed introducing CO2 monitors in detail during these meetings. The CSA advised the Secretary of State for Education, who decided to buy the CO2 monitors. Researchers also provided guidance on the specifications for the CO2 monitors and what fraction of England classrooms the department should deliver the monitors to. Again, the research evidence was crucial to support the decision and feed into the guidance that the Department provided to schools on how to use the CO2 monitors. For example, findings on optimal CO2 levels fed into guidance instructing schools to increase ventilation when certain CO2 levels are exceeded.

Co-Trace researchers identified a lack of official support for teachers using CO2 monitors. The Co-Trace project therefore developed the CoSchools website containing various easy to read materials in text and video format **explaining how CO2 monitors can help teachers manage classroom ventilation**. The website supported the rollout of the CO2 monitors by providing

guidance. Because a third party and not the government had developed the CoSchools website, the Department for Education could not disseminate it. Therefore, researchers who saw that schools did not have sufficient understanding of how to use the CO2 monitors reached out to leading teaching unions, major news outlets, and some action groups, and e-mailed individual schools. The feedback from schools was positive. In this way, the ability to deliver evidence-based guidance to improve air quality in schools significantly supported the government's rollout of the CO2 monitors.

D.3. Contribution analysis: UKRI's role

The UKRI supported and facilitated the convening of projects submitted to the UKRI Agile Call on topics relevant to policy decisions and responding to the pandemic. UKRI had a list of areas the research should be targeting, and proposed projects had to fit under those headings. UKRI supported projects that had relevant partners/users on board from the start of the project or required the applicants to make sure such partnerships were established. EPSRC worked closely with the PIs at the submission stage to ensure that the research fitted priority areas and that impact was at the heart of the projects. For the Agile R&I Calls, EPSRC portfolio managers were more engaged than usual in shaping applications to meet the objectives of the call. The exchange happened rapidly at the point of submission but before the assessment. This was to ensure the projects had the right partners on board and an understanding of how to achieve tangible impacts in a short time. In a sense, UKRI tried to create a different mindset – re-focusing from academic impact to policy impact.

UKRI had a significant role in establishing the links and coordinating with various government departments and SAGE regarding what research was most relevant. They also supported initiatives that facilitated partnerships or identification of relevant research areas. For example, UKRI provided a scientific networking grant to the Royal Society initiative RAMP (Rapid Assistance in Modelling the Pandemic) that brought together modellers from different disciplines to assist in the pandemic and who maintained links with SAGE. The UKRI grant facilitated them to hold meetings, and workshops and encouraged information exchange. This proved important in preventing duplication of projects and maximising contributions. For example, Professor Cook found out through this network that a proposed project on schools would be duplicative and UKRI was able to redirect his efforts to the Events Research programme where it added substantive value.

Similarly, the Co-Trace project's thematic focus primarily benefited from RAMP guidance. Several researchers were active in RAMP Task 7 on environmental and aerosol transmission. It was out of that that they thought about several specific places where transmission may be important, and the groups might be vulnerable. But it was not only RAMP that informed the thematic focus of the Co-Trace project. For example, before the pandemic, researchers had already looked at air quality in schools in the scope of the Natural Environment Research Council Clean Air programme funded TAPAS (Tackling Air Pollution at School) network. Experience within the TAPAS network also showed the need to involve schools in the project to enable observation and monitoring in schools. From the expertise of TAPAS, researchers knew it was difficult to access schools, and they approached schools early on, before the start of the project. They approached school senior leaders to get them involved and explored if they would be interested, what they could commit to, and what would be an issue. Previous lessons from TAPAS' work and early engagement enabled close collaboration with schools, which was crucial for the project implementation.

Besides the UKRI role, the Events Research Programme coordinated by DCMS, BEIS and DHSC and delivered by several research groups across the UK was an important source of evidence for the decision-makers. The AIRBODS project contributed to the Events Research Programme

efforts but was not the only source of evidence leading to the decision of re-opening the events industry.

D.4. Barriers and challenges

As demonstrated above, all four awards achieved significant outcomes and impact, and there were no critical barriers prohibiting impact achievement. However, researchers faced several challenges working with non-academic partners, especially in terms of open dissemination of findings. In one case, the timing of funding decisions also slightly complicated the achievement of impact. Finally, two PIs also observed and reflected on the challenges of rapid funding for early career researchers.

While close partnerships with policymakers and other research users were crucial to achieving the impact, the **close collaboration with non-academic partners was not without challenges**. For example, the two transport awards faced difficulties with the time-consuming establishment of data agreements with transport operators. They had to establish the agreements because the transport operators shared sensitive data such as CCTV recordings. As a result, they could not start the work before data agreements were in place, which led to a delay of around 3-4 months. However, eventually, this did not negatively affect impact achievement but rather was a complication for the researchers as they had to complete certain tasks very fast.

Further, there were some challenges and risks in terms of **openness of research findings**. If a partnership relies on a single organisation providing, for example, access to a specific environment to collect samples, then any difficulties or delays in ensuring the access or data use can delay all project progress or completion. In one award, because the research relies on data and an environment controlled by the partner organisation, the partner made decisions about the public availability of publications outlining research findings. In this case, the PI believes all findings will eventually be made public. Still, the partners' data ownership leading to their authority in deciding if the findings can be made public can be in tension with researchers' principles of public dissemination of their research findings. If the research user limits the publication of findings, it can be challenging to achieve academic impact. Also, another PI reported having to receive ministerial approval for the academic paper based on project findings before it could go to publication.

Difficulties with disseminating the findings were also present in another award. Despite an overall positive collaboration with the DfE, supporting the decision to introduce the CO2 monitors in the UK schools, Co-Trace researchers had to spend a lot of time on dissemination activities to inform schools about the website providing guidance on monitor use. This meant a lot of work for the researchers – they had spent weeks contacting all the unions and action groups, news outlets, and directly approaching schools because the DfE could not centrally disseminate the website researchers had developed. The lack of central distributions also means that the research and guidance it provided have achieved less impact than it might have.

Finally, several PIs pointed out that it was challenging **to communicate sensitive findings with the potential for significant impact to the users and the broader public via media**. It is crucial to avoid misinterpretation of the findings, highlighting limitations and assumptions in an understandable way to the public. This applies to communication with the partners, the project stakeholders, and the media and the general public. Therefore, some PIs expressed the need for some training, support or general guidance on research communication and talking to the media for the award holders working on potentially sensitive topics with a far-reaching impact.

Two projects reported **problems with the funding application and decision processes**. This did not result in difficulties achieving impact in either case. But researchers had to complete work in short timelines to compensate for time lost due to slow application and decision processes. In one case, the PI of the award felt the application documentation for the UKRI Agile R&I Call was unnecessarily long and shorter, more to-the-point forms would help save time and arrive at funding decisions faster. Researchers waited for five months for the funding decision in the other case. When they finally found out about the funding, researchers had to work very hard to complete everything on time. They worked for seven days a week to meet the schedule of their work programme and to be able to deliver findings that were expected to be (and eventually were) relevant for soon to come government decisions on re-opening public events. If they had had the funding announcement earlier, it would have given a much more reasonable work timeframe. Other award holders reported that although the decisions for their awards were not as delayed as in the case above, they expected the process to be faster, and their partners were very keen to start the research as soon as possible.

Several teams had **delays in achieving scientific impact** because of the practical focus and need to deliver evidence to the government rapidly. Delivering findings fast meant almost no time for scientific conferences and writing academic articles. These activities are postponed to the final stages of the awards or will be completed once the projects end. This has no significant implications for the ability to achieve scientific impact or for the careers of the PI's. However, several PIs pointed out that this is **problematic for the early career researchers**, especially post-docs and their career development. While they had the opportunity to be part of very impactful work, the short duration of awards means they cannot take research to conferences and develop academic publications – both crucial for career progression. According to Professor Noakes, there should be more follow-ups with early-career researchers involved in rapid response as they will be the next generation responding to the crisis in the future. Still, most of them were employed for a short duration and went on to look for other opportunities without a systemic follow-up. As suggested by consulted PIs, UKRI could conduct a survey of early-career researchers inquiring about the effect of the pandemic on their career progression.

D.5. Sources

D.5.1. Documents

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- Track (2022). TRACK (Transport Risk Assessment for COVID Knowledge). Available: https://track-project.org.uk/
- UCL Department of Civil, Environmental and Geomatic Engineering (2022). UCL VIRAL: Reducing the Risk of Virus Transmission on London's Public Transport Vehicles. Available: https://www.ucl.ac.uk/civil-environmental-geomatic-engineering/research/groups-centres-and-sections/hirg/ucl-viral-reducing-risk-virus-transmission-londons-public
- UKRI award EP/W002779/1: Airborne Infection Reduction through Building Operation and Design for SARS-CoV-2 (AIRBODS). Available: https://gtr.ukri.org/projects?ref=EP%2FW002779%2F1#/tabOverview
- UKRI award EP/W001411/1: COVID-19 Transmission Risk Assessment Case studies – education establishments. Available: https://gtr.ukri.org/projects?ref=EP%2FW001411%2F1
- UKRI award: EP/V026895/1: COVID-19: Reducing the Risk of Transmission on London's transport vehicles. Available: https://gtr.ukri.org/projects?ref=EP%2FV026895%2F1#/tabOverview

D.5.2. Interviewees

- Interview with Stephanie Day, EPSRC Senior Portfolio Manager, conducted on 17/03/2022.
- Interview with Dr Lena Ciric, University College London, VIRAL project Principal Investigator, conducted on 31.03.2022.
- Interview with Dr Malcolm Cook, Loughborough University, AIRBODS project Principal Investigator, conducted on 01.04.2022.
- Interview with Dr Henry Burridge, Imperial College London, Co-Trace project Co-Investigator, conducted on 06.04.2022.
- Interview with Dr Catherine Noakes, University of Leeds, TRACK project Principal Investigator, conducted on 07.04.2022.
- Interview with the Department for Transport, COVID-19 Science Cell representative, conducted on 11.04.2022.

D.5.3. Annex

Table 6 Overview of the awards

Organisations (lead in bold)	**COVID-19 award title**	**UKRI award size**	**Other funding (if applicable)**
University College London University of Leeds Transport of London	**COVID-19: Reducing the Risk of Transmission on London's transport vehicles (VIRAL)**	£535,584	
University of Leeds Cambridge University Imperial College London Newcastle University Public Health England Defence Science and Technology Laboratory Department for Transport	**TRACK: Transport Risk Assessment for COVID Knowledge**	£1,374,632	
University of Cambridge University of Surrey Imperial College London University of Southampton Arup Group Ltd Public Health England	**COVID-19 Transmission Risk Assessment Case Studies – Education Establishments (Co-Trace)**	£2,314,899	

Defence Science & Tech Lab DSTL Gilberts (Blackpool) Ltd SIR Norman Foster & Partners Department for Education Monodraught Ltd Bar Hill Community Primary School Guildford Borough Council Willowfield School Cundall Johnston & Partners Elangeni School Hoare Lea St Thomas of Canterbury Primary School Volution Ventilation UK Limited Chestnut Lane School Attigo Academy Trust Churchfield Primary School			
Loughborough University University College London University of Cambridge University of Nottingham University of Sheffield London South Bank University Chartered Institution of Building Services Engineers	**Airborne Infection Reduction through Building Operation and Design for SARS-CoV-2 (AIRBODS)**	£1,256,284	Events Research Programme
	Total:	**£5,481,399**	

Table 7 Key outputs

Award	Key outputs (up to April 2022)
COVID-19: Reducing the Risk of Transmission on London's transport vehicles (VIRAL)	Malki-Epsthein, L., Stoesser T., Ciric, L., Stubbs, A., Tyler, N. (2020). Report on Scientific advice to TfL on bus driver assault screen modifications due to the Covid-19 pandemic. Available: https://www.ucl.ac.uk/civil-environmental-geomatic-engineering/sites/civil_environmental_geomatic_engineering/files/tfl_drivers_cab_modifications_ucl_full_report_2020-10-28_0.pdf Contributions to two SAGE Environmental Modelling Group reports. Several journal articles in preparation. Regular (bi-monthly) presentations of findings in project Policy Steering Committee meetings.
TRACK: Transport Risk Assessment for COVID Knowledge	Regular (weekly) meetings with the Department for Transport to communicate emerging findings. Two policy reports for the Department for Transport (not publicly available). Journal articles (others in preparation): Miller, D., King, M. F., Nally, J., Drodge, J. R., Reeves, G. I., Bate, A. M., Noakes, C. J. (2022). Modelling the factors that influence exposure to SARS-CoV-2 on a subway train carriage. Indoor air, 32(2), e12976. Regular (bi-monthly) presentations of findings in project Policy Steering Committee meetings.
COVID-19 Transmission Risk Assessment Case Studies – Education Establishments (Co-Trace)	Regular meetings with the Department for Education to communicate emerging findings and recommendations. Co-schools website for schools: https://www.coschools.org.uk/ Journal articles: Burridge, H. C., Fan, S., Jones, R. L., Noakes, C. J., Linden, P. F. (2021). Predictive and retrospective modelling of airborne infection risk using monitored carbon dioxide. Indoor and Built Environment. https://doi.org/10.1177/1420326X211043564 Kumar, P., Omidvarborna, H., Tiwaria, A., Morawska, L. (2021). The nexus between in-car aerosol concentrations, ventilation and the risk of respiratory infection. Environment International. https://doi.org/10.1016/j.envint.2021.106814

	Sharma, A., Omidvarborna, H., Kumar, P. (2021). Efficacy of facemasks in mitigating respiratory exposure to submicron aerosols. Journal of Hazardous Materials. https://doi.org/10.1016/j.jhazmat.2021.126783 Vouriot, C. V. M., Burridge, H. C., Noakes, C. J., Linden, P. F. (2021). Seasonal variation in airborne infection risk in schools due to changes in ventilation inferred from monitored carbon dioxide. Indoor Air, 31 (4), pp. 1154-1163. DOI: 10.1111/ina.12818
Airborne Infection Reduction through Building Operation and Design for SARS-CoV-2 (AIRBODS)	Regular meetings with the Department for Digital, Culture, Media&Sport and Events Research Programme board to communicate emerging findings and recommendations. Department for Digital, Culture, Media&Sport (2021). Events Research Programme Phase 1 Findings. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/998312/ERP_Phase_1_Report__accessible_.pdf Journal articles (others in preparation): Jones B., Sharpe P., Iddon C., Hathway EA, Noakes CJ, Fitzgerald, S. (2021). Modelling uncertainty in the relative risk of exposure to the SARS-CoV-2 virus by airborne aerosol transmission in well mixed indoor air. Build Environ. DOI: 10.1016/j.buildenv.2021.107617

Appendix E Case study 4: Economic recovery

Case study 'Economic Recovery' summary

The case study showcases the outcomes and impacts achieved by six UKRI-funded awards in social sciences. UKRI-funded research was relevant for evidence-informed introduction, design and understanding of the Coronavirus Job Retention Scheme (furlough), informing monetary policy decisions, understanding the impact of lockdowns, and informing on socioeconomic effects of lockdown easing. All these policy areas benefited from timely new data and knowledge to support decisions and understand the impact of the pandemic and specific measures. Historical research and innovation investments and outputs, the design and processes of the UKRI Agile Call and the UKRI convening role facilitated rapid research and findings relevant to policymakers. Additional research funding (e.g., university and other funding) was also an important impact driver.

E.1. Introduction and description of awards

Social science research was crucial in response to COVID-19, providing insights and seeking solutions to socioeconomic challenges caused by the pandemic. UKRI-funded social science research in response to COVID-19 covers many topics (UK Research and Innovation, 2021). **This case study focuses on the role of UKRI funded research in understanding the impact of pandemic control measures (lockdown), influencing the design of government economic and job support schemes, and providing real-time evidence of the effectiveness and impact of these schemes**. The specific policy measures informed by the research are the COVID-19 Job Retention Scheme (CJRS/furlough) and Bank of England monetary policy decisions on adjusting interest rates and asset purchases. The research also contributed to understanding the impact of lockdown and informed lockdown easing.

Annex E.6 Table 8 summarises the six awards, award size and other funding used to complete the research.

- Two awards provided timely **household and businesses survey data** to support the pandemic response. Of note, neither were introduced in response to the pandemic but were longitudinal surveys functioning long before and thus representing long term or historical investments by UKRI. Both surveys introduced additional data collection in response to the pandemic.

- **Understanding Society** is a household panel study addressing key scientific and policy questions. It collects high quality annual longitudinal data on individuals of all ages in households' representative of the UK population. The Institute for Social and Economic Research (ISER) at the University of Essex leads the Understanding Society study. In April 2020 Understanding Society launched a COVID-19 survey focusing on questions relevant to understanding the pandemic.
- The other survey focuses on businesses: the **Decision Maker Panel (DMP)** is an international collaboration delivering a representative monthly online survey of over 9,000 executives from small, medium, and large UK companies. It explores questions on current policy issues and insights into companies' perceptions of challenges and opportunities facing the UK economy. DMP's initial work focused on Brexit, and in 2020 the focus of attention shifted towards COVID-19. The University of Nottingham, the Bank of England and Stanford University established the DMP in 2016. The University of Nottingham hosts the DMP Analyst Team. Professor Paul Mizen (University of Nottingham) is the principal investigator (Decision Maker Panel, 2022). In 2021 the DMP won the Economic and Social Research Council (ESRC) Celebrating Impact Prize, recognising research excellence and societal impact.
- Two awards conducted **economic modelling**:

- The **Institute for Fiscal Studies (IFS)** is an independent microeconomic research institute and has conducted numerous studies relevant to the response to COVID-19. ESRC provides funding to the IFS via the ESRC Centre for the Microeconomic Analysis of Public Policy. In this case study, we focus on Professor Nesheim, who led a UKRI award on modelling the effects of pandemic control measures and financial support on businesses, regions and households. The research aimed to develop two complementary models to support policy decisions. One model aimed to assess the impacts of specific policy interventions. The other focused on estimating consumer behaviour to understand lockdown effects on households' spending decisions and living standards.
- The UKRI award provided to the **National Institute of Economic and Social Research (NIESR)** focused on modelling the effects of lockdowns. NIESR is an independent research institute that conducts economics research and is a significant partner for government economic policy decision-makers. In this case study, we focus on the UKRI award led by Dr Young on modelling the impact of COVID-19 on the UK economy. Researchers aimed to design a sectoral model to understand the spillover effects of the pandemic control measures across different industries.

Finally, this case study covers two awards focused on the pandemic's **impact on workers and gendered effects**.

- **The University of Oxford** received a UKRI award to analyse the impact of COVID-19 on economic inequality and employment progression. Led by Professor Adam-Prassl, researchers sought to provide timely information about the emerging effects of the crisis and collected novel survey data from a representative sample of UK workers to understand the effectiveness of different policies (UKRI award ES/V004042/1).
- **King's College London** researchers led by Professor Cook aimed to fill the gap in understanding of how pandemic response policies can include gendered perspectives. It explored whether the UK social policy response is gender-sensitive in design, access, and impacts (UKRI award E S/V009370/1).

E.2. Main results (outputs, outcomes, impacts)

E.2.1. Introduction, adaptation of the design and understanding of the COVID-19 Job Retention Scheme

On 20 March 2020, the UK government announced the COVID-19 Job Retention Scheme (CJRS). The scheme's purpose was to provide grants to employers to ensure that they could retain and continue to pay staff, despite the effects of the COVID-19 pandemic. The CJRS initially applied from 1 March to 30 May 2020 and, following several extensions, lasted until 31 October 2020 (House of Commons Library, 2021b). The CJRS was a new policy instrument for the UK and implied significant public spending and evidence on the labour market and the scheme's effects was therefore crucial.

Several quantitative indicators illustrate the relevance of the scheme in preventing job loss. It **supported 11.7m jobs and 1.3m employers**. In January 2021, **41% of eligible employers had staff on furlough** (HM Revenue and Statistics, 2021). It is concluded that this policy response **supported economic output and helped avoid firms' failure**. CJRS **protected workers' incomes and maintained capacity** (Barnes et al, 2021). However, the scheme was not without its weaknesses and UKRI-funded social science research has pointed to some of those.

Among other sources of information, business's survey DMP data were relevant as robust and timely evidence that a mechanism like CJRS might be necessary. DMP data showed that the spread of COVID-19 had created a significant new source of concern for firms, who reported expecting COVID-19 to impact on sales, employment and investment. The DMP survey was in

the field in early March and showed business concern increasing day by day. DMP sent industry-level data to government departments, and the data illustrated the pandemic impacts on overall business uncertainty and the impact on different sectors. For example, data showed a significant negative impact (e.g., around 80% decrease in sales) on hospitality, passenger transport, and non-essential retail sectors of the economy. Among other sources and considerations, the DMP near real-time data helped decide on and justify the introduction of the CJRS. The DMP started the UKRI COVID-19 response funding award in May 2020; therefore, the DMP data relevant to introducing the CJRS built on historical UKRI support for the DMP.

Professor Adams-Prassl led an award looking at the impact of COVID-19 on economic inequality and employment progression that provided a strong message to the government about the need for flexible furlough. The initial design of the furlough was binary – employees were prohibited from working whilst furloughed or had to work full/usual hours if not furloughed. According to the research, this binary nature was potentially leading to fraud, and it was inefficient because many workers could work part-time from home. According to the survey researchers conducted in April and May 2020, 19% of employees reported being explicitly asked to work by their employer despite being furloughed. Researchers also looked at the experience in other countries. Other countries had used similar schemes before and had introduced the measures again in response to the pandemic. Adams-Prassl led researchers highlighted that similar schemes in other countries showed that the instrument design allowed flexible reductions in hours. The research (among other evidence) informed the change in the design of the CJRS. The UK scheme changed in July 2020 when the government adjusted furlough to be flexible, and employers could bring furloughed employees back to work and claim subsidies for typical hours not worked by an employee. Research not only informed the design of the change but provided longer-term lessons for future UK policy, concluding that the policy should allow employees to work part-time from the scheme's introduction (Adams-Prassl et al, 2020a).

The research feeding into the decision to make CJRS flexible is not documented in writing. It fed into policymaking through several meetings researchers had with HM Treasury, the National Audit Office, the cross-Whitehall labour market group, the Department for Business, Energy and Industrial Strategy (BEIS) and the Department for Work and Pensions (DWP). All meetings happened during the early summer of 2020 to inform their analysis and policy proposals. For example, the National Audit Office was concerned about the misuse of the CJRS and Professor Adams-Prassl provided feedback to the National Audit Office's internal methodology and survey investigating the misuse. Also, according to Professor Adams-Prassl, policymakers considered their paper on furlough which pointed to the need for a flexible scheme. One of the HM Treasury special advisors approached Professor Adams-Prassl based on her appearance on the Vox podcast discussing the topic. Other research groups provided similar evidence, for example, the Resolution Foundation and IFS, which made the evidence stronger.

Furthermore, several UKRI R&I COVID-19 awards covered in this case study aided understanding of how the CJRS worked, the impact of the scheme and how the government could improve it in the future. In particular, the research was relevant to understanding the impact on household income and the gendered effects of the CJRS.

Understanding Society and the two awards focusing respectively on **gendered effects** (led by Dr Rose Cook) and economic inequality and employment progression (led by Dr Adams-Prassl) were relevant to understanding the impact of the CJRS. Professor Adams-Prassl was invited to give verbal evidence to the Women and Equalities Select Committee in July 2020 and became a Specialist Advisor to the Committee in September 2020. She actively engaged with the committee in drawing together the emerging evidence base on gender inequality in the

economic impact of the pandemic. Professor Adams-Prassl provided ideas for potential changes in scheme design to better address gender inequality.

The House of Commons Women and Equalities Committee report analysing the Coronavirus gendered economic impact refers to UKRI-funded awards. The report references US data showing the proportion of women on furlough and employment trends during the lockdown. The report also quotes work led by Professor Adams-Prassl that showed that women were more likely to be furloughed or lose their jobs, especially if they were on zero-hours contracts (House of Commons, 2020). The UKRI-funded research helped the parliament scrutinise the effect of the pandemic and CJRS in particular. However, the House of Commons Women and Equalities Committee reports that drew on the research did not further feed into any policy change.

The above findings and those of another gender-focused award led by Dr Cook also had a comparative perspective. The findings of Dr Cook's work suggest that although some countries' schemes have features that help women, most may disadvantage women by design due to gaps in eligibility/access and inadequate support. It suggests potential gender bias and a lack of gender mainstreaming within one of the primary policy tools implemented in response to the pandemic. In terms of CJRS, researchers also found that men returned to their previous working hours at a higher rate than women after having access to furlough. Women who had accessed furlough also had lower perceived job security than men. Dr Cook reports that the workshops organised by the researchers have created a community of scholars and policy actors interested in how the pandemic affects women. They also received further funding (ESRC Impact Acceleration Account) to work with the International Labour Organisation and established a network of stakeholders in social policy and gender in different European countries. The network showcases the evidence and policy examples to build momentum for these policy issues.

Understanding Society data were relevant for understanding the CJRS impact on **household incomes**. HM Treasury used Understanding Society COVID-19 survey data to complete a distributional analysis of the impact of COVID-19 on working household incomes. The modelling showed that household income for the lowest decile increased slightly in May 2020, compared to February 2020, due to CJRS and other programmes. HM Treasury used the Understanding Society data and their model to estimate what would have happened to households' income if the CJRS had not been introduced. This showed that on average, household income for people who benefited from CJRS would have fallen by almost 20%, risking moving them into poverty (HM Treasury, 2020). HM Treasury also used the Understanding Society data for the distributional analysis of the 2021 budget, and this modelling showed that government interventions supported the poorest working households the most (HM Treasury, 2021). HM Treasury used Understanding Society data because it contained detailed information on individual and household characteristics relevant to the HM Treasury distributional analysis of the impact on household incomes.

E.2.2. Informing monetary policy decisions

DMP and Understanding Society were relevant for evidence-informed approaches to responding to and recovering from the pandemic by justifying monetary policy decisions such as interest rate cuts and increases in funding schemes and asset purchases by the Bank of England. It led to cheaper borrowing for households and businesses, encouraging companies to employ people and invest. DMP and Understanding Society data influenced the Bank of England decision to slightly increase the interest rates to manage inflation at the end of 2021.

The DMP provided near real-time data about business performance relevant to decision making. In particular, the Bank of England used the DMP and Understanding Society data to inform the work of its Monetary Policy Committee (MPC) and the Financial Policy Committee.

The Bank of England MPC sets monetary policy to keep inflation low and stable. The MPC does that by, for example, setting interest rates that banks and building societies earn on deposits. In response to the pandemic and to support the recovery, the Bank of England has supported households and businesses through low interest rates and quantitative easing. Lower interest rates mean cheaper loans for households and businesses. This reduces their costs and encourages companies to employ people and invest (Bank of England, 2021a). US and DMP data fed into and justified the MPC decisions on these tools. The Bank of England quarterly Monetary Policy Reports aiming to explain the decisions on interest rates regularly cite DMP data to explain and justify these decisions. All Bank of England quarterly Monetary Policy Reports since the start of the pandemic quote DMP data and evidence on the impact of COVID-19 on businesses and business decision making. For example, MPC refers to DMP data to explain business investment rates in COVID-19 related uncertainty (Bank of England, 2022a).

DMP and Understanding Society data were relevant to signal that the economy was starting to recover from the pandemic and understanding the changes in productivity due to working from home, which might, to some extent, continue after the pandemic. One MPC report (November 2021) refers to Understanding Society and DMP data to understand the implications of working from home for productivity for returning to 'normal'. Understanding Society data showed that workers who wished to work from home more after COVID-19 reported self-perceived greater productivity gains when working from home. Bank of England analysis of the two surveys concluded that working from home could boost productivity by around 0.5%-0.7% (Bank of England, 2021b).

Further to understanding price trends, DMP data also played a part in the Bank of England's decision to slightly increase the interest rates for the first time in three years at the end of 2021 to manage the inflation. The DMP suggested that the inflation threat intensifies and might be persistent because companies reported plans to raise prices. As reported by the Financial Times: "One of the things that has alarmed MPC members most has been the regular discussions it has with businesses across the UK, including via its survey of decision makers in the corporate world." (Financial Times, 2021)

Reduced interest rates aided **cheaper borrowing, encouraged investment and facilitated employment** (Bank of England, 2022b). Monetary policy experts claim that thanks to a timely monetary policy response, among other pandemic control measures such as fiscal stimulus and vaccines, the economic recovery from the pandemic has been fast in relation to stabilisation of financial markets and lessening losses of businesses (Fischer, 2021).

E.2.3. Understanding the impact of lockdown and informing lockdown easing

Two awards covered in this case study provided insights into **understanding the impact of lockdown on the economy and informed decisions about easing lockdown** by modelling the effects on the economy. As a result of the IFS award led by Professor Nesheim, researchers provided a briefing note to the government providing the first **analysis of the causal impact of public health restrictions in the UK on spending**. Researchers provided data on the effect of shutting hospitality and non-essential retail venues on expenditures for categories of goods and services, showing how consumers substitute for different items when restrictions are imposed. Researchers established links with the ONS, discussing with them how the research can potentially help improve some methods they use to analyse particular parts of the economy and the impact of lockdown on the economy. Due to computation difficulties and time-consuming development of further modelling, modelling household expenditure will complete in spring 2022 and has not yet fed into policy decisions.

However, the other model developed with the award - the computable general equilibrium model of the UK economy – has informed the work of KPMG delivering modelling services to their clients in various industries. The KPMG team have incorporated some of the forecasting

ideas into their forecasting methods and is using them to analyse the macroeconomic impacts of COVID-19. KPMG had conversations with a wide range of businesses about modelling the effect of the pandemic and public health measures, particularly the lockdowns. During the pandemic, businesses interested in the impacts were wholesale distributors, chains of coffee shops, energy companies, banks, real-estate firms and several other industries trying to figure out what would happen with their businesses. The modelling tools developed with the award helped KPMG model the effects for at least six business projects in financial services and retail.

Data and analysis from the NIESR award led by Professor Young **informed government decisions on easing the first lockdown**. The sectoral model developed by researchers showed that a supply shock in one sector could spill over to another sector as a demand shock. For example, if manufacturing cannot take place, manufacturing will no longer have demand for the services sector. Researchers calculated that stay-at-home measures that directly reduced GDP by 15 % could reduce GDP by 25 % once spillovers are taken into account. Researchers discussed with BEIS and the Cabinet Office economists the relaxing of some measures and whether any sectors have to be relaxed first because of the spillovers. The government asked what would happen if they relaxed measures in manufacturing or construction and found the model to be helpful. The government economists asked researchers to provide quick input which they included in briefings to 10 Downing Street on the day of the request. The government economists had explained to Professor Young that the sectoral approach modelling formed part of the evidence base, which informed decisions on reopening the economy after the first lockdown. Importantly, economic policymakers can use the model in the future. The sectoral approach might be relevant for the ex-post evaluation of COVID-19 policies or looking at other policy areas, for example, 'levelling up'.

E.3. Contribution analysis: UKRI's role

UKRI's prior investments and activities to facilitate research uptake contributed to impact achievement. Several award holders used previous research outputs and infrastructures that enabled impact. Researchers achieved progress with COVID-19 research based on knowledge and a well-established social science research infrastructure developed over many years. Key examples of this are the IFS, DMP and Understanding Society. One of the reasons why ISER introduced the Understanding Society COVID-19 survey so quickly was the Understanding Society Innovation Panel – a smaller sample of households used by researchers pre-pandemic as a test-bed for innovative ways of collecting data. Previous experimental work with the Innovation Panel provided valuable lessons about which days of the week are best to send the survey out on, at what time and how many reminders to send. Lessons from the previous experimentation with the Innovation Panel were crucial for the COVID-19 survey.

With the support from UKRI, the IFS, DMP and Understanding Society had built links and connections with policymakers over many years, which helped share COVID-19 findings. DMP has had close collaboration with the Bank of England, the Office for National Statistics and many government departments since 2016 for their work on Brexit. Dr Paul Fisher from the ISER had previously presented Understanding Society work to the HM Treasury before the pandemic. As a result, the HM Treasury Labour Markets and Distributional Analysis team reached out to Understanding Society to ask specifically about the COVID-19 survey based on the contacts established at past events.

Both Understanding Society and DMP already had mechanisms in place to consult with the research community and wider stakeholders on the topics of relevance and could be covered by survey questions. For example, another UKRI supported award covered in this case study provided the Understanding Society COVID-19 survey input. Some questions Dr Adams-Prassl and her team used in their survey that started already in March 2020, later were taken up in

the Understanding Society COVID-19 survey. Also, policymakers provided suggestions for the survey questions.

Based on previous experience and established dissemination approaches, Understanding Society provided support and guidance to the data users, enabling smooth data processing and use. For example, interested users can access the COVID-19 data dashboard to build charts based on variables from the COVID-19 study. In addition, Understanding Society prepared several briefing notes – snapshots of Understanding Society data highlighting the key issues and publicising that the data are available. Press releases accompanied the briefing notes. For example, the University of Essex ISER and University of Oxford researchers, whose research used Understanding Society data, informed understanding of the CJRS, published in one of the briefing notes, and this worked as a catalyst for informing the HM Treasury work.

This historical survey (and research using survey data) and dissemination work supported impact generation in two ways. First, researchers introduced the COVID-19 topics very rapidly because the survey mechanism was already functioning and only had to be adjusted. The ability to adapt and rapidly produce data is particularly relevant for the crisis response when policymakers need to access data fast. For example, the DMP survey's rapidity was crucial in achieving impact. The DMP survey is launched on the first day of the month and closes within two weeks. Within two days, DMP then has the data ready for use. The process repeats every month, supplying policymakers with a regular and trusted data source. Policymakers recognised the data source and knew it was reliable because of the historical research and dissemination work.

Previous research outputs and dissemination activities were also relevant for other awards and their ability to achieve impact. For example, Professor Adams-Prassl had received the ESRC Future Research Leaders grant, which supported her research on atypical work and zero-hours contracts. This was a relevant background that helped identify relevant research during the pandemic. Also, many of the contacts used to disseminate the research on the impact on employees came through historical networks that Professor Adams-Prassl had built with the help of the ESRC Future Research Leaders grant. For example, in early 2020, Professor Adams-Prassl and colleagues hosted Department for Work and Pensions (DWP) researchers for a day of discussion around the areas of their research interest. Professor Adams-Prassl sent briefing notes to DWP, and the department invited her to talk at its conferences. This was how they started working with the Cross Whitehall labour market group looking at the impact of CJRS.

Similarly, NIESR used their contacts in BEIS built over many years of NIESR work. They were also talking to BEIS in early March 2020 about how the economy will respond to Covid-19, and BEIS were looking for someone to do the modelling and encouraged the researchers to apply for UKRI funding. These contacts were beneficial because it would have been difficult to feed into policymaking without the pre-existing contacts. Additionally NIESR publishes a quarterly publication that discusses the UK economy and forecast, which is well covered in the UK press and considered by government economists. For example, based on the UKRI funded research modelling work, the May 2020 publication already discussed the effect of spillovers of closing specific sectors during the lockdowns. Researchers incorporated the sectoral modelling in the long-existing National Institute Global Econometric Model, which was a significant pre-existing infrastructure enabling the impact of the COVID-19 award.

Professor Nesheim highlighted the role of ESRC foundational funding for the Centre for Microdata Methods and Practice (CEMMAP) – a joint undertaking between IFS and University College London. Professor Nesheim used the links with ONS built from the previous work of CEMMAP. As a result, Professor Nesheim provided insights of modelling work to the ONS to help them analyse the impacts of lockdown on the economy.

Several projects used Research England quality-related (QR) funding and ESRC Impact Acceleration Accounts Funding to complement Agile R&I Call funding. For example, the University of Nottingham used the Research England QR funding to run the DMP survey a little longer and Impact Acceleration Accounts funding to add additional questions to the survey based on policymakers' interests. Also, the research looking at the gendered effects of the pandemic led by Dr Cook at the King's College London used Impact Acceleration Account funding to support the project website, blogs and workshop series – all relevant for dissemination and achieving impact.

UKRI had several mechanisms to facilitate the dissemination of findings. In spring 2020 ESRC set up an internal Impact and Engagement group, which identified ways for ESRC to connect researchers to policymakers. This resulted in specific mechanisms that several PIs of the awards covered in this study used and found to enable impact. For example, the ESRC Executive Chair met with Chief Scientific Advisers to ensure early social science research findings were highlighted to relevant government departments.

The UKRI and the Government Social Research Profession also organised the "Actionable Insights" seminar series. The seminar series provided a platform for UKRI-supported researchers to present their COVID-19 research findings to policymakers and analysts across the government. The seminar series was well-received, with 90% of attendees reporting being satisfied or very satisfied. Two PIs of the awards covered in this case study presented their findings in these seminars. DMP PI Professor Paul Mizen took part and presented DMP data in the seminar on economic impacts and recovery, focusing on insights on business resilience and how different sectors had been affected. Professor Nesheim presented at the levelling-up seminar, where he outlined findings on the impact of geography and region on fiscal responses to COVID-19. Both received follow-up inquiries from policymakers attending the seminars.

Finally, UKRI funded projects to synthesise evidence, such as the Economics Observatory and the International Public Policy Observatory. The Economics Observatory aims to bridge the gap between academic research, government policy and the general public. It organises events and publishes articles and videos that aid in understanding the pandemic and the challenges of recovery. DMP PI Professor Mizen found the Economics Observatory to be relevant for disseminating the evidence from the DMP survey. It provided a platform to publish results quickly, and Professor Mizen reported that a policymaker from the Cabinet Office approached him with interest in DMP data based on the information provided by the Economics Observatory.

There were several instances when award holders benefited from other research funding, either public or private, and that funding acted as a multiplier and facilitated the impact achievement. In some instances, funding (or expected funding) from UKRI helped to mobilise additional funding. For example, the Understanding Society COVID-19 study received funding from the Health Foundation, which provided funding early on to conduct two telephone surveys on mental health, which was of particular interest to the Health Foundation.

Institutional funding from universities supplemented UKRI funded research in two cases. University College London provided additional funding to support modelling work led by Professor Nesheim. Researchers used the funding to cover staff costs related to extra effort due to computation difficulties and time-consuming modelling of the lockdown effects, allowing researchers to complete work and potentially produce impact in the future.

Professor Adams-Prassl received seed funding from her department at the University of Oxford to be able to launch the labour market survey in March 2020 before the UKRI Agile Call was open. The first surveys came out two days after the UK went into lockdown, in late March 2020. This helped facilitate the impact – researchers were being contacted by the media and by people in government. They realised they should scale up and later (in April 2020) applied for

UKRI funding. This example illustrates the role of university funding in providing resources rapidly to answer urgent and policy-relevant questions and points to the need for government emergency response funding to be available as early on in the crisis as possible. Also, the Cambridge Keynes Fund complemented this UKRI award by paying for research assistants to help with survey preparation. When applying for the first UKRI Agile Call, researchers were unsure about the funding amount to request and the chances of success if they asked for a larger budget. Acknowledging the potential relevance of this research, researchers decided to underbudget researchers' time to increase the likelihood of receiving funding. However, this later meant a need to find additional resources. This highlights a lesson for the future for the need for an emergency funding scheme as part of the funding system that researchers can recognise (know its rules) and rely on in case urgent research is needed.

E.4. Barriers and challenges

Researchers faced some methodological challenges that either complicated impact achievement or delayed it.

There can be tensions between ensuring robust research methodology and the quest for rapid findings relevant to policymaking. As explained in the previous section, DMP and Understanding Society made an effort to understand the research community and policymakers' needs and interests regarding what survey questions to ask. There was significant interest in covering various topics and nuanced questions; however, they could not include all topics while also ensuring survey robustness and meeting time limits. As a result, significant sifting took place to arrive at a limited list of questions. This might have left some topics of interest out, though the widespread use of both surveys data means that the topical coverage still met the needs of many data users.

The IFS award on modelling the impact of lockdown also faced methodological challenges – to ensure modelling robustness, research took more time than anticipated, which delayed impact. Researchers applied a modelling approach that has not been used for a crisis on the pandemic's scale, and it turned out to be more time-consuming than anticipated, delaying model completion and feeding into policymaking. At the time of writing, it is expected the findings will be presented by mid-2022 and might be relevant for scrutinising the policy in the future.

Finally, the research does not always lead to a change in policy, even if policymakers consider it. The example of the research on gendered effects of the pandemic shows that the House of Commons hearings and reports heavily relied on the research findings. But there may be other factors that play a role in policy decisions, and eventually, the findings did not lead to a specific change in policy.

E.5. Sources

E.5.1. Documents

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A.1.1. Interviewees

- Interview with Charlotte Sausman, ESRC Senior Research Advisor and Sophie Martin, ESRC Strategic Lead for the Economic Performance and Environment portfolio, conducted on 15/03/2022.
- Interview with Paul Mizen, University of Nottingham, Decision Maker Panel Principal Investigator, conducted on 23/03/2022.
- Interview with Chris Coates, University of Essex, Understanding Society impact manager, conducted on 25/03/2022.
- Interview with Lars Nesheim, University College London and Institute for Fiscal Studies Principal Investigator, conducted on 28/03/2022.
- Interview with Abigail Adams-Prassl, University of Oxford, Principal Investigator, conducted on 07.04.2022.
- Interview with Dr Garry Young, National Institute of Economic and Social Research, Principal Investigator, conducted on 12.04.2022.

E.6. Annex

Table 8 Overview of awards covered in the case study

Organisations (lead in bold)	**COVID-19 award title**	**UKRI award size**	**Other funding (if applicable)**
University of Nottingham Office for National Statistics IFF Research The Bank of England Stanford University London School of Economics & Political Science	Measuring the effects of Covid-19 on businesses and the UK economy (Decision Maker Panel)	£667,485	-
Institute for Fiscal Studies	Modelling the effects of pandemic control measures and financial support on businesses, regions and households	£135,210	UCL funding for staff costs related to extra effort
University of Essex	Understanding Society COVID-19 survey	£1.4m	£208,000 (Health Foundation)
National Institute of Economic and Social Research	Modelling the Impact of the Coronavirus Pandemic on the UK economy	£66,309	-
University of Oxford	The Impact of COVID-19 on Economic Inequality and Employment Progression	£69,235	£10,000 (University of Oxford Department of Economics)
King's College London	Gendering the UK's social policy response to the COVID-19 crisis	£69,245	-
	Total:	**£2 407 484**	

Source: Gateway to Research and consultation with award holders

Table 9 Key outputs and output indicators

Award	**Key outputs (up to April 2022)**
Decision Maker Panel	Rapidly generated monthly aggregate survey data summaries Around 30 research publications (e.g., conference papers, discussion papers, etc.) 11 blog posts Eight presentations in international conferences

Award	Key outputs (up to April 2022)
Understanding Society COVID-19 survey	Rapidly generated UK household survey COVID-19 study datasets (more than 2000 downloads of the datasets) Several economic briefing notes prepared by US team 145 academic papers, six books, 11 parliamentary papers, 73 reports, and 18 working papers using US data that mention COVID-19 directly
IFS award on modelling the effects of pandemic control measures and financial support	Model providing understanding of the pandemic and lockdown policies impact on household finances across the UK Davenport, A., Joyce, R., Odgen, K., Phillips, D., Rasul, I., Waters, T. (2020). The geographic impact of the pandemic on household spending. IFS Briefing note. Levell, P. (2021). Consumption spending in the wake of the pandemic. IFS Briefing note.
NIESR award on modelling the impact of the pandemic on the UK economy	• Sectoral approach to modelling the UK economy incorporated into the NIESR National Institute Global Econometric Model • Küçük, H., Lenoël, C., Macqueen, R. (2021). UK economic outlook: Brexit Britain in Covid recovery ward. National Institute Economic Review, 255, E1. • Lenoël, C., Young, G. (2020). PROSPECTS FOR THE UK ECONOMY. National Institute Economic Review, 252, F10-F43.
University of Oxford award on the impact of COVID-19 on economic inequality and employment progression	Adams-Prassl, A., Boneva, T., Golin, M., Rauh, C. (2020). Inequality in the Impact of the Coronavirus Shock: Evidence from Real Time Surveys. Journal of Public Economics, vol. 189 (Covid SI). Adams-Prassl, A., Boneva, T., Golin, M., Rauh, C. (2020) Furloughing. Fiscal Studies, vol. 41(3) (Covid SI). Adams-Prassl, A., Boneva T., Golin, M., Rauh, C. (2020). Inequality in the impact of the coronavirus shock: new survey evidence for the UK. Cambridge-INET Working Paper Series No:2020/10.
King's College London award on gendering the UK's social policy response to the COVID-19 crisis	Cook, R., Grimshaw, D. (2021) A gendered lens on COVID-19 employment and social policies in Europe, European Societies, 23:sup1, S215-S227. https://doi.org/10.1080/14616696.2020.1822538 Gendering COVID-19 social policy network of international researchers and practitioners working on the COVID-19 policy response

Source: Gateway to Research and information provided by award holders.

Appendix F Case study 5: Healthcare innovations

Case study 'Healthcare innovations' summary

This case study illustrates the outcomes and impacts achieved by five UKRI-funded grants focused on improving healthcare delivery through the commercialisation of innovative products. UKRI's funding has increased UK's medical capability to address COVID-19 and future pandemics by enabling the development of diagnostic testing and supporting the early clinical trial of the DIOS-CoVax vaccine which offers a broad protection against SARS-Cov2 variants and other Betacoronaviruses. The funding has also enabled the smooth management of healthcare services during the COVID-19 pandemic (or future pandemics) by supporting the development of Appt, an automated booking system for healthcare appointments and MedicCom, a device enabling clear communication whilst wearing personal protective equipment (PPE). The innovative technologies described in this case study will have a wide range of applications in addressing other healthcare needs beyond COVID-19. In most cases, the outputs and impacts presented in this case study build upon prior UKRI grants which influenced participants' readiness to respond to the pandemic and deliver rapid outputs.

F.1. Introduction and description of awards

This case study focuses on five UKRI grants that responded to the pandemic by developing a range of innovative healthcare products and processes.

- Two awards address innovative technologies to increase UK's testing capacity for COVID-19:
  - In December 2020, **Attomarker**, a nanophotonic biochemical testing company, received a UKRI grant to commercialise a rapid, multiplexed COVID-19 antibody test indicating whether a person has had the virus or whether their vaccine has produced detectable antibody levels. The project also set out to develop a rapid, saliva-based antigen/antibody test for both COVID-19 and four different strains of the flu. Prior to obtaining this UKRI award, Attomarker had secured philanthropic donations, raised through the University of Exeter, to support the early development and the Medicine and Healthcare Products Authority (MHRA)-approval process of the COVID-19 antibody test.
  - **BiologIC Technologies**, a Cambridge based bio-tech company, received a UKRI grant to develop 3D printed, miniaturised bio-processing units (BPUs) capable of performing complex biological workflows. The project set out to develop application specific BPUs that can detect multiple pathogens and run multiple diagnostic tests in new environments (such as on transport systems). The initial idea behind the product was inspired by the computing information processing revolution and the transition from bulky mainframe computers to tablets and pocket-size phones. This project builds on prior UKRI funding.
- Two awards cover innovative technologies to enable the more effective management of the pandemic and ease the burden on the healthcare system:
  - The first award is led by **Appt-Health**, a digital health social enterprise created by a former GP to improve the accessibility of primary healthcare appointments for patients. In June 2020, the company won a UKRI grant to explore ways in which their existing technology for general practice appointments could be applied to drive the public uptake of COVID-19 vaccination appointments. With this project, Appt-Health aimed to help administer the vaccination programme more efficiently by developing a patient engagement tool integrated into GP practice IT systems. This tool aimed to remove the need for expensive administrative tasks such as making medical appointments via

letters and staff-led phone call, and instead use digital technology, SMS, and automated voice methods.

  - The second award is led by **Project Pitlane**, a non-profit group set up in response to the government's call for urgent help in creating medical devices for the fight against COVID-19. It consists of seven UK-based Formula One (F1) teams (Mercedes, Red Bull, McLaren, Renault, Racing Point, Haas and Williams) and their respective technology arms. Together with the University of Leicester, they received a UKRI grant to develop a communication device (**MedicCom**) designed to amplify the volume of speech and enable clear communication whilst wearing Personal Protective Equipment (PPE). The added functionality of the technology aimed to allow the microphone to connect to personal phones and the hospital internal phone system to enable connections to other departments and ambulance services. The idea of creating the device was born after Professor Tim Coats from the University of Leicester experienced first-hand difficulties of communicating whilst wearing PPE.

- Finally, a UKRI grant to a biotech start-up, **DIOSynVax**, focused on the development of an antigen vaccine that protects against COVID-19 as well as future mutations of the virus, or other similar outbreaks. Traditional vaccines currently available are specific to one virus which puts their effectiveness at risk when viruses mutate to adapt to their surroundings and more effectively move from host-to-host. This project set out to commercialise a next-generation, needle-free vaccine that is more broadly protective against multiple viruses and the large number of mutations found in different variants. Prior to obtaining this UKRI grant, DIOSynVax had obtained funding from the Department of Health and Social Care (DHSC) to support Research & Development (R&D) activities and the development of the vaccine. The company sought UKRI funding to progress to the clinical trial stage and commercialise the vaccine.

Table 10 Description of grants

Ref	Title	Duration	Participants	Grant Value
85395	Multiplexed Covid-19-Flu-20 Antigen-Antibody Testing (COVIDFLU)	Dec 20 – Nov 21	Attomarker Limited	£431,585
84877	Miniaturised transport biosecurity system hardware that is 3D printed, next-generation, data-connected, machine learning with integrated biological configurability	Dec 20 – Jul 21	BiologIC Technologies limited	£99,996
72822	A new innovation in approaching vaccine programme administration and public engagement using accessible digital communication technology at-scale	Jun 20 – Jun 21	Appt-Health Ltd	£301,020
81872	MedicCom - Overcoming the communications barriers caused by Personal Protective Equipment (PPE)	Sep 20 – Mar 21	Project Pitlane Ltd	£125,443
			University of Leicester	£37,128
72845	DIOS-CoVax - A vaccine designed to protect against COVID-19 and future	Aug 20 – Mar 22	DIOSynVax Ltd	£927,899

	Coronavirus epidemics, mitigating antibody enhanced disease.		University of Cambridge	£207,639
			University Hospital Southampton NHS Foundation Trust	£755,519

Source: Gateway to Research

F.2. Main results (outputs, outcomes, impacts)

UKRI's funding has improved the UK's preparedness for future pandemics by supporting innovative products that increase our medical capability and enable the smooth management of the pandemic in healthcare settings. The outputs from these projects provide applications in wider settings for the treatment of other diseases and are expected to provide lasting impacts beyond the COVID-19 pandemic. However, the case study has also revealed the challenges of commercialising innovative products at speed, and while these products hold great promise for the future, to date, they have had a limited impact on the pandemic in terms of reducing the spread of the virus and protecting human health. The sections below outline the key outputs and impacts from the five grants considered in this study.

F.2.1. Innovative products increasing the UK's testing capacity for COVID-19

The UKRI grant to Attomarker aided the commercialisation of a next-generation **multiplexed COVID-19 Antibody Immunity Test.** This test can detect fully quantitative levels of different proteins of the virus[8] and up to three classes of antibodies[9] from a blood sample analysed in seven minutes at the point of care. The technology shows people whether they have developed immunity to the virus due to recovery from a past infection or a vaccine.

The test is currently available in four different primary care clinics around the world: independent clinics in London, Malta, and the Cayman Islands, as well as a central laboratory partner offering UK-wide testing. The company has also engaged in early discussions in several other countries. As a result of the recently agreed partnership with a central laboratory, the test is widely available and more people from across the whole country can have their samples taken at local phlebotomy centres and sent for analysis at the central lab. Before this partnership was agreed, a key obstacle preventing the company from rolling out the COVID-19 antibody test more widely was the lack of resources in terms of team members and funding to support manufacturing, supply chain, marketing, and customer care for many clinics. More recently, the team has grown and many of these functions are now being outsourced (particularly manufacturing enabling a more global operation).

The test allows people to make personalised health-related decisions by showing an accurate profile of their current antibody levels (i.e. level of immunity to the virus). The level of antibodies after recovery from a COVID-19 infection range widely between individuals[10]. Some people develop strong and long-lasting immunity to the virus and others have a weaker response. Attomarker's test provides information on whether people need additional protection, for example, if their antibody levels have declined faster than expected. At the same time, the test helps to inform decisions on the timing of booster vaccines by predicting how long the

[8] Spike, Omicron Spike, Receptor Binding Domain, and Nucleocapsid

[9] IgM, IgG and IgA, although the test is currently sold as IgG only

[10] Dynamics of SARA-CoV-2 neutralising antibody response and duration of immunity: a longitudinal study, June 2021, https://www.sciencedirect.com/science/article/pii/S2666524721000252

current level of protection will last above the necessary immunity threshold. The test helps to reduce the risk of autoimmunity caused by over-stimulating the host's immune system by repeated vaccinations with the same antigen in those already exhibiting very high antibody levels[11]. While Attomarker's antibody COVID-19 test helped to diversify UK's testing capacity, the extent to which this helped to reduce the spread of the virus in the UK is unclear. The test has had a more discernible impact abroad. Most notably in the Cayman Islands there is evidence to suggest that the test aided the uptake of booster vaccinations by testing various people in private clinics and showing that they had very low levels of immunity, below the predicted protective threshold.

For Attomarker, the funding from UKRI has facilitated new partnerships and private investments to accelerate the development of the technology and expand its market reach. The company recently announced a new partnership with Innova Medical Group, a global manufacturer and distributer of COVID-19 tests who will become an official distributor of the testing product to global customers[12]. Attomarker has also received a significant investment from an animal health company to develop a hand-held version of their testing instrument. The technology is expected to have a transformative impact by allowing medical staff to perform rapid tests on hand-held devices, getting a result in 5 minutes at the point of care instead of mailing away a sample and waiting for the results. This would equip, for example, pharmacists, care home staff, GPs or A&E staff with actionable diagnostic information allowing them to act quickly, driving down costs and ultimately saving lives. Unlike rapid COVID-19 tests relying on a swab sample from a patient's throat or nose, Attomarker's blood test provides an indication of the patient's immune response to the virus (i.e. the degree of recovery and protection from reinfection). The UKRI facilitated this collaboration indirectly by assisting with skill and expertise development within Attomarker and providing exposure to investors willing to pay for the development costs of the device. This UKRI project helped the company to raise more private funds because the grant gave confidence to investors that they were on the right path. Two investment rounds raised £1.5m in the end of 2020 just after the project started and £1m was raised in early 2022. The funding rounds have allowed the team to increase the number of people working to improve the technology and expand its market reach. The company still has a relatively small team, but they have grown form 3 FTE to 7 FTE, indirectly attributed to the UKRI funding and the additional funding secured in subsequent rounds.

As part of the same UKRI funded project, Attomarker also explored if a **saliva-based diagnostic test** has the potential to deliver more convenient, sensitive, and rapid COVID-19 testing than traditional PCR tests. While this saliva-based test was not commercialised, the team has made significant breakthroughs in showing that saliva can be used as a matrix for antigen testing. Initial experiments proved challenging because the different salivary proteins (e.g. mucin) contributed to non-specific binding and refused to wash off the surface of the company's sensor chip. With advances in the buffer technology, they have developed the test to the point where they can sensitively detect COVID-19 antigens and antibodies in saliva samples. The project funding has been beneficial in enabling the accumulation of knowledge and understanding focused on the development of a sensor chip technology that can use saliva as a matrix for testing. This technology is expected to have applications for different illnesses, providing lasting benefits beyond the pandemic. The sensor-chip developments enabled by

[11] Self-Organised Theory of Autoimmunity, 2009, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0008382

[12] Innova Medical Group Forms Strategic Partnership with Attomarker to Accelerate COVID Immunity Testing, May 2022, https://www.prnewswire.co.uk/news-releases/innova-medical-group-forms-strategic-partnership-with-attomarker-to-accelerate-covid-immunity-testing-886410400.html

this funding are expected to accelerate the route to market for a wider range of tests that can be performed on the same instrument. This includes tests for food allergies, liver function, non-alcoholic fatty liver disease, and precision fertility. These future tests will be underpinned by the instrument developed for the pandemic and as part of the UKRI-funded project.

This case study shows a second example of a UKRI funded project that has improved UK's preparedness for future pandemics by supporting the creation of innovative diagnostic testing. The project led by BiologIC Technologies has helped to improve UK's capability in the field of transport bio-surveillance by building a **3D printed bio-processing unit** that can detect COVID-19 infections in new environments such as transport systems. Meta analysis of studies show that air travel played a role in the long-distance transmission of COVID-19[13]. Public understanding of the spread of infectious diseases via air travel has also been documented in the past with Ebola (Pigott et al, 2014), SARS/MERS (Poletto et al, 2016), and seasonal influenza (Khan et al, 2009).

With the funding from this grant, the team developed a bio-processing unit prototype and demonstrated that it can be used to preform 18 PCR tests at the same time when used in different environments, such as on buses and planes. The technology allowed for the detection of pathogens by sampling the air in closed environments and processing the information outside of the lab to counter the spread of the virus in real time. Despite having the same size as a Rubik's cube, the device has already demonstrated its potential to simplify and accelerate existing laboratory processes. It has secured one comprehensive patent with ten claims (filed in the US, UK, and Europe), allowing the company to become a world leader in this technology.

The funding from this grant allowed the team to progress the Technology Readiness Level (TRL) to a point where the product can be demonstrated to customers. They have secured more funding and a new partnership with a large commercial partner in the aerospace industry, helping them to adapt their technology to airplanes. Once the product is incorporated into aircraft air handling systems, as it is currently planned, it will offer a potential to reduce the health-burden from pandemics by identifying infected individuals and taking corrective actions to limit the spread of infectious diseases (e.g., asking infected passengers to self-isolate). The bio-processing unit technology will allow for a broad treat agent coverage (including viral, bacterial, and other pathogen detection) with the same sensitivity as current state of the art laboratory diagnostic testing.

In the case of another pandemic, the predictive disease detection system enabled by this project could provide a competitive advantage to the UK economy by allowing the free flow of non-infected passengers in transport systems and enabling airlines to safely operate valuable international flight routes. The aviation industry was severely impacted by the spread of COVID-19 due to the suspension of flight and the reduction in global passenger numbers. In April 2020, global scheduled flights in the UK were ~93% lower than the same month in the previous year. On a global level, the aviation industry lost $230 billion just in the first year of the pandemic[14]. The transport-based PCR testing developed by BiologIC Technologies has improved the UK's preparedness for future pandemics by supporting rapid diagnostic testing at scale, and in different environments, whilst maintaining the accuracy of laboratory testing.

[13] COVID-19 pandemic and air transportation: Successfully navigating the paper hurricane, July 2021, https://www.sciencedirect.com/science/article/pii/S0969699721000454#bib116

[14] Taking stock of the pandemic impact on global aviation, March 2022, McKinsey & Company, https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/taking-stock-of-the-pandemics-impact-on-global-aviation

As a result of their UKRI grant, BiologIC Technologies has attracted angel investments and commercial revenue both of which are helping them to develop the bioprocessing unit technology further. Beyond the life of this project, the technology will be developed to improve the UK's readiness in all aspects of pandemic management, including diagnostic, vaccine research and manufacturing. The technology has also found applications in a variety of research areas, including new food and biofuel to reduce climate change, as well as the medical sector for the development of therapies and treatment. One example of significant potential for the technology is the cell and gene therapies market which is expected to grow to £14 billion by 2025[15]. The company plans to utilise know-how developed as part of their UKRI project to develop cheaper cancer therapies, with an ambition of reducing average development costs by a factor of 10 or even 100 in the long run.

In March 2022, it was announced that Oxford Biomedica, a gene and cell therapy company specialising in gene-based medicines development, will use BiologIC's biocomputer to develop a viral vector for personalised cancer therapies. Under the agreement, BiololC will provide a new application of its biocomputer to improve novel viral vector manufacturing processes[16]. Since BiologIC's technology offers a fast, cost-effective, and scalable alternative to traditional drug development manufacturing processes, this collaboration offers an opportunity to accelerate the development of treatments and reduce the cost of very expensive therapies. With the help of UKRI's funding, BiologIC's biocomputer is now finding applications in other non-COVID1-9 fields of medicines and the technology is adopted by industry leaders, including Oxford Biomedica which produced more than 100m doses of the AstraZeneca vaccine. As a result, the size of the team driving this technological progress has grown from 3 to 11 employees, including senior scientists, engineers, and software programmers.

F.2.2. New technologies and processes reducing the burden on the healthcare system

Funding from UKRI allowed Appt-Health to develop **an innovative patient engagement tool** designed to increase the uptake of healthcare appointments. The app uses SMS and automated voice recordings to minimise the administrative burden of staff-led phone calls and letters. Appt-Health was not involved in the national COVID-19 vaccination roll-out, as was intended under this project, because they were not a major service provider when the government introduced a framework for IT systems for vaccinations and they were not able to access it at a later point. However, throughout the pandemic, the booking technology has been used for flu/child vaccinations programmes, as well as for helping to clear the backlog of appointments for chronic conditions that accumulated during the pandemic.

With the help of this UKRI award, the company has expanded the use and applicability of the core functionality of the software and made it vastly scalable and practicable in the NHS. The company has increased their user base from one borough in east London to seven boroughs, winning contracts from GP practices that they hadn't contacted previously (such as Leicestershire integrated care system). The popularity of the product has grown as the standard long-term health condition management incentives have returned post-COVID, and new GP practices sign up every week. The company expects to scale their product quickly over the next 18 months, with a goal of reaching 3,000 GP practices by the end of 2023.

[15] Cell and Gene Therapy in 2040, https://www.paconsulting.com/insights/2021/cell-and-gene-therapy-in-2040/

[16] Oxford Biomedica collaborate on novel biocomputer system, March 2022, https://www.biologic-tech.com/component/content/article/12-blog-new/29-oxford-biomedica-agreement?Itemid=111

Appt offers two main benefits. It increases the uptake of preventative healthcare appointments to diagnose patients' diseases at early stages and it minimises the cost to GP practices to deliver services sustainably. A 2019 pilot study tested the effectiveness of the Appt-Health booking service in 17 GP practices in the London Borough of Barking and Dagenham (LBBD) and showed that the service was effective in improving patients' experiences and increasing the uptake of appointments, ultimately saving lives by diagnosing health conditions at an early stage.[17] The technology has also demonstrated its potential to deliver cost savings to GP practices. The company found that it costs on average £3.90 per booking with the Appt-Health service (inclusive of all costs) and £5.12 without it. The team estimated that if the technology is scaled to all patients who need recalling, applied at a national level in the UK, the NHS would save around £70 million. The team also sees an opportunity to increase the cost saving in the future.

On the back of their project, Appt-Health has managed to secure £250k additional funding from private sector sources to exploit the full commercial potential of their innovative booking system. The assistance the company received from Innovate UK EDGE in forming their investment slide deck helped them to achieve a higher level of funding that they would otherwise not have reached. The funding from UKRI also allowed the team to build a significant network within NHS digital and among those GP practices who accepted them as an approved supplier. More recently, the company has also submitted a successful joint bid with Queen Mary University of London to explore how they can approach excluded groups (such as those living in poorer regions as the London Borough of Barking and Dagenham (LBBD)) in COVID-19 vaccinations (including boosters).

Another UKRI award led to the creation of a **communication device** which enhances speech clarity whilst wearing Personal Protective Equipment (PPE). While PPE played a critical role in reducing the spread of the virus in clinical settings, it also reduced speech clarity and complicated communication with patients, especially with people who relied on lip reading, the elderly, and those with hearing loss[18]. An experimental study on the impacts of PPE on speech clarity and performance during the COVID-19 pandemic revealed that background noise increased from 45 dB in office environments to 70 dB in clinical settings, and the median comprehension test score dropped by 37%.[19] Feedback from frontline healthcare workers also showed that communication constrains whilst wearing PPE interfered with daily tasks, reduced work efficiency, and obstructed the ability to express non-verbal cues of sympathies with patients and their relatives.

The communication device developed as part of this UKRI project acts as a voice amplifier picking up a clear sound from a throat microphone. It is developed in a way that allows an easy connection to a mobile phone/wired telephone and the hospital internal phone system to enable connections to other departments and ambulance services. To deliver this project, the lead organisation, Project Pitlane, partnered with the University of Leicester, Innova Technology, and one NHS Hospital Trust. Professor Tim Coats from the University of Leicester

[17] Appt-Health – Innovation around Health Checks booking in Barking and Dagenham, https://modgov.lbbd.gov.uk/Internet/mgIssueHistoryHome.aspx?IId=76836&Opt=0

[18] Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal, https://bmjopen.bmj.com/content/11/1/e046199

[19] Hampton T et al. The negative impact of wearing personal protective equipment on communication during coronavirus disease 2019, https://www.cambridge.org/core/journals/journal-of-laryngology-and-otology/article/negative-impact-of-wearing-personal-protective-equipment-on-communication-during-coronavirus-disease-2019/313C848250464F737DA8088637739F3C

developed the initial prototype of the device using commercially available components after experiencing, first-hand, difficulties communicating whilst wearing PPE[20].

The project team produced a working prototype of the communication device within six months, representing astonishing progress which would normally take a year to accomplish. Although certain elements of this device were available on the market, only the MedicCom communication device offers an integrated solution suitable for the easy switching between functions. Professor Tim Coats attributed the project's success to his collaboration with Project Pitlane because they benefited from existing technologies employed in Formula One.[21] Having access to Alpine F1 Team's UK headquarters in Oxfordshire allowed the team to produce twenty prototypes and to make further improvements to the device (including reducing its size and weight). The final prototype has received positive feedback from clinicians in Leicester's Hospital and the Medical Devices Technology Evaluation Centre in Birmingham.

The team is in the process of securing additional funds to manufacture the device at scale and supply it to NHS hospitals. The project participants benefited from business support from Innovate UK EDGE in the form of commercialisation know-how and contacts for potential partners. The device has already demonstrated that it works effectively in improving communication clarity and if it is successfully applied in clinical settings, there is potential to i) improve the quality of patients' healthcare experience; ii) decrease the risk of errors due to miscommunication; and iii) improve the efficiency of work by reducing time waste and fatigue.

F.2.3. *Innovative vaccine development improving UK's preparedness to control the future spread of infectious disease*

One UKRI project covered in this case study explored if a different type of vaccine technology provides a better and longer-lived immune response than traditional vaccines. The UKRI grant has enabled DIOSynVax to take their **next-generation coronavirus vaccine** from the R&D and development phases into the clinical trial side of vaccine development. The R&D activities that enabled the vaccine technology to be developed were initially funded by the Department of Health and Social Care (DHSC). With the help of UKRI funding, DIOSynVax has generated the early clinical data necessary to pass regulatory requirements in demonstrating the safety of the vaccine for a proof-of-concept Phase I human trial and move through the manufacturing process for a first batch of the vaccine. In December 2021, the company embarked on their first clinical trial at the National Institute for Health and Care Research (NIHR) Southampton Clinical Research Facility, with the results expected to become available towards the end of 2022.[22]

Vaccine technology developed by DIOSynVax provides innovative solutions in terms of the way the vaccine is administered and the way the technology is designed to provide protection against multiple threats. If approved, the solutions made possible by this UKRI-funded project will deliver human health benefits by creating a vaccine that is more broadly protective as viruses mutate and become better at evading the host's immune system. This project offers the potential to move the vaccine field into the direction of next-generation vaccine development, which can best protect against broader sets of viruses, improving the global

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[20] MedicCOm: A Case Study, October 2021, https://ktn-uk.org/perspectives/mediccom-a-case-study/

[21] "Alpine F1 engineers help create communication device for hospitals as part of Project Pitlane", June 2021, https://corp.formula1.com/alpine-f1-engineers-help-create-communication-device-for-hospitals-as-part-of-project-pitlane/

[22] Southampton trial needle-free vaccine for COVID-19 variants and future coronaviruses, December 2021, https://www.southampton.ac.uk/news/2021/11/cambridge-covid-vaccine.page

preparedness for future pandemics. If the trial delivers successful results, the vaccine could be used as a booster to protect against COVID-19 and other variants of the virus, as well as other coronavirus relatives such as SARS and MERS.

Another benefit from this project is demonstrating that DIOSynVax's next-generation vaccine technology doesn't require a cold-chain for delivery. This is particularly beneficial in resource-constrained contexts where it may not be feasible for vaccines to be stored consistently at low temperatures. Around 3 billion people (~38% of the world population) currently live in countries where temperature-controlled storage is insufficient[23]. With this funding, DIOSynVax were also able to collaborate with a partner, PharmaJet, who developed an effective way of administering the vaccine with a needle-free technology allowing the content to be pushed into the skin using a jet of air. Alternative ways of administrating vaccines can benefit a share of the population who are afraid of needles. The charity Anxiety UK estimated that between 3.5% and 10% of the UK adult population have some degree of needle phobia.[24]

In the future, DIOSynVax expects to seek additional funding to go beyond the first phase of clinical trials and commercialise the product. The company has already obtained a larger grant through the Coalition for Epidemic Preparedness Innovations (CEPI) to progress the technology even further[25]. This benefit was partly attributed to UKRI's funding as it allowed the company to demonstrate the project's progress.

F.3. Contribution analysis: UKRI's role

The outputs and impacts presented in this case study build upon prior UKRI grants or funding secured from other sources. For example, since BiologIC Technologies was created in January 2020, the company has secured six grants from UKRI, and they all contributed to the development of their 3D printed bioprocessing unit (BPU) technology. Immediately before the company secured the COVID-19 grant discussed here, they won funding for one feasibility study and another collaborative R&D project to explore ways in which their BPU technology can be used to cultivate meat directly from cells (rather than growing animals) to reduce the threat from climate change and the spread of zoonotic diseases[26]. The transport biosecurity grant covered in this case study came at an early stage in the company's development and it was very important in helping them develop the technology that now underpins all other more recent developments.

Similarly, Appt-Health and the LBBD Insight Hub jointly won UKRI funding in March 2019 to fully develop a two-way booking system for NHS Health Checks. This project was born from a successful pilot study which showed promising results in increasing the uptake of health check-ups. When the pandemic hit, the lead participant saw an opportunity to aid UK's vaccination efforts by creating a new application of their booking technology for COVID-19 vaccinations. As such, the outputs delivered from this project built upon the achievements from a previously funded UKRI-project as it influenced their readiness to respond to the pandemic and have

[23] Vaccine storage issue could leave 3B people without access, October 2020, https://apnews.com/article/virus-outbreak-pandemics-immunizations-epidemics-united-nations-fc4c536d62c5ef25152884adb1c14168

[24] Injection Phobia, https://www.anxietyuk.org.uk/anxiety-type/injection-phobia/

[25] CEPI and DIOSynVax partners in quest to develop broadly protective Betacoronavirus vaccine, March 2022, https://cepi.net/news_cepi/cepi-and-diosynvax-partner-in-quest-to-develop-broadly-protective-betacoronavirus-vaccine/

[26] Feasibility study reference: 62915. Collaborative R&D grant reference: 84594

rapid outputs[27]. Since then, the company has received support from Innovate UK EDGE in forming their investment proposition, helping them to secure more private sector investments than they would have otherwise.

Another example where UKRI's long-term investment has influenced their COVID-19 response is DIOSynVas's coronavirus vaccine project. The vaccine technology described in this case study was originally identified in a project administered by Innovate UK and funded by the Department of Health and Social Care (DHSC) as part of the UK Vaccine Network (UKVN)[28]. Part of this funding was re-purposed to respond to the pandemic and apply the vaccine technology they had been using in other areas (such as the haemorrhagic fever and Influenza vaccine field) into the coronavirus space. The additional funding from UKRI allowed the company to capture all the necessary data required by regulatory bodies, manufacture a first batch of the vaccine, and move into a clinical trial. The company has also received support from UKRI in organising discussions with a few organisations in India about holding potential clinical trials in the country.

Prior to the MedicCom project covered in this case study, Project Pitlane were involved in the government's ventilator challenge, an effort put in motion by UKRI's efforts in convening participants with the necessary skillset needed to meet the needs of the NHS[29]. Project Pitlane appeared as a suitable partner because they brought excellent expertise in advanced engineering, access to facilities for manufacturing complex systems, and an extensive supply chain for sourcing of materials. When Professor Tim Coats from the University of Leicester needed assistance to create a prototype of the MedicCom communication device, a representative from the Knowledge Transfer Network (KTN) suggested a collaboration with Project Pitlane as they had already presented a strong track record of addressing technological challenges in the context of the pandemic.

One project received funding from another non-UKRI source. Philanthropic donations raised through the University of Exeter supported the early development of Attomarker's COVID-19 test by funding an extensive pilot study at St. Thomas' Hospital in March 2020[30]. The study used serum samples from 74 patients who tested for the virus on admission to hospital and 47 historical control patients who had provided a serum sample in the previous year. A further analysis with an additional 200 patients showed that the test delivered favourable sensitivity of up to 96%. The pilot study led to the publication of a paper in the Royal Society of Chemistry (from the peer-reviewed scientific journal, Analyst) and aided the authorisation of the test from the MHRA in July 2020[31]. The funding from UKRI allowed the company to advance the testing technology and launch it to market. It also helped the company to secure follow-on funding from private sector sources.

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[27] The project is called "Transforming the commissioning and delivery of NHS Health Checks, enabled by accessible digital technology (Ref: 27686). It is delivered in collaboration with Together First – a consortium of GPs in LLBD, the Clinical Commissioning Group and LBBD Public Health representatives, https://gtr.ukri.org/projects?ref=27686

[28] UK Vaccine Network, https://www.gov.uk/government/groups/uk-vaccines-network

[29] Project Pitlane: how rival F1teams unit in battle against COVID-19, May 2020, https://www.theguardian.com/sport/2020/may/24/project-pitlane-how-rival-f1-teams-united-in-battle-against-covid-19

[30] Attomarker's Triple Antibody Test for COVID-19 authorised by the MHRA following positive trial results at St. Thomas' London, July 2020, https://www.attomarker.com/attomarkers-triple-antibody-test-for-covid-19-authorised-by-the-mhra-following-positive-trial-results-at-st-thomas-london

[31] Real-world evaluation of a novel technology for quantitative simultaneous antibody detection against multiple SAR_CoV-2 antigen in cohort of patients presenting with COVID-19 syndrome, A. Shaw at ell (July 2020), https://pubs.rsc.org/en/Content/ArticleLanding/2020/AN/D0AN01066A#!divAbstract

F.4. Barriers and challenges

The time needed to develop innovative technologies and the speed at which the pandemic response evolved meant that the outputs from projects covered in this case study showed limited impact on the COVID-19 pandemic. All of them are either helping with the recovery effort or improving the UK's preparedness for future pandemics. As the benefits of commercialised products take longer to materialise than the benefits emerging from the transfer of knowledge, the impact of these awards is expected to transpire beyond the lifetime of the awards. Despite challenges, project participants have found creative ways to make substantial progress with their project objectives and find new applications for their innovations. The information below summarises the lessons learnt from past experiences to help facilitate better future outcomes.

The level of public trust in the efficacy of antibody tests may have suffered due to poor performance of competing tests. Early in the pandemic, regulators in the UK discontinued the sales of several antibody tests because it was shown that corners had been cut to develop the tests. Identified problems included misleading clinical trials with only serious disease patients, use of finger-prick samples (instead of the venous blood samples required) and highly inflated accuracy rates[32]. In addition, government advice in the UK states that the level of antibodies necessary to protect against infection is not yet proven[33]. According to the guide, the interpretation of antibody tests is limited to providing an indication of whether a person is more protected than if they had no antibodies, but not if they are fully protected. Hence, an antibody test should not be interpreted as an indication of a specific level of immunity or protection from COVID-19. In the US, the FDA has adopted similar advice to the public.[34]

The booking technology developed by Appt-Health as part of this project was not extended to cover the national COVID-19 vaccination roll-out. Given Innovate UK's connections to government, the team would have benefited from additional support in terms of understanding the inner workings of the NHS and how things change in a fast-moving environment. The impact from this project funding could have been maximised if the NHS's framework for IT systems for the COVID-19 vaccination programme had been more transparent and open to all players in the market, and particularly SMEs / startups.

While UKRI funding helped Medicom to develop a working communication device, there is a risk that the product won't be commercialised and supplied to NHS hospitals without further funding. Furthermore, there are other alternative measures available to medical staff that may reduce the need for a communication device. For example, loose-fitting respirators incorporate all the safety features of a mask, but also provide a transparent face cover. The clear plastic shields allow patients to see the movement and expressions in the user's mouth and eyes. As would always happen, new products must compete with similar innovations arising from other sources and all such developments have to show clear advantages over established products and systems to a degree that would have caused healthcare systems to switch to the new solutions.

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[32] Is Attomarker's Triple Antibody Test for COVID-19 now the best by far?, September 2020, https://www.attomarker.com/is-attomarkers-triple-antibody-test-for-covid-19-now-the-best-by-far

[33] Antibody testing for SARS_CoV-2: key information, April 2022, https://www.gov.uk/government/publications/antibody-testing-for-sars-cov-2-key-information/antibody-testing-for-sars-cov-2-information-for-general-practitioners

[34] Antibody Testing Is Not Currently Recommended to Assess Immunity After COVID-19 Vaccination: FDA Safety Communication, May 2021, https://www.fda.gov/medical-devices/safety-communications/antibody-testing-not-currently-recommended-assess-immunity-after-covid-19-vaccination-fda-safety

Finally, DIOSynVax reported experiencing challenges recruiting for their vaccine clinical trial in the UK because most of the population has already been infected by COVID-19. While the team is confident that they can deliver a successful clinical trial by the end of 2022, to date, they have made slower progress than what was initially expected due to slow recruitment.

F.5. Sources

- Interview with Hector Smethurst, Founder of Appt-Health, contacted on 12/04/2022
- Interview with Bob Bell, Strategic Advisor at Alpine, Project Pitlane, contacted on 12/04/2022
- Interview with Gemma Lang, Head of Financial Reporting & Tax at Alpine, Project Pitlane, contacted on 12/04/2022
- Interview with Andy Damerum, Commercial Development Officer at Red Bull Advanced Technologies, Project Pitlane, contacted on 12/04/2022
- Interview with Ben Farrar, Executive Officer at Attomarker, contacted on 28/04/2022
- Interview with Richard Vellacott, CEO of BiologIC Technologies, contacted on 28/04/2022
- Interview with Rebecca Kinsley, Chief Operating Office at DilOSynVax, contacted on 06/05/2022

Appendix G Case study Fiches

Fifteen Short Case Studies (see Table 11) were created to both showcase the individual achievements of a selection of awards and to supplement the overall analysis of impact for the evaluation. A range of award types, sizes, funders and institutions were chosen to reflect the diversity of UKRI's COVID-19 portfolio. They were developed using documentary (e.g. applications), survey (both UKRI M&E and the Technopolis evaluation surveys) and secondary data (e.g. from ResearchGate). Drafts of these case studies were shared with the lead of each award for iterative feedback and validation before being finalised.[35]

Each case comprises between three to four pages of content and includes: a summary of the case, a brief description of the UKRI COVID-19 award, notable outputs and outcomes (each with a summary against the corresponding evaluation KPIs), an assessment of the main impact pathways, and the sources used in the case.

Summary findings from the Short Cases

The rapid engagement with and dissemination of results to the wider research community, practitioners and policymakers were the most common pathways to impact identified across the 15 cases. All awards had elements of engagement built into their work to ensure that their new product, crucial piece of knowledge or practical insight to help combat the COVID-19 pandemic was either informed by users or reached them as quickly as possible. One ESRC award led by Kings College London (Short Case 7) incorporated a stakeholder opinion group into their work on how the discrimination of patients and healthcare practitioners may generate inequalities in health professions and service during the COVID-19 pandemic. The team's approach helped them to co-develop policy guidance on a range of issues, such as helping maximise COVID-19 vaccine uptake in ethnic minority groups, and to influence the development of the Race Equality Action Plan for the Welsh Government.

Key enablers to quickly producing and applying R&I solutions to the COVID-19 pandemic were the pre-existing collaborations, physical resources and bodies of grant funded experience awardees had. For example, ISARIC 4C (Coronavirus Clinical Characterisation Consortium - Short Case 8) were able to pivot so quickly to COVID-19 because ISARIC had more than nine years of experience as a consortium (funded by UKRI, NIHR and other funders) on severe acute respiratory infections, and were preparing for such an outbreak. The Diamond Light Source's work in supporting and hosting over 60 COVID-19 related projects (Short Case 3) was possible thanks to years of investments made by UKRI and Wellcome. That funding equipped Diamond with world leading facilities (e.g. its XChem platform allows structural biologists to screen up to 500 structures a day) and many international projects that allowed it to support researchers to hit the ground running on rapid response science to understand and address COVID-19. Existing connections with policymakers and practitioner communities from prior/existing grants (e.g. UKRI studentships and platforms) underpinned the success of those and other awards.

COVID-19 (e.g. lockdowns) and data sharing/access were major challenges identified via the short cases. COVID-19 restrictions hindered some research staff in performing experiments, but also affected staff recruitment, retention and led to some isolation (Short Case 15). Though data sharing was identified as an enabler by some (e.g. open data sources for air quality in Short Case 1), issues around establishing data sharing agreements with partners (Short Cases 12&13) as well as IP implications for the dissemination of results (Short Case 15) caused delays.

[35] 14/15 awardees responded to this exercise.

Table 11 Index of short case studies

#	**Project title**	**Grant holder and organisation**	**Amount Awarded**	**Council** and call
1	Air quality benefits from multi-year changes in post-pandemic working and travel patterns	Prof James Lee, University of York	£179,189	**NERC** COVID 19 Agile Call
2	Covid-19 - SARS-CoV-2 Multi Surface Disinfection Spray System	Sally Pritchard, Pritchard spray technology ltd	£177,000	UKRI Ideas to Address COVID-19 – **Innovate UK** de minimis funding strand
3	Diamond Light Source - unmasking the virus	Diamond Light Source	N/A	**STFC**
4	Ensuring Respect for Human Rights in Locked-Down Care Homes	Prof Wayne Martin, University of Essex	£172,980	**AHRC** COVID 19 Agile Call
5	GCRF_NF143 Barcoding Galapagos: Recording and mitigating Covid-19 impacts using key-workers in eco-tourism	Dr Camille Bonneaud, University of Exeter	£463,568	**UKRI/GCRF** GCRF Agile COVID 19 RR
6	Identification of host cell components essential for the SARS-CoV-2 life cycle	Prof Allan Bradley, University of Cambridge	£451,937	**BBSRC** COVID 19 Agile Call
7	Identifying and mitigating the impact of COVID-19 on inequalities experienced by people from BAME backgrounds working in health and social care	Prof Stephani Hatch, King's College London	£506,200	**ESRC** COVID 19 Agile Call
8	ISARIC - Coronavirus Clinical Characterisation Consortium (ISARIC-4C)	Prof Kenneth Baillie, University of Edinburgh	£4,908,946	**MRC/NIHR** COVID-19: UKRI/NIHR Rapid Response Call 1
9	Phase 1 COVID-19 Data and Connectivity – National Core Study (Phase 1 D&C-NCS)	Prof Andrew Morris, Health Data Research UK	£15,150,000	**MRC** COVID-19: National Core Studies
10	PhD student develops world-first five minute test for COVID-19 at his kitchen table	Prof Tim Dafforn & Dr Jake Carter, University of Birmingham	N/A	**BBSRC** Repurposed
11	REACT Long COVID (REACT-LC)	Prof Paul Elliott, Imperial College London	£2,718,200	**MRC/NIHR** COVID-19 Long COVID
12	Responding to the Covid-19 domestic abuse crisis: developing a rapid police evidence base	Dr Katrin Hohl, City, University of London	£141,739	**ESRC** COVID 19 Agile Call
13	The Pandemic and Beyond: The Arts and Humanities Contribution to Covid-19 Research and Recovery	Prof Pascale Aebischer, University of Exeter	£240,720	**AHRC** COVID 19 Agile Call
14	Use of wastewater analysis to evaluate the incidence of coronavirus (SARS-CoV-2) in the UK population	Prof Davey Jones, Bangor University	Initially £52,235 + £197,108 uplift	**NERC** Urgent Grant
15	VIPIRS - Virus Identification via Portable InfraRed Spectroscopy	Prof Hui Wang, University of Ulster	£410,730	**EPSRC** COVID 19 Agile Call

G.1. Short case study 1 - Assessing the effects of COVID-19 lockdowns on UK air quality

Award title	Air quality benefits from multi-year changes in post-pandemic working and travel patterns (NE/W00481X/1)		
UKRI investment type	COVID 19 Agile Call (NERC)		
Award holder (PI)	Prof James Lee	**Institution/ organisation**	University of York
Award size	£179,189	**Award duration**	15/01/06/2021 - 30/11/2022
Summary			
This ongoing study seeks to understand the long-term effects of the reductions in working and travel patterns caused by COVID-19 restrictions on air quality in the UK. To date, the team has simulated a business-as-usual scenario for 2021 that assumes COVID-19 and the associated restrictions had not taken place. Next, simulated air quality data will be compared to actual observed air quality data for 2021 with the aim of quantifying the effects of reduced air pollution on air quality in the long run. The anticipated findings may serve as a useful analogy for future scenarios in which remote working and electric vehicles are more common.			

G.1.1.Description of the award

This award is studying the effects of reduced levels of economic activity and wider patterns of industrial and domestic consumption of resources, caused by COVID-19 lockdowns and associated restrictions, on air quality. In the UK, the series of lockdowns in 2020 and 2021 helped reduce disease transmission but also caused major changes in commuting modes and homeworking.

The longer-term improvements in urban air quality resulting from these shifts in behavioural patterns are not yet well quantified, though there are many reports of reductions in air pollution as a short-term consequence of them. It is expected that reductions in air pollution in cities have the potential to deliver benefits in the near-term, even if sustained for just a small number of years. Specifically, the main benefits in terms of improved air quality are likely to materialise in the years immediately following the pandemic, especially considering the UK's ongoing transition towards transport electrification.

The way in which short-term pollution reduction will impact long term air quality is still uncertain, though reduced traffic volumes are generally accepted to lead to lower levels of air pollution (e.g. lower nitrogen dioxide [NO_2] levels). The main aim of this award is to quantify the effect of short-term pollution reductions on air quality and identify public health implications. This work can potentially provide evidence on the effects of pollution controls on public health and the environment. In this sense, the COVID-19 lockdowns can be treated as an analogy of how air quality responds to multi-year reductions in emissions from vehicles in general, which could lead to important considerations for air quality strategies and policies.

The team consists exclusively of researchers from the Chemistry department of the University of York and builds on previous work of the principal investigator, Professor James Lee, an expert in atmospheric oxidants and a research fellow affiliated with the National Centre for Atmospheric Science (NCAS) (Lee et al., ACP, 2020).

G.1.2.Outputs

The award is progressing according to schedule, meeting all of its planned milestones to date since it started in June 2021. During the first phase of the work, data from UK air quality

monitoring sites (AURN[36]) was acquired and a random forest model (a machine learning classification algorithm), was run to create a business-as-usual scenario up to the end of March 2021. This business-as-usual scenario is essentially a simulation of air quality levels in the absence of the COVID-19 pandemic and associated restrictions. Comparisons were subsequently made between the business-as-usual scenario against the measured air quality data as well as an assessment of the correlation of NO_2 reductions with traffic volume data. These comparisons and assessments effectively demonstrated that air pollution levels were higher in the business-as-usual scenario than in the observed data and that NO_2 levels were positive correlated with traffic volume.

In the second phase of the award, the researchers expanded the machine learning calculations to simulate air quality data in the absence of COVID-19 for all of 2021. This phase was completed in January 2022. Currently, the award is on target to reach its 12-month deadline for the analysis of NO_2 changes against traffic data. The investigators are carrying out the analysis of the full set of air quality data from 2021, which will be completed by November 2022. The key findings of this study will therefore not emerge until the end of the current phase of the work. These are expected to feed into scientific publications in the future.

To date, early findings from the research have already been presented at a conference of the American Geophysical Union in December 2021[37]. The conference presentation shared lessons learned from the changes in air pollution as well as greenhouse gas level comparisons from the lockdowns and reopening actions. As part of the session, methodologies for assessing the effects of restrictions on emissions were examined and local, regional and global studies using remote sensing or modelling data were encouraged.

The outputs of the award are contributing to the generation of data, knowledge and understanding of the impacts of COVID-19 measures and approaches to recovery at pace by assessing the environmental impact of the lockdowns and associated restrictions (non-pharmaceutical interventions).

Key outputs and output indicators

KPI: Data, knowledge & understanding of the impacts of COVID-19 measures delivered at pace – The award is collecting and analysing air quality data on the impacts of COVID-19 lockdowns and restrictions on air pollution and quality. On the basis of this, the award has already observed an average reduction in NO_2 levels of 52% across the UK.

KPI: Communication materials: Conference presentation - Lee, J. D., Liu, F., Gilman, J., & Levelt, P. COVID-19 lockdowns: What have we learned about air pollution and carbon emissions from local to global scale?. In *AGU Fall Meeting 2021*. AGU.

G.1.3.Outcomes and impacts

This study is expected to complete in November 2022. To date, a major milestone regarding the simulation of air quality data for the whole of 2021 was reached in January 2022, paving the way to the next phase of the research in which the simulated -business-as-usual scenario will be compared against actual air quality data measured over the course of 2021. This is an important outcome in itself since it relates to the capture of time-critical data given that COVID-19 restrictions have gradually been lifted since the end of 2021. Moreover, once completed, the study findings will help to improve the understanding of the effects of the pandemic on the environment and public health in the context of air pollution and quality.

[36] Automatic Urban and Rural Network, see: https://uk-air.defra.gov.uk/networks/network-info?view=aurn

See: [37] https://agu.confex.com/agu/fm21/meetingapp.cgi/Session/139827

The anticipated impact of the research is to inform the evaluation of the effects of changing urban emissions regimes by quantifying the effects of reduced air pollution in the short-term on long-term air quality. This can help inform decision-making around proactive air pollution controls and the implications for air quality, which is highly relevant in the context of transport electrification. Specifically, the changes in transport patterns observed during COVID-19 may mimic future scenarios in which traffic emission decline through the uptake of electric vehicles and the rise of remote working. This will be disseminated in the form of an open access publication, aimed to be published by the end of the project.

The team's sharing of early research findings has also contributed towards increasing openness in research. The aforementioned contribution to the 2021 AGU conference has brought researchers from across the globe together to discuss their own findings regarding the effects of COVID-19 lockdowns on air quality and greenhouse gas emissions. This was an opportunity to share methods and insights as to how different cities and regions have observed changes in air quality. Further dissemination of the award's results is anticipated as the team plans to make their findings publicly available in open access publications as well as a dedicated report.

Key outcomes and output impact indicators

KPI: Time-critical data & resources captured during the pandemic to inform research of and response to future pandemic or public health threats – The award was able to rapidly capture air quality data from Automatic Urban and Rural Network (AURN) measurement sites. The capture of this data was highly time-sensitive as one of the objectives of the award is to quantify the impacts of COVID-19 lockdowns and restrictions on air pollution and quality in the period immediately following those measures.

KPI: Research undertaken & shared rapidly – Although the award is still ongoing, early findings have already been disseminated at a conference (see above).

G.1.4.Impact pathways

The team were able to draw on pre-existing data sharing facilities as well as research infrastructures for the delivery of the research. Specifically, the near-public and public availability of air quality data from AURN measurement sites has enhanced the delivery of the work. A challenge of the work has been getting hold of traffic flow data. To date this has proved difficult, however the team have started to make progress with a contact at the DFT which will help complete the work. Furthermore, national COVID-19 restrictions were regarded as a minor challenge by the investigators.

G.1.5.Sources

- Gateway to research data, retrieved from: https://gtr.ukri.org/projects?ref=NE%2FW00481X%2F1
- COVID Agile call survey rounds 1-3
- COVID Agile call awardee survey
- American Geophysical Union Fall Meeting 2021 Proceedings. Available at: https://agu.confex.com/agu/fm21/meetingapp.cgi/Session/139827

G.2. Short case study 2 - Spraying COVID-19 away using environmentally friendly methods

Award title	Covid-19 - SARS-CoV-2 Multi Surface Disinfection Spray System (Grant ID: 77807)		
UKRI investment type	UKRI Ideas to Address COVID-19 – Innovate UK de minimis funding strand (Innovate UK)		
Award holder (PI)	Sally Pritchard	**Institution/ organisation**	Pritchard Spray Technology Limited
Award size	£177,000	**Award duration**	15/01/09/2020 – 31/05/2021
Summary			
Pritchard Spray Technology Limited has developed an environmentally friendly antiviral spray in partnership with the British Army. The spray, VIRUSEND, can kill more than 99.99% of COVID-19 in the sprayed area in one minute. This quick disinfection-time makes it ideal for use on a variety of surfaces within high footfall areas such as the mass testing and vaccination sites, as it reduces risk as far as practically possible and provides an environmentally friendly and sustainable solution to infection control. This award aimed to enable the company to generate the necessary technical and clinical evidence to support regulatory approval and access to the healthcare market.			

G.2.1.Description of the award

The COVID-19 pandemic triggered the development of a range of innovative ways to prevent and reduce the spread of the virus. These involve cleaning (remove organic matter, dust) and disinfection (reduce number of micro-organisms to a level where they are not harmful). The latter is particularly important in the context of COVID-19 which can be found on surfaces for up to 72 hours. Workplaces are, therefore, hot spots for transmission events amongst staff and customers. It is therefore important to disinfect surface on a regular basis with a product that meets the necessary standards.

Pritchard Spray Technologies Limited, based in Essex, has developed an environmentally friendly antiviral spray called VIRUSEND in partnership with (and partially funded by) the British Army, and Ploughshare who managed the licence to Pritchard Spray on behalf of the Ministry of Defence (MOD). Although the spray was already available on the market, it had still to comply with the EU Medical Device Directive (MDD 93/42/EE) to be used within a healthcare context. This Innovate UK award aimed to enable the company to generate the necessary technical and clinical evidence to support regulatory approval and access to the healthcare market. In particular, the award included the following work packages:

1 Human Factors evaluation carried out by the Medical Devices Testing and Evaluation Centre (MD-TEC) to film study participants using a range of disinfectant wipes, sprays and VIRUSEND where the solution has been treated with a UV marker

2 Regulatory approval carried out by Med-Tec Consulting, British Standards Institution (BSI) to produce a technical file and implementation of ISO13485 quality management system that is required for CE Mark approval under MDD

3 NHS Study set-up by NIHR and Leeds Teaching Hospitals (LTH) NHS Trust on ethical and research approval, and staff training on VIRUSEND

4 Evaluation of current and VIRUSEND infection control practice by NIHR and LTH NHS Trust

5 Data analysis and preliminary reporting carried out by NIHR and LTH NHS Trust

Throughout the award, Pritchard Spray was able to certify the spray against 18 British and European Standards, patent a re-useable trigger system, enter the healthcare market and increase its presence in the online consumer market.

G.2.2.Outputs

VIRUSEND uses compressed air, instead of volatile organic compounds (VOC) flammable gasses, to disinfect any surfaces in a rapid yet effective way. Due to its patented spray

technology, VIRUSEND works in any orientation, including upside down. The bottle is fully recyclable and has a patented re-useable trigger system (with a lifetime replacement guarantee). The formula behind the spray is currently patent pending.[38]

The spray has been independently tested with 99.99% efficacy against COVID-19 by the Centre of Excellence for Infectious Disease Research and the Liverpool School for Tropical Medicine. This is in line with the British and European standards and means that, once applied on a surface, VIRUSEND can kill more than 99.99% of COVID-19 particles in one minute. Specifically, VIRUSEND has proven efficacy against:

- All Enveloped Viruses using the Vaccinia surrogate in both suspension (BSEN 14476) and surface testing (BSEN 16777) to >Log 4 (>99.99%)
- A Coronavirus (feline coronavirus) which is validated for EN test methods
- The live pandemic strain of the Coronavirus

This quick disinfection-time makes VIRUSEND ideal for use on a variety of surfaces within high footfall areas, such as mass testing and vaccination sites, as it reduces transmission risk and provides an environmentally friendly and sustainable solution to infection control. The spray was rapidly made available on multiple online retailers' sites (e.g. Amazon[39]) for around £10 depending on the retailer. At Amazon.co.uk, VIRUSEND is listed as one of the top 50 best-seller products within the category "Disinfectant Sprays & Liquids".

The main research results associated with the ability of VIRUSEND to inactivate SARS-CoV-2 have been published and can be used as an input to further develop other disinfectants.

Key outputs and output indicators

KPI: Publication: Academic journal article: Anderson, E. R., Hughes, G. L., & Patterson, E. I. (2021). Inactivation of SARS-CoV-2 on surfaces and in solution with Virusend (TX-10), a novel disinfectant. *Access microbiology*, **3**(4), 000228. https://doi.org/10.1099/acmi.0.000228

KPI: Certified product: VIRUSEND has obtained 18 British and European Standards.

KPI: Patented technology: VIRUSEND holds two patents (on its 360° spray technology and re-usable trigger) and has currently a patent pending for its formula.

KPI: Communications materials – News article published on the results of the award

G.2.3.Outcomes and impacts

While VIRUSEND has been proven to be effective against COVID-19, the next step was to test whether the spray could be useful in the NHS. The Medical Health Research Authority has conducted an evaluation of VIRUSEND in LTHT using observations, interviews and questionnaires. The aim was to "*determine the clinical environments where VIRUSEND Spray offers most potential, barriers and enablers to implementation at organisational, ward and individual levels, and any unintended consequences*".[40] For this study, the Leeds Hospital purchased 2k VIRUSEND bottles and the user response has been extremely positive. In particular, participants have "*found VIRUSEND easy to use and were enthusiastic about the*

[38] https://virusend.co.uk/product/virusend-refill-box-12-365ml/

[39] https://www.amazon.co.uk/Military-Disinfectant-Powerful-Eliminates-Surfaces/dp/B08T24L16C/ref=zg_bs_22813818031_45/262-7145858-3695755?pd_rd_i=B08T24L16C&psc=1

[40] https://www.hra.nhs.uk/planning-and-improving-research/application-summaries/research-summaries/clean-clinical-evaluation-virusendtm-covid-19/

product and its functionality." Hence, in November 2020, the UK Research Ethics Committee (REC) gave a favourable opinion towards the use of VIRUSEND in healthcare environments.

Around 50k bottles of VIRUSEND disinfectant have been deployed to military personnel across the country who are working alongside the NHS at coronavirus testing stations as part of the military's ongoing support to civil authorities.[41]

VIRUSEND has also been proven to be effective against other viruses (e.g. Common Cold, Influenza, and Respiratory syncytial virus) and bacteria (e.g. E.coli, Salmonella), further contributing to mitigating the effects of the current pandemic and proving its potential usefulness for future pandemics.

VIRUSEND has also formed a partnership with Rowdown Inspire to Aspire Foundation, a charity that provides funding to enable gifted pupils at Rowdown (New Addington) to pursue an area of talent, to distribute the spray across 13 different schools to protect thousands of students and staff. This further increases the societal impact of the spray, at it allows students to continue their studies within a classroom environment with the highest possible levels of protection.

Key outcome and impact indicators

KPI: Improved management of COVID-19 pandemic, including solutions to social-distance challenges – VIRUSEND is being used at several public schools.

KPI: Effective management of the economic impacts of COVID-19, including businesses able to safely re-open to the public – VIRUSEND can be used to disinfect the workplace efficiently.

G.2.4.Impact pathways

One of the main risks of this award was the relatively short timeframe to obtain the necessary certification to use VIRUSEND within a healthcare context. However, the spray is available to consumers and has clearly demonstrated its market value and usefulness, as tens of thousands of units have already been sold.

The wide range of viruses and bacteria against which VIRUSEND is effective, as well as its quick disinfection-time, can decisively contribute to safer work environments and allow businesses to remain safely open to the public. From a healthcare perspective, its quick disinfection rate can help cleaning hospital facilities in a faster but effective way, therefore reducing patient turnaround time and allowing healthcare professionals to see more patients.

G.2.5.Sources

- Gateway to research data, retrieved from:
  https://gtr.ukri.org/projects?ref=77807#/tabOverview
- Health Research Authority, retrieved from:
- https://www.hra.nhs.uk/planning-and-improving-research/application-summaries/research-summaries/clean-clinical-evaluation-virusendtm-covid-19/
- Annual Report 2020/2021 Liverpool School of Tropical Medicine, available at: https://www.lstmed.ac.uk/sites/default/files/content/publications/attachments/LSTM_Annual%20Report%202020-21-Digital_0.pdf
- Royal Russel webpage, retrieved from:
  https://www.royalrussell.co.uk/discover/community/community-engagement

[41] https://www.gov.uk/government/news/army-develops-spray-to-kill-coronavirus

G.3. Short case study 3 - Strengthening the power of research collaboration to unmask the virus

UKRI investment type	STFC Legacy investment – multiple projects		
Award holder (PI)	N/A	**Institution/ organisation**	Diamond Light Source
Award size	N/A	**Award duration**	N/A
Summary			
Diamond Light Source, the UK's national synchrotron science facility, supports national and international researchers by providing access to its world class facilities. During the pandemic, Diamond has established a mechanism for rapid access for researchers who require instrument time for projects directly related to SARS-CoV-2 viral proteins. Additionally, it has redirected internal resources to work on COVID-19 and making those research results and data available to other researchers. Thanks to these enabling efforts, researchers are developing a general understanding of the virus' structure, working on new vaccine design and efficiency, enabling drug development (including both new drugs and re-purposing existing drugs) and developing new therapies.			

G.3.1.Description of the award

Diamond Light Source is the UK's national synchrotron science facility, located at the Harwell Science and Innovation Campus in Oxfordshire. It is a not-for-profit limited company founded in 2002 as a joint venture between what are now UKRI and Wellcome. Over 14k researchers from across the life and physical sciences from academia and industry use Diamond to conduct experiments, assisted by around 700 staff.[42] Diamond is considered one of the most advanced scientific facilities in the world, and it has been crucial in advancing the knowledge.

Since the beginning of the COVID-19 pandemic, researchers at Diamond have been working on over 60 projects aimed at enhancing the scientific knowledge about COVID-19 and how to combat it. In particular, researchers have undertaken work into identifying new drug targets, on the spikes, receptor binding and the main protease of SARS-CoV-2. Diamond has enabled the study of how new and existing drugs, that have already been tested and approved for other diseases, can be repurposed and used to treat COVID-19 patients.[43] This has been possible due to its XChem platform (an X-ray structure-accelerated, synthesis-aligned lead discovery engine), which allows structural biologists to screen up to 500 structures a day.

Considering the urgency of COVID-19, Diamond has worked quickly to activate existing and new collaborations with individual research groups and other national institutions. This includes seven researchers at Diamond (Walsh and von Delft groups), researchers from the Weizmann (London group), and Exscientia Ltd. Diamond has established links with Public Health England (Carroll group), Shanghai (Rao group), Beijing (Wang group) and the University of Oxford (Owens group). In addition to the drug discovery work, Diamond has worked on the accuracy of lateral flow devices and the effect of the illness on the lungs, as well as looking at the effectiveness of vaccines and treatments.

Diamond has been redirecting internal resources to work on COVID-19 and making their research results and data available to help other researchers. It established a mechanism for rapid access instrument time for researchers on projects related to SARS-CoV-2 viral proteins.[44]

[42] https://www.diamond.ac.uk/Home/About.html

[43] https://www.diamond.ac.uk/Home/News/LatestNews/2021/11-05-21.html

[44] https://www.diamond.ac.uk/covid-19/for-scientists/rapid-access.html

G.3.2.Outputs

The suite of instruments at Diamond have been crucial for researchers to improve their understanding of how the SARS-CoV-2 virus spreads and also how complications arise when mimicking the virus in vaccines. This research has contributed to finding therapies and alternative targets to the spike protein, as its rapid mutations threaten the effectiveness of current vaccines and antibody therapies.

Diamond played a major role in identifying new drug targets and is now enabling the study of how existing drugs, that have already been tested and approved for other diseases, can be repurposed and used to treat other patients. The array of specialised tools and instruments at Diamond, along with the scientific and technical expertise of its staff, allow for many different techniques to be used, from looking at the structure of the virus and fitting drugs into it, to taking direct images of the virus without its infectious material, making it possible to see how it interacts with drugs.

A summary of notable outputs of Diamond supported COVID-19 research is provided below.

Researchers uncover how the SARS-CoV-2 virus spreads at the celluar level and how complications arise when mimicking the virus in vaccines

A team of 20 researchers led by Dr Luiza Mendonça (Wellcome Trust Centre for Human Genetics, University of Oxford, Oxford, UK) have used Diamond facilities to reveal that the SARS-CoV-2 virus completely re-organises the cell when replicating and preparing to release. In particular, the research team have used multiple image techniques (such as cryo-electron microscopy and soft X-ray cryo-tomography) and saw that virus replication and assembly was confined to localised compartments within the cell, which explains how the virus replicates so efficiently. Understanding these mechanisms will help researchers to find new drugs and treatments for COVID-19. Two publications resulted from this work.

Studying the relationship between vaccines and blood clots

A team of 24 researchers from the School of Medicine at the University of Cardiff, Wales and a range of US institutions have used Diamond's facilities to study what mechanical interactions could be causing the blood clots associated with some vaccines.[45] They focused on adenoviruses (used by the virus to transmit SARS-CoV-2 proteins in the body during infection), which can be injected safely and present SARS proteins to the immune system and prepare it for when a real SARS virus comes along. However, there was an autoimmune response that in certain patient groups against one of their own proteins called PF4, which explained the development of blood clots. Data collected at Diamond's I03 Macromolecular Crystallography (MX) beamline as well a vast database from previous experiments to run simulations were crucial to uncover the mechanisms behind the blood clots.

Drug compounds ready for clinical trials

Diamond is a member of the COVID Moonshot, a non-profit, open-science consortium, formed in 2020 to identify new drug molecules that could block the SARS-CoV-2 infection and develop an antiviral drug that would be globally affordable and easily manufactured. The collaboration has successfully identified five compounds, which are going into clinical trials.

A new approach to treat COVID-19

Research led by scientists at the Rosalind Franklin Institute, and including researchers from Diamond, Oxford University and Public Health England, has shown that nanobodies – a smaller,

[45] https://www.science.org/doi/10.1126/sciadv.abl8213

simple form of antibody generated by llamas and camels – can effectively target the SARS-CoV-2 virus. This unique type of tiny antibody could provide a new frontline treatment against COVID-19 that can be taken by patients as a simple nasal spray. The nanobodies, which bind tightly to the SARS-CoV-2 virus, neutralising it in cell culture, could provide a cheaper and easier to use alternative to human antibodies taken from patients who have recovered from COVID-19. Human antibodies have been a key treatment for serious cases during the pandemic, but typically need to be administered by infusion through a needle in hospital. The nanobodies have significant potential for both the prevention and treatment of COVID-19.

Key outputs and output indicators

KPI: Number of publications: Over 30 academic journal articles e.g. Silvestrini, L., Belhaj, N., Comez, L. et al. (2021) The dimer-monomer equilibrium of SARS-CoV-2 main protease is affected by small molecule inhibitors. *Sci Rep* **11**, 9283. https://www.nature.com/articles/s41598-021-88630-9

KPI: Data, knowledge and understanding of COVID-19 for public health impact are generated rapidly – Diamond has supported national and international researchers by providing access to its facilities.

KPI: Communication materials – Diamond's work on COVID-19 related projects has been covered widely by the media.

KPI: Rapid increase in medical capability/capacity to address COVID-19 – Research at Diamond has provided insights on the relationship between vaccines and blood clots + work on the effectiveness of vaccines (policy impact by providing accurate data for decision making).

KPI: Research & innovation delivered at pace – Diamond is a legacy investment that enabled researchers and Diamond itself to respond rapidly to the R&I needs of the pandemic

G.3.3.Outcomes and impacts

The suite of facilities provided at Diamond have been essential for researchers to improve their knowledge on the virus behind the pandemic to find new drugs and novel treatments for the virus. As a result, Wellcome has provided strategic investment to support clinical work for 5 of the most promising drug compounds from the early discoveries at Diamond.

Diamond provided time-critical data and resources to researchers, helping them to identify crucial areas of research (such as the relation between vaccines and blots clots as well as the effectiveness of vaccines on new strains). This has contributed to the improved public understanding of COVID-19 and to the better management of future pandemics and other unexpected events.

Key outcome and impact indicators

KPI: Time-critical data & Speed at which results were produced from awards – Researchers have used Diamond's facilities to conduct cutting-edge research at a rapid pace. Publications and news items have been rapidly produced by researchers and Diamond.

KPI: Increase in openness in research and research focused on societal challenges – Diamond has committed to share results openly with other researchers to further support R&I on COVID-19 and its impacts [there is a dedicated website: https://www.diamond.ac.uk/covid-19.html]

A.1.2.Impact pathways

One of the main reasons behind Diamond's ability to contribute quickly and decisively to enhance the scientific knowledge on COVID-19 was the prior investment from Wellcome and UKRI on its world-leading facilities. This has allowed Diamond to be at the forefront of scientific research and enabled researchers to develop a substantial number of projects and international collaborations in a short period of time.

Researchers at Diamond have also made their studies and results readily available to promote the dissemination of information amongst the scientific community and wider public. This has

decisively contributed to the rapid advance of knowledge across the different research fields and has strengthened the collaboration amongst both national and international researchers during the pandemic.

G.3.4.Sources

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G.4. Short case study 4 - Exploration of Human Rights in locked-down care homes during the COVID-19 Pandemic

Award title	Ensuring Respect for Human Rights in Locked-Down Care Homes (AH/V012770/1)		
UKRI investment type	COVID-19 Agile Call (AHRC)		
Award holder (PI)	Prof Wayne Martin	**Institution/ organisation**	University of Essex
Award size	£172,980	**Award duration**	15/02/11/2020 – 01/11/2021
Summary			
This award involved a survey, mapping out restrictions to the movement and transfer of care home residents as well as changes to "Do Not Attempt Cardio-Pulmonary Resuscitation" (DNACPR) decisions in the context of the COVID-19 pandemic and resulting lockdowns. The findings have been formulated into series of Webinars presented to practitioners and decision-makers in the field, and the team has provided evidence to one key Parliamentary Committee, the Ministry of Justice, DHSC, the National Mental Capacity Forum and regional NHS bodies. Due to active dissemination, the findings have also added to voices of concern regarding issues around DNACPR and moved on to consider ethical implications around the COVID-19 Status Certifications			

G.4.1.Description of the award

This AHRC award examined three common practices in care homes during the pandemic: blanket restrictions on the movement of residents and visitors, restrictions on transferring unwell residents to acute-care hospital facilities, and the blanket use of "Do Not Attempt Cardio-Pulmonary Resuscitation" (DNACPR) decisions without the consultation of the patient or their families.

The award examined all three of the above practices with the aim of determining ways to best ensure the protection of human rights in care homes both, during the initial stages of the COVID-19 pandemic, and after emerging to the 'new normal'. The team posed two questions:

- How should the human rights to life, liberty and non-discrimination (enumerated in the Human Rights Act) be interpreted and applied to these three practices in the context of a public health emergency?
- How can existing roles (e.g. best-interest assessors) best be adapted to help ensure respect for the human rights of residents who are living (or dying) in locked-down care homes?

The award was led by Professor Wayne Martin from the School of Philosophy and Art History with Professor Sabine Michalowski from School of Law as a Co-Investigator, both at University of Essex[46]. The research team included Dr Margot Kuylen, Dr Vivek Bhatt and Dr Aaron Wyllie from the university and organisational partners, Shropshire County Council, 39 Essex Chambers and the National Mental Capacity Forum.[47] The award is a part of the Essex Autonomy Project, a multi-disciplinary research initiative founded in 2010 with the aim to clarify the ideal of self-determination in history, theory and practice.

The team built and launched a survey for care professionals who had worked in residential care facilities during the COVID-19 pandemic. The survey received 262 responses, and 22 of the responding professionals participated follow-on focus groups.[48]

[46] https://gtr.ukri.org/projects?ref=AH%2FV012770%2F1

[47] https://gtr.ukri.org/projects?ref=AH%2fV012770%2f1&pn=0&fetchSize=10&selectedSortableField=date&selectedSortOrder=ASC

[48] https://committees.parliament.uk/writtenevidence/40624/pdf/

G.4.2.Outputs

Since late 2020, the team produced a number of outputs enabling an increased understanding of COVID-19 and measures to address its impacts in care homes. In December 2020, a chapter titled 'Discrimination, Triage, and Denial-of-Treatment: Lessons from COVID-19 in the UK' by Professor Martin was published in 'Tackling Torture: Victims with Disabilities in the COVID-19 Outbreak'. The chapter communicates the differentiated impact that the pandemic has had on people with protected characteristics.

In March 2021, the Conversation published a short article by Dr Kuylen and Professor Martin. The article discussed the issues around DNACPR, and whether the decisions not to attempt cardio-pulmonary resuscitation had influenced medical decisions beyond CPR. Citing a finding from the award, the article concluded that in nearly one out of five times this was the case.[49] In the same month, Professor Martin delivered a webinar on 'Liberty, Proportionality and Human Rights in Locked-Down Care Homes' as a part of the Switalskis Mental Capacity Act Webinar Series 2021.[50] The series is a dedicated space for discussing the latest thinking in Mental Capacity Law and an avenue to educate relevant sectors and increase the openness of research.

Prior to the pandemic, the annual conference preceding the above webinars (Annual Review of the Mental Capacity Act 2005) attracted over 300 people in 2019, while the 2021 webinar series is still accessible online, enabling a wide-spread engagement.[51] Later on, in July, Professor Martin took part in episode three of the 'Pandemic and Beyond' podcast in which he spoke to a Senior Fellow at the Institute of Mental Health, Victoria Tischler, about the impact of COVID-19 in care homes.[52] In the same month, the research team also published a survey report (later revised in October 2021) summarising the findings from an online survey they conducted with professionals working at and with care homes across England and Wales. The survey residents' access to health care, types of guidance used, and whether DNACPR decisions were added to residents' files without their consultation.[53] These activities have contributed to academic knowledge as well as the public's knowledge of the measures to addressing the pandemic.

Key outputs and output indicators

Data, knowledge and understanding of COVID-19 for public health impact are generated rapidly – The award produced their findings quickly and shared the results with the wider academic community and the public

KPI: Communication materials generated - Pandemic and Beyond, (2022), Episode 3: Human Rights in Care Homes with Professor Wayne Martin and Angela Rhodes. [podcast]

KPI: at least seven Publications – for example, Martin, W. (2020), Discrimination, Triage and Denial-of-Treatment: Lessons from COVID-19 in the UK, in Allen, S., (ed) Tackling Torture: Victims with Disabilities in the COVID-19 Outbreak, pp. 23-37, Validity Foundation, https://www.researchgate.net/publication/347707836_Discrimination_Triage_and_Denial-of-_Treatment_Lessons_from_COVID-19_in_the_UK

G.4.3.Outcomes and impacts

Information collected and analysed in this award was used to help care professionals and policy makers alike to protect human rights in care homes. The Webinars have been made

[49] https://theconversation.com/care-homes-evidence-emerging-of-inappropriate-use-of-do-not-attempt-cpr-orders-during-pandemic-157921

[50] Full webinar: https://vimeo.com/519933357?embedded=true&source=video_title&owner=125532913

[51] https://www.switalskis.com/conferences/

[52] https://pandemicandbeyond.exeter.ac.uk/media/podcasts/

[53] https://autonomy.essex.ac.uk/wp-content/uploads/2021/10/Basic-Survey-Report_abridged_v2.1.pdf

available to front-line workers in the care sector during the pandemic, providing the opportunity to explore the dilemmas of practice and disseminate authoritative guidance and to exchange information.[54] The team's work in delivering the webinars was reported to and published by the Government,[55] they served both as a training opportunity for frontline workers and as a data-gathering exercise to use in informing policy development.

The award directly enabled the team to engage with regulatory bodies and government to inform the decision-making process. Advisory support was provided to the ethics committee of a local NHS Foundation Trust on ethical issues around the high demand for ICU services. The team's subsequent focus on the ethical and human rights aspects of the COVID-19 Status Certificates have also been considered by the Scottish Human rights Commission and have influenced debates in UK Parliament via a rapid-response analysis of human rights issues arising from COVID-19 Status Certifications produced at the request of Dr Ben Spencer MP.[56]

The award's findings add to a growing body of concern around DNACPR decisions during the pandemic, exemplifying the need of research focused on societal issues. Reports by the Compassion in Dying and Care Quality Commission both aligned with the findings in the award around blanket DNACPR decisions being made without the consultation of the patient or their families, or with insufficient information about the subject.[57,58] The topic was written about in the Guardian around respecting individuals' human rights in connection to DNACPR decisions.[59]

The team submitted its findings to the Parliamentary Joint Committee on Human Rights, as part of its inquiry into Human Rights in Care Settings.[60] The Special Advisor to the Inquiry commented: "[This is] exactly the sort of gritty stuff that is needed to be able to ground recommendations." Prof Martin was invited to deliver oral evidence to the Committee based on this submission.[61]

Key outcomes and outcome indicators

KPI: Knowledge / understanding mobilised to inform policy decisions – the paper on the implications of COVID-19 Status Certificates informed Parliamentary deliberations on the topic, as well as human rights in care settings

KPI: Improved management of COVID-19 pandemic, including evidence-based public health advice, effective and targeted solutions (…) to addressing social inequalities, solutions to social distancing challenges – produced materials have enabled frontline staff to take human rights dilemmas into consideration in managing the COVID-19 response in care homes reducing negative social impacts of the pandemic.

KPI: Citations of publications supported by the intervention in policy documents (uptake) – The Scottish Human Rights Commission (2021), COVID-19 Status Certificates: Human Rights Considerations, URL: https://www.scottishhumanrights.com/media/2176/21_04_28_-covid-certificates-and-human-rights-vfinal.pdf

G.4.4.Impact pathways

The award benefitted considerably from existing connections, such as the Essex Autonomy Project (as a familiar Hub for expertise and visibility for award findings) and the collaboration

[54] https://gtr.ukri.org/projects?ref=AH%2FV012770%2F1

[55] UK Government in HM Government, National Mental Capacity Forum: Chair's Annual Report 2020-2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1057881/nmcf-chair_s-fifth-annual-report-2020-21.pdf

[56] https://www.scottishhumanrights.com/media/2176/21_04_28_-covid-certificates-and-human-rights-vfinal.pdf

[57] https://compassionindying.org.uk/wp-content/uploads/2021/03/Better-Understanding-Better-Outcomes-DNACPR-decisions-before-and-during-the-pandemic.pdf

[58] https://www.cqc.org.uk/news/stories/cqc-review-use-dnacpr-during-pandemic

[59] https://www.theguardian.com/society/2021/mar/18/blanket-do-not-resuscitate-orders-imposed-on-english-care-homes-finds-cqc

[60] https://committees.parliament.uk/writtenevidence/40624/pdf/

[61] https://parliamentlive.tv/event/index/8197df07-192b-409b-aa1f-79138937f7b3

with a local council, chambers and a national forum. This granted the team the additional space to communicate their resources for enhanced medical consideration quickly and effectively to the right people, to advocate for those involved and spread awareness. The Essex Autonomy Project's twelve-year history has retained experience in providing human rights workforce training to frontline care professionals. It thus provides considerable experience for the research team, as well as an established platform as an educator on matters related to protecting human rights in care professions.[62]

However, according to the PI, the most direct form of impact to date has been through direct communication with practitioners through materials like the Webinars, which were also co-hosted by the National Mental Capacity Forum. These webinars have each been attended by hundreds of frontline professionals, as well as by government officials with oversight responsibilities for care homes. Moreover, the webinars were recorded, and the recordings made available on the Essex Autonomy Project website and on the website of the Social Care Institute of Excellence. These have been reviewed thousands of times, effectively enhancing public and decision-makers' awareness of the full implications of COVID-19 to human life.[63]

G.4.5.Sources

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- Timeline of Essex Autonomy Project, URL: https://autonomy.essex.ac.uk/about-us/timeline/
- UKRI Award AH/V012770/1: Ensuring Respect for Human Rights in Locked-Down Care Homes, URL: https://gtr.ukri.org/projects?ref=AH%2FV012770%2F1

[62] https://committees.parliament.uk/writtenevidence/40624/pdf/

[63] Information from UKRI M&E survey, round 1-3

G.5. Short case study 5 - 'Barcoding' species in the Galapagos supports local communities hit by COVID-19

Award title	GCRF_NF143 Barcoding Galápagos: Recording and mitigating Covid-19 impacts using key-workers in eco-tourism (EP/V029118/1)		
UKRI investment type	GCRF Agile COVID-19 Rapid Response (UKRI/GCRF)		
Award holder (PI)	Dr Camille Bonneaud	**Institution/ organisation**	University of Exeter
Award size	£463,568	**Award duration**	21/08/2020 – 20/11/2021
Summary			
The Barcoding Galápagos award set out to catalogue rare species on the Galápagos Islands with locals employed and trained to collect samples from land and sea. The employment of those Galapageans helped mitigate the effects of the COVID-19 pandemic which heavily impacted the Islands' ecotourism economy and put local flora and fauna at imminent risk of harvesting for food and trade. The project met its goals, collecting over 10k species of which 30-40% were new to science in terms of their gene sequences. Over 70 citizen scientists conduct the sampling and testing, supporting the recovery of the local economy when it was needed most.			

G.5.1.Description of the award

The Galápagos Islands are a volcanic archipelago and province of Ecuador in the Pacific Ocean. They are an area of unique biodiversity, home to thousands of species that are found nowhere else on the planet. Scientists are in a race against time to catalogue these species to protect them from climate change, illegal species trafficking, invasive species, illegal fishing, and unsustainable tourism practices. However, lockdowns imposed in response to the COVID-19 pandemic halted the free movement of researchers and removed the tourism-based livelihoods of many local residents which typically makes up 80% of their income. This in turn threatens the biodiversity on which the Galápagos relies for its ecotourism as Islanders may turn to harvesting endangered species for food and trade, such as lobsters and sea cucumbers.

The University of Exeter led the Barcoding Galápagos award funded under the Global Challenges Research Fund (GCRF) rapid response programme to help support the Galápagos economy and protect its biodiversity. The award was led by Dr Camille Bonneaud at Exeter and included collaborators in the UK and in Ecuador: Prof Andrew Russell and Dr Tomas Chaigneau (University of Exeter, UK), Prof Carlos Mena, Prof Diana Pazmiño and Prof Jaime Chaves (Universidad San Francisco de Quito, Ecuador). The team have worked together before on conservation research and on undergraduate field courses for Exeter students. The Galápagos Conservation Trust (UK) and the Agencia de Bioseguridad de Galápagos (Ecuador) joined as local partners to help disseminate the results of the award.

This award aimed to ensure that: (1) the genetic profile of Galápagos was documented and curated so that the impacts of environmental perturbations can be quantified; and (2) naturalist guides (using a gender balanced selection), who are central to economic recovery for a population almost entirely reliant on ecotourism, receive immediate capacity-building employment; (3) the socio-economic consequences of the team's approach at the level of individuals and the community will be recorded to guide future attempts at using locally-driven research to improve the socio-economic well-being and resilience of key ecotourism workers.

The team employed (fully paid) residents as 'citizen scientists' and trained them to collect samples from land and sea, cataloguing the biodiversity of Galápagos, from microbe to mammal, using new genetic barcoding approaches. The 'genetic barcodes' can define connectivity between populations, identify sub-species and uncover the genetic signature of individuals within a specific area. The citizen scientists processed the samples in portable DNA sequencing machines set up in three island laboratories. Significant dissemination in schools and the wider community via the local partners was planned to extend the impact of this work.

G.5.2.Outputs

The now completed award met all its intended objectives within the one-year funded period, demonstrating a rapid response to supporting communities hit by the effects of COVID-19.

The citizen scientists' cataloguing of samples has achieved widespread coverage across the Galápagos' land and marine areas. The team registered over 10k species ranging from mammals to bonefish to snakes, fungi and plants, plankton and bacteria. Around 30-40% of the species found did not match any others in a global bank of gene sequences, meaning that this work was able to discover new species as well as catalogue known ones. Much of this was time critical data as some species (e.g. lobsters and sharks) were at risk of harvesting for food and trade due the ecotourism decline. The team was able to pay 74 citizen scientists to do this work (local guides, farmers and fishers) for the duration of the award, contributing to reducing social inequalities (via gender balanced hiring) and informing how research can contribute to economic recovery approaches from future pandemics.

No academic publications have yet been published directly linked to this award. However, the data collected at biological and societal levels was intended to be published on the topics of island biogeography and speciation. The data was planned to be archived online to be used as a new resource cataloguing the molecular signature of the biodiversity of Galápagos, so that comparisons can be made with old and future Galápagos datasets. Publications are planned on lessons learned during implementation to guide future approaches to similar research in the Galápagos and other vulnerable communities.

Several news articles were published at the launch of the award to raise awareness (e.g. by UKRI[64]) and to recruit citizen scientists.[65] A subsequent news article summarised the results and sharing images from the field work.[66] There were plans for the Galápagos Conservation Trust to disseminate the work into schools to highlight the long-term benefits of sustainable natural resources for employment and education.

Key outputs and output indicators

Daily Mail (24 August 2021) Local citizen scientists map genetics of Darwin's Galápagos. Available at: https://www.dailymail.co.uk/wires/ap/article-9922323/Local-citizen-scientists-map-genetics-Darwins-Galapagos.html

KPI: Time elapse between grants and data and knowledge generated & how UKRI response enabled R&I at pace – objectives completed and findings disseminated in the news by the end of the award

KPI: Data sources and solutions generated to address recovery and reopening of the economy – the team were able to hire locals in the award, supporting economic recovery

KPI: Communications materials – News article published on the results of the award

[64] From report: UKRI (2021) Evaluation Report - Tackling COVID-19 Strategic Priority. Link to post: https://www.facebook.com/weareUKRI/photos/a.170860879754292/1597718643735168/?type=3&theater

[65] Galapagos Science Centre (2020) Barcode Galapagos. Available at: https://galapagosscience.org/galapagos-barcode-2/

[66] Daily Mail (24 August 2021) Local citizen scientists map genetics of Darwin's Galapagos. Available at: https://www.dailymail.co.uk/wires/ap/article-9922323/Local-citizen-scientists-map-genetics-Darwins-Galapagos.html

G.5.3.Outcomes and impacts

Figure 6 Training on DNA extraction

Source: Daily Mail

The approach of hiring and paying Galapagean citizen scientists helped reduce the societal impacts of COVID-19 by supporting those residents financially for nine months during a severe downturn in ecotourism income. One resident who participated in the programme said: *"This is the first science project in the Galápagos that has been done with Galápagos citizens, which we have always wanted to participate in, but hadn't been given the opportunity, I'm happy to be doing science."*[66] This suggests the work was able to help mitigate the negative economic effects of travel bans due to COVID-19 in the Galápagos by providing some locals with employment who would have otherwise been hit hard by the loss in ecotourism. It also informs future methodologies as its approach was novel in its implementation by involving locals as citizen scientists.

The award contributed more widely to the UN Sustainable Development Goals (SDGs), which is a condition of GCRF awards. First, by conducting an extensive scientific survey of the fauna and flora (including microbial) present in the islands' marine and terrestrial ecosystems, the award contributed to the careful and sustainable management of life below water (SDG14) and life on land (SDG15). Second, by providing infrastructure and training on key sampling and transferrable molecular techniques, this award provided quality education (SDG4) and built local capacity and resilience, with implications for well-being (SDG3) and socio-economic growth (SDG8). Third, it provided jobs contributing to the Islands' sustainability (SDG8) for naturalist guides and support services (e.g. transportation) usually entirely dependent on tourism, thereby helping to alleviate poverty (SDG1) caused by the COVID-19 pandemic. Finally, by ensuring the employment of an even number of women and men across the project, this award furthered gender equality (SDG5) in a field that is still largely male-dominated.

Key outcome and impact indicators

KPI: Examples of improved management of COVID-19 pandemic, including approaches to addressing social inequalities – The team hired a gender balanced citizen science team

KPI: Speed at which results were produced from awards - News article published on the results of the award before the funding period ended

KPI: UKRI COVID-19 projects with objectives around capturing time-critical data – The award contributed to preventing the harvesting of rare flora and fauna that may have happened due to the negative economic effects of COVID-19 on the local population

Reduced societal impacts of COVID-19 – the hiring of locals reduced the negative economic effects of COVID-19 on the local population

G.5.4.Impact pathways

The hiring of local citizen scientists was a key mechanism for achieving socio-economic impact in terms of reducing the negative effects of the downturn in ecotourism. The training contributed to capacity building and resilience in the local population post-award (e.g. further employment as researchers and medical staff). The rapidity of the project funding also helped to further mitigate both those economic effects but allowed for the collection of time critical data, preventing some of the harvesting of local biodiversity. The team's prior relationship was likely a factor in their ability to respond quickly to UKRI's call for proposals, as well as their having the equipment and barcoding method ready to deploy.

G.5.5.Sources

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G.6. Short case study 6 - Uncovering the differences between RNA and DNA vaccines for COVID-19

Award title	Identification of host cell components essential for the SARS-CoV-2 life cycle (BB/V011316/1)		
UKRI investment type	COVID 19 Agile Call – Biotechnology and Biological Sciences Research Council (BBSRC)		
Award holder (PI)	Prof Allan Bradley	**Institution/ organisation**	University of Cambridge
Award size	£451,937	**Award duration**	08/07/2020 – 07/01/2022
Summary			
This award aimed to identify non-essential host (human) cell components that were required for the life cycle of the SARS-CoV-2 virus. If successful, this could provide critical intervention points for developing drugs that could prevent SARS-CoV-2 virus infection or hamper viral replication. Researchers at the University of Cambridge have discovered that the common method of using DNA transfected into a mammalian cell did not yield as much of the necessary spike protein that the body's immune system recognises. They identified this as a splicing issue, resolved it, and have produced several fold improvements to pseudo-type virus titres.			

G.6.1.Description of the award

The development of vaccines that work against SARS-CoV-2 have helped change the course of the pandemic by reducing illness, hospital admissions and deaths from the virus.[67] There are currently two main type of COVID-19 vaccines:

- **Messenger RNA (mRNA) vaccine**: this works by creating pseudo-versions of the SARS-CoV-2 virus that teach human cells how to make a protein that will trigger an immune response
- **Vector vaccine:** this is based on adenovirus DNA vectors as carriers for the genetic information for the SARS-COV-2 spike glycoprotein[68]

The award, led by Dr Allan Bradley and Dr Kart Tomberg (Co-Investigator) from the Cambridge Institute of Therapeutic Immunology & Infectious Disease (CITIID), Department of Medicine at the University of Cambridge, aimed to study the life cycle of the SARS-CoV-2 virus and identify any non-essential human cell components. The researchers developed a cell-based system consisting of a cell line expressing Cas9, ACE2 and TMRPSS2 (the virus receptors). A key technical requirement is that the cell needs to be highly infectible, ideally close to 100%, with a lentivirus in which the envelope has been changed to become SARS-Cov-2 spike protein (pseudo-typed). The results of this research could provide critical intervention points for developing drugs that could prevent SARS-CoV-2 virus infection or hamper viral replication.

Other researchers involved in the award include Liliana Antunes and Dimitrios A. Garyfallos (both from CITIID), YangYang Pan (CITTID and College of Veterinary Medicine, Shanxi Agricultural University, Taigu, China), Jacob Hepkema (Wellcome Sanger Institute, Hinxton, UK) and Ahmed Mahfouz (Department of Human Genetics, Leiden University Medical Center, Leiden; and Delft Bioinformatics Lab, Delft University of Technology, Delft).

G.6.2.Outputs

As a first step, researchers were able to develop the methods to express SARS-Cov-2 protein to achieve efficient pseudo-typing. However, they realised that none of these methods were optimal. After further investigation, they discovered that expressing a spike protein from a DNA vector (e.g. adenovirus platforms) transfected into a mammalian cell is highly inefficient. Most

[67] https://www.bmj.com/content/376/bmj.o298

[68] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8168329/

of the mRNA does not yield full length spike protein, or any protein in the correct reading frame. The resultant viral particles are not very infectious, presumably due to the low spike protein density. This observation may help advance the understanding for vaccines launched from a DNA vector.

Aside from this key finding, the researchers have tested their improved S-protein vectors as DNA-vaccines in mice and were able to obtain neutralising antibodies which were not achieved with other S-protein DNA constructs. This aspect of the work has been protected with a patent application (covering the use of intronization for enhanced protein expression) as the discovery has many potential applications. A summary of the main findings can be found in a pre-print version of the paper submitted to BioRxiv.

These findings help explain why the neutralising antibody titres (amounts) achieved with the RNA launched (Moderna, Pfizer/BioNtech) and protein launched (NovoVax) vaccines are several orders of magnitude higher than those achieved from adenovirus platforms (AZ/Oxford, Johnson and Johnson, Sputnik). The reporter cell lines developed to support this research can also improve the efforts with other laboratories and industrial partners, which could lead to new clinical solutions in terms of COVID-19 treatments. Having a better understanding of the relationship between the different types of vaccines available and COVID-19 is crucial to achieve a more effective clinical and medical management of future pandemics.

Key outputs and output indicators

KPI: Publication: Academic journal article: Intronization enhances expression of S-protein and other transgenes challenged by cryptic splicing. Kärt Tomberg, Liliana Antunes, YangYang Pan, Jacob Hepkema, Dimitrios A. Garyfallos, Ahmed Mahfouz, Allan Bradley. bioRxiv 2021.09.15.460454; doi: https://doi.org/10.1101/2021.09.15.460454

KPI: New technologies: Patent: the work has been protected with a patent application (covering the use of intronization for enhanced protein expression)

G.6.3.Outcomes and impacts

The findings of this research have solved the expression problem with DNA vaccines. This opens up an interesting opportunity as DNA is more stable than RNA and fewer copies should be needed per cell than RNA-based vaccines. The researchers have made contacts with different companies to maximise the potential of the discovery. Other investors have shown an interest in a DNA vaccine platform and application to other aspects of transgene expressions, such as Chimeric antigen receptor (CAR) T-cells, which could be used to treat certain blood cancers.[69]

Key outcome and impact indicators

KPI: Increased efficiency of clinical solutions to COVID-19 – the research findings could lead to new clinical solutions, including treatment and vaccines.

G.6.4.Impact pathways

While the plan of this award was hindered by some unexpected results at the early stages, the research team was able to identify the issue and find a solution. Thanks to their alternative approach, researchers were able to provide an explanation as to why different vaccine platform types achieve different antibody titres, which can significantly contribute to the

[69] https://www.cancer.gov/publications/dictionaries/cancer-terms/def/car-t-cell-therapy

development of effective future vaccines, both for the current SARS-CoV-2 pandemic, and future pandemics.

G.6.5.Sources

- Gateway to research data, retrieved from:
- https://gtr.ukri.org/projects?ref=BB%2FV011316%2F1#/tabOverview
- COVID Agile call survey rounds 1-3
- Intronization enhances expression of S-protein and other transgenes challenged by cryptic splicing. Kärt Tomberg, Liliana Antunes, YangYang Pan, Jacob Hepkema, Dimitrios A. Garyfallos, Ahmed Mahfouz, Allan Bradley. bioRxiv 2021.09.15.460454; doi: https://doi.org/10.1101/2021.09.15.460454

G.7. Short case study 7 - Addressing racial discrimination in the health sector in the COVID-19 Pandemic

Award title	Identifying and mitigating the impact of COVID-19 on inequalities experienced by people from BAME backgrounds working in health and social care (ES/V009931/1)		
UKRI investment type	COVID-19 Agile Call (ESRC)		
Award holder (PI)	Prof Stephani Hatch	**Institution/ organisation**	King's College London (KCL)
Award size	£506,200	**Award duration**	13/07/2020 –12/01/2022
Summary			
The team set out to understand how the discrimination of patients and healthcare practitioners may perpetuate and generate inequalities in health professions and service during the COVID-19 pandemic. The ESRC award enabled the team to develop training materials and the Race Equality Assessment Toolkit to help make discrimination visible in these spaces. The findings have been disseminated in a number of advisory boards for public and third sector entities, and the team was invited to produce a report on improving Race Equality in Health and Social Care as a part of the Race Equality Action Plan for the Welsh Government.			

G.7.1.Description of the award

The NHS is the largest employer of racial and ethnic minority staff in the UK with at least 20% of its workforce coming from those backgrounds. However, racial and ethnic minority healthcare workers experience greater levels of workplace harassment and racism, receive lower pay, have fewer decision-making powers, and predominate in lower grade roles compared to white staff. Together, these issues negatively affect mental health and occupational outcomes. The wider UK racial and ethnic minority population has also suffered disproportionally more from COVID-19 infections and deaths than other groups, a further health and social burden on racial and ethnic minority workers in the NHS during the pandemic.[70]

This award aimed to examine racial and ethnic inequalities in mental health and occupational outcomes among NHS staff, how COVID-19 exacerbated these inequalities, and the processes through which such inequalities are produced, maintained and resisted in an effort to avoid exacerbating the social and economic costs of mental ill health and worse occupational outcomes. This study builds on the existing Tackling Inequalities and Discrimination Experiences in health Services (TIDES) study[71] funded by Wellcome, which investigates how discrimination of patients and healthcare practitioners serves to create, perpetuate and generate inequalities in health and health service use.

The team was led by Professor Stephani Hatch from KCL (head of the Health Inequalities Research Group). It involved 12 academics from other universities and three peer researchers from three NHS trusts who supported engagement and consultation activities to inform the study design and procedures along with an Advisory Group, and wider Stakeholder Opinion Group comprising of clinical academics, experts by experience, senior leaders and healthcare staff from across the UK. The award was led by KCL with representatives from the NHS Workforce Race Equality Standard, NHS England and NHS Improvement, NHS Confederation, Black Thrive Global, Challenge Consultancy, Maudsley Learning and the Royal College of Nursing.

[70] https://gtr.ukri.org/projects?ref=ES%2FV009931%2F1

[71] https://tidesstudy.com

The TIDES team worked alongside the NHS CHECK study[72], an ongoing longitudinal study of the impact of the COVID-19 pandemic on the short and long-term health and wellbeing of all staff working within 18 partner NHS Trusts nationally, to co-develop an "Inequalities survey" with the TIDES team and incorporate it into NHS CHECK.

The research team carried out in-depth interviews with three samples: racial and ethnic minority NHS staff from the NHS CHECK study, TIDES phase 1 participants interviewed prior to the pandemic and senior NHS staff to investigate structural contexts and mechanisms. The team aimed to develop a Race Equality Assessment toolkit and Virtual Reality (VR) training resources. These will enable managers and staff to 'walk in the shoes of' ethnic minoritised staff in occupational roles most affected by racism, discrimination and other workplace adversity. Racial and ethnic minority service users and staff helped develop surveys, co-led interviews, and helped cocreate the toolkit and training resources.[70]

G.7.2.Outputs

Data from the phase 1 TIDES survey identified women, racial and ethnic minority staff, migrants, nurses, and healthcare assistants in the workforce as being most at risk of discrimination and harassment, and that these factors were associated with probable anxiety or depression.[73] The interviews unveiled racialised organisational hierarchies maintained by actions such as micro-aggressions, bullying, prejudice, exclusion and scapegoating behaviours. These behaviours were linked to intersecting factors such as race, migration status, religion and language, and were found to potentially increase segregation among the workforce.[74]

The team has produced seven open access publications (four published during the grant). These focused on key areas such as inequalities in psychiatric referral pathways, discrimination-related factors behind lower levels of COVID-19 vaccination uptake, the impact of discrimination on staff mental health and job intentions, and how the working environment maintains racialised inequalities in the workplace. The team enhanced the accessibility of these findings by producing engaging summaries available on the TIDES website and via four bitesize videos in their TIDES Video Series.[75]

The team presented organisational approaches to racial discrimination in the sector in two reports for the Wales Centre for Public Policy about improving Race Equality in Health and Social Care, and racial inequalities in employment and income.[76] The first report outlines evidence-based strategies for reducing racial inequities in health and social care systems, including training, open discussion, and discrimination reporting procedures. These form part of a series of six reports commissioned by the Centre providing independent evidence for the development of the Welsh Government's Race Equality Action Plan.[77]

The Race Equality Assessment Toolkit is now being co-developed to improve the workplace experiences of racial and ethnic minoritised NHS staff, by improving the culture and wellbeing of services for all staff through evidence led solutions. It is being created to help make sure that

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[72] https://nhscheck.org - funded by MRC, ESRC, UCL/Wellcome, Rosetrees Trust, NHS England and Improvement, Manolo Blahnik International Limited, as well as seed funding from National Institute for Health Research Maudsley Biomedical Research Centre, King's College London, National Institute for Health Research Health Protection Research Unit in Emergency Preparedness and Response at King's College London.

[73] https://pubmed.ncbi.nlm.nih.gov/33323151/

[74] https://onlinelibrary.wiley.com/doi/10.1111/1467-9566.13414

[75] https://www.youtube.com/channel/UC5ZqMvNytYwZOFUBAz7m7XA/playlists

[76] https://www.wcpp.org.uk/wp-content/uploads/2021/03/Improving-Race-Equality-in-Employment-and-Income.pdf

[77] https://www.wcpp.org.uk/wp-content/uploads/2021/03/Improving-Race-Equality-in-Health-and-Social-Care.pdf

the perspectives and lived experiences of racial and ethnic minoritised staff are prioritised in the education, research, and clinical applications for all NHS staff. It will also strengthen the development of education and training resources designed to reduce inequalities experienced by ethnic minoritised staff. It is planned to feature Virtual Reality training simulations named 'Walking in the Shoes of…' informed by data collected in the first and second phases of TIDES. The simulations are being piloted with TIDES collaborations in the NHS.

While the Toolkit was under assessment at the time of the latest update, the research team produced all other listed outputs within the award period, enabling rapid impact.

Key outputs and output indicators

KPI: Publications and communication materials – Nine, including: Rhead, R., et al. (2020), The impact of workplace discrimination and harassment among NHS staff working in London Trusts: Results from the TIDES study, British *Journal of Psychiatry Open*, 7, 16 Dec 2020, e10, 1-8 DOI: 10.1192/bjo.2020.137

KPI: knowledge / understanding mobilised to inform policy Decisions - Hatch, S., et al. (2021), Improving Race Equality in Health and Social Care, Wales Centre for Public Policy

G.7.3.Outcomes and impacts

While some outputs are yet to be publicly released (e.g. simulations being piloted), the team has provided evidence-based approaches to addressing behavioural, health and wellbeing needs to decision-making bodies in health care policy. Members of the team have participated in several health taskforces and advisory committees with a national reach, including the Anti-racist practice in Nursing and Midwifery Stakeholder Group and the NHS Race and Health Observatory. Following invitation, the team have also shared insights with other stakeholders such as the UK's leading cross-party think-tank (Demos) and NIHR MindTech. The TIDES team were invited to deliver numerous presentations locally (e.g. across King's Health Partners and London Workforce Race Equality Standards (WRES) Expert Training Programme comprising of HR Directors and Chief Nurses across the London NHS workforce), regionally (e.g. Health Education England, East of England) and nationally (e.g. Chief Nursing Officers' BME Strategic Advisory Group, NHS England and NHS Improvement, Royal College of Nursing).

The award enabled the team to directly promote measures and good practices for the wellbeing of racially and ethnically marginalised populations. The Advancing Mental Health Equalities Taskforce oversees the implementation of the NHS Advancing Mental Health Equality strategy and aims to make systematic and demonstrable progress towards reducing mental health inequalities.[78] In a similar vein, the team used insights from their award to influence the Race Equality Action Plan for the Welsh Government in support of their vision of "*a Wales that is Anti-racist by 2030*".[79] This body of engagement work helps to showcase the need and potential for R&I in addressing societal challenges and reducing social inequality.

Beyond policy, the findings contributed to the evidence in developing a nationally distributed public health infographic by the NHS Health and Race Observatory, highlighting key recommendations to help leaders maximise COVID-19 vaccine uptake among ethnic minority groups.[80] This intervention was designed to alleviate fears about the vaccination among racial and ethnic minority populations, aiming to increase immunity in these populations and overall resilience to public health challenges. Once ready for release, the Race Equality Assessment

[78] https://www.england.nhs.uk/wp-content/uploads/2020/10/00159-advancing-mental-health-equalities-strategy.pdf

[79] https://gov.wales/sites/default/files/consultations/2021-04/race-equality-action-plan-an-anti-racist-wales-summary.pdf

[80] https://www.nhsrho.org/publications/maximising-uptake-of-the-covid-19-vaccine-for-ethnic-minority-people/

Toolkit and 'Walking in the Shoes of…' simulations are expected to contribute to the reduction of inequalities experienced by ethnic minority staff, and thus help improve health outcomes.

During this award, survey and interview participants, along with the NHS Peer Researchers and Advisory and Stakeholder Opinion Group members were offered the chance to attend Microaggressions workshops, facilitated by TIDES collaborator, Challenge Consultancy. Participants were given the opportunity to talk about microaggressions that they might experience or witness and were provided with structured ways to address them.

Key outcome and impact indicators

KPI: Examples of how UKRI's funded research and innovation supported actions that led to improved health outcomes – NHS Race and Health Observatory (2021), Maximising uptake of the COVID-19 vaccine for ethnic minority people, **https://www.nhsrho.org/wp-content/uploads/2021/03/RHO-vaccine-uptake-infographic.pdf**

KPI: Examples of lessons learned in terms of effective approaches to rapidly address societal challenges through research and innovation – for example, adoption of the award insights in forming the Race Equality Action Plan for the Welsh government

KPI: Speed at which results were produced from awards – with the exception of the Toolkit, all listed publications and other outputs were produced within the award period

G.7.4.Impact pathways

The team's participatory, co-development and co-production approaches yielded committed involvement from NHS peer researchers, advisory group, stakeholder opinion group and participants. This involvement means that the research was aligned to the needs and experiences of those affected by the issues under study, was responsive to changes (e.g. throughout the pandemic), and allowed the team to reach a broader range of audiences.

The team accessed decision-making bodies, such as Public Health England and NHS England, due to established links.[81] The study has informed the NHS' approach to making sustainable transformations for NHS staff in workplaces and communities. Further training materials are being developed in collaboration with equality and diversity professionals and other relevant experts. Beyond pilots, these actions are going to be subject to upscaling through collaborators like NHS England workforce Race Equity Standard, leading to considerably improved management of the key workforce in COVID-19 pandemic and any future pandemics.[82]

In addition, Professor Hatch has been able to share findings through advisory roles within organisations such as the NHS Race & Health Observatory, NHS England and NHS Improvement and Health Education England, amongst others. In 2021 Professor Hatch was listed in The Health Service Journal's (HSJ) Top 50 most influential Black and minority ethnic people in health.[83]

While the team focused on expanding their understanding of inequalities in healthcare settings, they remain committed to improving the participation and representation of traditionally underrepresented racial and ethnic minority groups in research. To facilitate trust among potential participants, and gatekeeper organisations, and increase overall transparency, the team created video resources such as 'what we do with your data'.[84]

[81] Information from UKRI M&E survey rounds 1-3

[82] https://gtr.ukri.org/projects?ref=ES%2FV009931%2F1#/tabOverview

[83] https://www.nhsrho.org

[84] https://tidesstudy.com/what-we-do-with-your-data/

G.7.5.Sources

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G.8. Short case study 8 - Fighting COVID-19 on the clock: uncovering the main risk factors

Award title	ISARIC - Coronavirus Clinical Characterisation Consortium (ISARIC-4C)		
UKRI investment type	COVID-19: UKRI/NIHR Rapid Response Call 1 - Active intervention development		
Award holder (PI)	Prof Kenneth Baillie	**Institution/ organisation**	University of Edinburgh
Award size	£4,908,946	**Award duration**	25/03/2020 – 25/09/2022
Summary			
The Coronavirus Clinical Characterisation Consortium (ISARIC-4C) received UKRI funding to cover urgent research costs to obtain data and samples of UK COVID-19 cases and ensure that samples are distributed safely to researchers. Due to this award, researchers have been able to recruit over 300k patients, and have identified key risk factors of disease severity, revealed the impact of comorbidities and socioecomonic effects in explaining susceptibility in some ethic groups. In partnership with the GenOMICC study, they discovered human genes and specific mediators driving disease progression, leading directly to an effective new treatment for Covid (baricitinib). Additionally, a data analysis platform has been established at the Edinburgh parallel computer centre (the Outbreak Data Analysis Platform, ODAP) to future-proof the UK's response to outbreaks, enabling external researchers to access deep phenotyping and clinical data with proportional safeguards to protect privacy.			

G.8.1.Description of the award

At the beginning of the pandemic, clinicians did not have the data and tools needed to quickly and assess the severity of COVID-19 cases. In particular, clinicians were not sufficiently supported to effectively triage COVID-19 patients and allocate resources efficiently, which increased the pressure on emergency and intensive care staff and facilities.

Funded by two major awards from UKRI and NIHR, the Coronavirus Clinical Characterisation Consortium (ISARIC-4C) is a UK-wide consortium of doctors and scientists committed to answering urgent questions about COVID-19 quickly and openly;[85] Providing a foundation for other studies to help better understand the effectiveness of interventions to combat the effects of COVID-19 and; Providing real-time information about the course of COVID-19 while studying the underlying biology that explains illness severity with the goal of controlling spread and better treating those who contract it.

- ISARIC-4C is led by Prof Kenneth Baillie (University of Edinburgh), Prof Malcolm Semple (University of Liverpool, co-lead), and Prof Peter Openshaw (Imperial College London, co-lead), and expanded to include more than 80 co-Investigators and 200 local principal investigators from the universities of Cambridge, Edinburgh, Glasgow, Liverpool, Oxford, and Imperial College London.

ISARIC-4C is part of the broader International Severe Acute Respiratory and Emerging Infection (ISARIC) consortium, a global federation of 55 clinical research networks spanning 111 countries (supported by the MRC for more than a decade). This global initiative aims to ensure that clinical researchers have the open access protocols and data-sharing processes needed to facilitate a rapid response to emerging diseases that may turn into epidemics or pandemics.

This award aims to cover urgent research costs to enable sampling amongst UK COVID-19 cases and ensure that samples are distributed safely to researchers. The award is divided into three main research actions:

[85] https://isaric4c.net

- **Rapid point-of-care diagnostics**: researchers aimed to create a unique, globally accessible platform for evaluation of diagnostics on respiratory or blood samples from 1k acute presentations, and serum from 1300 cases and 5k existing controls
- **Evaluate adjunctive therapies**: researchers aimed to develop clinical trials in the UK to make use of ISARIC-4C unique characteristics, therefore improving efficiency and increasing the knowledge on COVID-19
- **Rapidly share clinical samples**: researchers have already established rapid sample sharing processes and shared samples with Public Health England (PHE)

So far, this study has involved almost 3k frontline NHS clinical and research staff, and volunteer medical students.[86]

G.8.2.Outputs

ISARIC-4C has recruited over 300k patients and identified key risk factors of disease severity, including the role of ethnicity on outcomes in hospitalised patients, revealing the effect of comorbidities in mediating part of the increased susceptibility in some groups.[87] The team has developed prognostic scores for COVID-19 patients, helping clinicians better manage patients, and is investigating the primary role for the host immune system in causing fatal disease. These results have helped to improve the overall management of the COVID-19 pandemic through reducing the burden on the NHS by helping to prioritise patients based on their risk factors.

Additionally, this research has been developed in a very short period of time of approximately five months, which has served as a foundation for other studies (such as clinical trials of new treatments). As recognised by Prof Peter Openshaw: "*This [ISARIC-4C] study is quite amazing in that it was launched with such speed and collected so much data. It highlights several crucial questions which researchers, healthcare professionals, the public and patients need answers to*". [88]

At the same time, ISARIC-4C has been publishing all research findings immediately on medRxiv (a preprint site) to provide real-time information about the course of COVID-19. This has decisively contributed to improve the public understanding of COVID-19. ISARIC-4C has also been providing weekly briefings for SAGE and public health agencies to be incorporated into clinical guidance.

A summary of the main results is presented below.

ISARIC-4C identifies four COVID-19 risk groups and enhances management of COVID-19 patients - ISARIC-4C researchers used clinical information and tests carried out on arrival at hospital to predict the patients' risk of death, ranging from low to very high. Data included age, sex, the number of pre-existing conditions, respiratory rate on admission and the results of two blood tests. The categorisations made new treatment pathways possible and have significantly improved the management of COVID-19 cases – patients who fall into low-risk subgroups could be treated at home, while those in the high or very high-risk groups could have more aggressive treatment like early admission to critical care.[89]

Women under 50 have worse long-term outcomes - Researchers have found out that women under 50 are five times less likely to report feeling fully recovered, twice as likely to report worse

[86] https://www.ed.ac.uk/files/atoms/files/ewen_harrison_slides_usher_isaric_2_pdf.pdf

[87] https://www.ed.ac.uk/edinburgh-international-data-facility/services/bespoke-services/isaric4c

[88] https://imperialbrc.nihr.ac.uk/2020/04/30/europes-largest-analysis-of-hospitalised-uk-patients-with-covid-19/

[89] https://www.bmj.com/content/370/bmj.m3339

fatigue, and seven times more likely to be more breathless. These results can help designing future policy measures to mitigate the negative social and economic impacts of COVID-19, and address gender inequalities issues in terms of health recovery.[90]

Discouraging use of antibiotics - ISARIC scientists reported that the use of antibiotics to treat COVID-19 during the first wave was "very high" (in 85% of the cases), even though bacterial infection was uncommon. They highlighted that the overuse of antibiotics should be avoided to prevent emergence of antibiotic resistance.[91]

Key outputs and output indicators

KPI: Publications - Academic journal articles: researchers have published more than 35 academic papers, with an average altmetric score above the 99th centile, leading global efforts to understand of COVID-19.

KPI: Data, knowledge and understanding of COVID-19 for public health impact are generated rapidly – all research findings were made publicly available, contributing to the development of other studies and improving the public understanding of COVID-19.

G.8.3.Outcomes and impacts

The award has enabled the researchers to contribute to other ongoing studies by providing new insights on the risk factors of COVID-19, access to real-time data (e.g. genotype and whole-genome sequence data) and access to computational resources. Those studies, including PHOSP-COVID, COG-UK and GenOMICC, are using data from an open-access integrated analysis platform created by ISARIC-4C for linked clinical data called ODAP - Outbreak data analysis platform. This platform aims to facilitate biomedical research to advance the understanding of severe infectious disease.

ISARIC-4C was able to respond to 120 clinical data requests, providing data to 100 collaborators, ship a total of 21k samples from its hub labs in Liverpool and Glasgow, and provide sample sets to 21 different institutions (including Universities, Public Health England). Clinical data collection through ISARIC4C was additionally supported by an NIHR grant (COVID-19 Clinical Information Network (CO-CIN)).

- ISARIC-4C data have also been used to inform the NHS England Independent Advisory Group concerning the use of neutralising monoclonal antibodies and anti-viral drugs in high-risk clinical subgroups. Data have also been used by Public Health Scotland, Public Health England, the Scientific Pandemic Influenza Group on Modelling (SPI-M), the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) and SAGE. Other key UK policy documents citing ISARIC4C / CO-CIN data include (a) the COVID-19: the green book; and (b) the Remdesivir – national prescribing guidance.
- Additionally, ISARIC-4C has coordinated a number of medical and genomic studies across the UK to help guide pandemic response and discover new treatments. These collaborations with other research studies have made major advances in the understanding of COVID-19, improving the management of the pandemic, reducing the negative societal impacts of COVID-19 in the longer term and directly leading to new treatments entering clinical trials.

[90] https://www.ukri.org/news-and-events/tackling-the-impact-of-covid-19/understanding-coronavirus-covid-19-and-epidemics/isaric-identifies-four-covid-19-risk-groups/

[91] https://www.sciencemediacentre.org/study-on-bacterial-co-infection-and-use-of-antibiotics-in-patients-hospitalised-with-covid-19/

Key outcome and impact indicators

KPI: Improved management of COVID-19 pandemic – several studies on the long-term effects of COVID-19

KPI: Improved management of COVID-19 pandemic – ISARIC-4C data have been used to inform the NHS England Independent Advisory Group on COVID-19, as well as other public institutions

KPI: Improved management of COVID-19 pandemic: Data sharing – ISARIC-4C has developed an open-access platform called ODAP (Outbreak data analysis platform) to provide an accessible, usable data resource to enable research relevant to COVID-19 and future outbreaks

G.8.4.Impact pathways

ISARIC-4C has been able to respond quickly to COVID-19 because ISARIC has more than nine years of experience as a consortium on severe acute respiratory infections, and were preparing for a potential outbreak such as was realized by Sars-2-CoV. The accumulated knowledge and skills meant that doctors and scientists were prepared to collect data and conduct research on COVID-19 in a short period of time. The research developed at ISARIC-4C has significantly contributed to a better understanding of the main risk-factors of COVID-19 severity. This has led to an increase in the efficiency of the allocation of resources at the hospital level, reducing the pressure on pressure on emergency and intensive care staff and facilities. In the longer term, the achieved results can significantly transform and improve both the clinical and medical management of future pandemics and other unexpected events.

G.8.5.Sources

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G.9. Short case study 9 - Leveraging health data for COVID-19 research

Award title	Phase 1 COVID-19 Data and Connectivity – National Core Study (Phase 1 D&C-NCS) (MC_PC_20058)		
UKRI investment type	COVID-19: National Core Studies (MRC)		
Award holder (PI)	Prof Andrew Morris	**Institution/ organisation**	Health Data Research UK
Award size	£15,150,000	**Award duration**	01/04/2021 – 30/09/2022
Summary			
The Data and Connectivity study is one of six National Core Studies (NCS). Within the set of NCS, this project it tasked with the collation and centralisation of key health datasets that have been identified for COVID-19 research by the other NCS'. To achieve this, the team has worked with a number of data custodians across the UK to make these datasets available and discoverable and is maintaining a dedicated portal to bring them together. The latter has grown considerably in terms of available datasets as well as registered use and there is evidence that demonstrates that the study has already been successful in supporting a range of research efforts on the effects of COVID-19 around the world.			

G.9.1.Description of the award

The Data and Connectivity (D&C) study, led by Health Data Research UK (HDR UK) – the UK's national institute for health data science, is one of six National Core studies (NCS) on Epidemiology and Surveillance, Clinical Trials Infrastructure, Transmission and Environment, Longitudinal Health and Wellbeing, and Immunity.[92] The D&C study is intended to provide the needed health data research capability to support ongoing COVID-19-related research in the other NCS' by making relevant datasets more easily discoverable and accessible.

HDR UK, in partnership with the ONS, is working with stakeholders from all UK nations to bring together medical, biological and social science data assets at an unprecedented scale. These stakeholders include the ONS Secure Research Service, NHS Digital Data Processing Service, SAIL Databank (Wales), National Data Safe Haven (Scotland), Honest Broker Service (Northern Ireland), and OpenSAFELY. Working with these partners, the project makes datasets that have been identified for research by the other NCS' available in their corresponding Trusted Research Environments (TREs) as well as through a dedicated Health Data Research Innovation Gateway. Any data produced as part of the NCS' will be made available via these means.

The efforts in centralising critical datasets for COVID-19-related research is a critical element in supporting the other NCS' and enabling them to address their respective research questions. The main anticipated outcomes for the first phase of the HDR-UK NCS includes a continuous response to emerging COVID-19 research priorities, such as mapping out the key datasets required by the other NCS'. Secondly, to develop data infrastructure and services that improve access to health, administrative, molecular, and behavioural data for researchers working on COVID-19. Lastly, existing TREs and the Health Data Research Innovation Gateway will be strengthened and extended so that priority datasets for COVID-19 research are more easily findable, accessible, inter-operable, and reusable.

G.9.2.Outputs

Progress reporting covering all NCS' from January 2022 provides concrete examples of recent progress made in the D&C study. The centralisation of key datasets identified for COVID-19 research make a direct contribution to the rapid generation of relevant health data that help generate a better understanding of the impact of the pandemic on public health. It is worth

[92] For more on the National Core Studies, see: https://www.hdruk.ac.uk/covid-19/covid-19-national-core-studies/

emphasising that a data collation exercise of this scale was unprecedented in the UK. At the time of writing, the Health Data Research Innovation Gateway has more than 2k registered users, over 750 datasets, and 470 requests for new datasets. In addition, the gateway provides information on previous use cases involving the listed datasets as well as 199 courses on health data analytics and over 1,800 research papers on COVID-19.

Beyond the portal itself, one highlight is a collaboration with the Alan Turing Institute to fund nine projects to a total of £2m. These projects used large-scale linked data to address priority research questions on improving understanding of the pandemic and informing the continued policy response using NCS-enabled datasets and infrastructure.[93] Furthermore, the D&C study has collaborated with the EAVE II[94] team at the University of Edinburgh to study the effectiveness of the Oxford-Astra Zeneca COVID-19 vaccine in Scotland and Brazil. This work has found evidence of waning protection within three months of second vaccine doses and was published in the Lancet. In a separate collaboration with the EAVE II study, it was found that Omicron (a COVID-19 variant) was less likely to lead to hospitalisation, which was published in a pre-print working paper.[95]

Key outputs and output indicators

KPI: Data, knowledge and understanding of COVID-19 for public health impact are generated rapidly – The project is providing data infrastructure that, in turn, is enabling the provision and sharing of health data earmarked for COVID-19 research

KPI: Communication materials – Online materials related to the Health Data Research Innovation Gateway and ongoing work of the D&C study are provided on an ongoing basis.

KPI: Publications - Katikireddi, S. V., Cerqueira-Silva, T., Vasileiou, E., Robertson, C., Amele, S., Pan, J., ... & Sheikh, A. (2022). Two-dose ChAdOx1 nCoV-19 vaccine protection against COVID-19 hospital admissions and deaths over time: a retrospective, population-based cohort study in Scotland and Brazil. *The Lancet*, *399*(10319), 25-35.

G.9.3.*Outcomes and impacts*

The main areas in which the D&C study has had impact is in terms of making COVID-19 relevant health data available to the wider research community. In addition to facilitating COVID-19 research, it provides a means of sharing related results, findings, methodologies, and lessons learnt. The Health Data Research Innovation Gateway is a major vehicle for this and the study team continues to make improvements to the portal on the basis of user feedback. The team is adapting the data access processes from the COVID-IMPACT Consortium[96] led by the British Heart Foundation Data Science Centre which reduced authorisation time from 120 days to within 30 days for most projects.[97] Data assets provided through the D&C study have already been used in research to explore variations in COVID-19 mortality rates by occupation in Scotland[98]. Data integration and the harmonisation of methods and standards enables rapid R&D of new interventions and technologies relevant to COVID-19, and knowledge transfer to other clinical health areas.

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[93] See: https://www.hdruk.ac.uk/news/new-advanced-analytics-research-to-deliver-next-level-of-insights-into-covid-19/

[94] See: https://www.ed.ac.uk/usher/eave-ii

[95] See: https://www.research.ed.ac.uk/en/publications/severity-of-omicron-variant-of-concern-and-vaccine-effectiveness-?fbclid=IwAR1qHNz_yVI6KVtg7oq0XESOX-j9o5m9i9cxlE1r11LYZ787xdHHwj8nF_Q

[96] See: https://www.hdruk.ac.uk/projects/cvd-covid-uk-project/

[97] See: https://web.www.healthdatagateway.org/dataset/7e5f0247-f033-4f98-aed3-3d7422b9dc6d

[98] Pattaro, S., Bailey, N., & Dibben, C. (2021). Occupation and COVID-19 deaths: Scotland in a comparative perspective.

Aside from directly supporting COVID-19 research, the study serves to improve the public understanding of the effects of COVID-19 more widely, albeit indirectly. For instance, the finding that Omicron is less likely to lead to hospitalisation has since been cited by the Wall Street Journal and received direct comment[99] from Scotland's First Minister Nicola Sturgeon. With regards to tracking and responding to COVID-19 impact inequalities, the team worked with NHS Digital and the ONS on a Public Health Research Database[100]. Overall, the improved availability of data for wider research use will also increase the scope of benefits beyond the NCS', and boosting UK research capacity more generally.

Key outcome and impact indicators

KPI: Research undertaken & shared rapidly – Multiple publications have cited the D&C study or data made available through it, including: The Wall Street Journal, December 2022, Two Studies Show Much Lower Risk of Hospitalization With Omicron; Shi, T., Pan, J., Vasileiou, E., Robertson, C., Sheikh, A., Scotland, P. H., & EAVE II Collaborators. (2022). Risk of serious COVID-19 outcomes among adults with asthma in Scotland: a national incident cohort study. *The Lancet Respiratory Medicine*.

G.9.4.Impact pathways

There are two key assumptions that underpin the project's potential to achieve impact. First, there is the assumption that the Health Data Research Innovation Gateway is indeed able to provide access to the datasets required for COVID-19 research, and that individual researchers are able to access and make use of it. The steady growth in the number of registered users to over 2k currently as well as the large number of datasets that have been added (751) and data uses (736) provides a clear indication that this is the case. A second assumption is that, with data access, meaningful research on COVID-19 is indeed enabled. Evidence already exists as several studies in Scotland and Brazil have already been conducted and results published. Together, this means that longer-term impacts such as improving health outcomes of COVID-19 patients, increased openness in research, as well as more effective clinical, medical and social management of future COVID-19 outbreaks or similar pandemic will likely materialise as well.

G.9.5.Sources

- Gateway to Research data, retrieved from: https://gtr.ukri.org/projects?ref=MC_PC_20058
- HDR UK, 2021, New advanced analytics research to deliver next level of insights into COVID-19. Retrieved from: https://www.hdruk.ac.uk/news/new-advanced-analytics-research-to-deliver-next-level-of-insights-into-covid-19/
- Sheikh, A., Kerr, S., Woolhouse, M., McMenamin, J., & Robertson, C. (2021). Severity of Omicron variant of concern and vaccine effectiveness against symptomatic disease: national cohort with nested test negative design study in Scotland.

[99] See: https://twitter.com/NicolaSturgeon/status/1473907802305449984?ref_src=twsrc%5Etfw

[100] See: https://web.www.healthdatagateway.org/dataset/a325f33e-bac8-49af-896f-1e025941dae8

G.10. Short case study 10 - PhD student develops world-first five minute test for COVID-19 at their kitchen table

Award title	Novel nucleic acid chemical modifications for the development of in vitro diagnostics using synthetic biology approaches (1915128)		
UKRI investment type	Repurposed funding (BBSRC)		
Award holder (PI)	Dr Jake Carter	**Institution/ organisation**	Birmingham University
Award size	Repurposed studentship	**Award duration**	10/2017 – 01/2022
Summary			
Jake Carter, a PhD student at Birmingham, successfully developed a 5-minute COVID-19 test in collaboration with Birmingham academics and Linear Diagnostics Ltd. The test results and methods have been published in a peer reviewed journal article and a patent has been filed by Dr Carter and the University Enterprise service. The team hope that with further funding for development, the test can be rolled out in the NHS to help detect COVID-19 transmission faster and cheaper than current testing approaches.			

G.10.1. Description of the award

Jake Carter (now Dr Carter) was a final year chemistry PhD student at the University of Birmingham when they were forced to leave the laboratory due to the first UK lockdown. Dr Carter used this time to begin researching COVID-19 tests, applying their biosciences and chemistry knowledge to the problem. Current tests for COVID-19 include the 'gold standard' PCR (polymerase chain reaction) test and the more rapid but less accurate lateral flow tests. The former takes more than an hour to process, while the latter still requires 30 minutes to get a result. PCR tests use a reverse transcriptase enzyme to convert RNA to DNA as the first step, then use a DNA polymerase enzyme to copy the DNA, 'amplifying' the material many times over to detectable levels. The method developed by Dr Carter, Reverse Transcriptase Free EXPAR (RTF-EXPAR), uses very short, single strands of DNA (Binder DNA) that recognises and binds to the viral RNA, plus an enzyme that recognises the DNA once RNA is present and cuts a short section. This releases the RNA to bind to more Binder DNA, and the cycle repeats. The entire test can be run on standard laboratory equipment at lower temperatures, resulting in an approach to developing a rapid, accurate test which could increase NHS testing capability by up to five times.

Dr Carter was assisted in this effort by co-supervisors Profs Tim Dafforn and Jim Tucker from the schools of Biosciences and Chemistry respectively. As part of Dr Carter's Doctoral Training Programme, they had completed a work placement with Linear Diagnostics Ltd to better understand the practical aspects of assay research and to increase their bioscience skills. The relationships and skills they had developed with the team there meant they could turn to them for their knowledge and advice on how to progress the research.

G.10.2. Outputs

The new test takes less than five minutes using RTF-EXPAR. It gives a 'sample-to-signal' time of under 10 minutes, even for low viral levels where current lateral flow tests are less effective than PCR tests. The team used a three-way comparison study to confirm that their method is just as sensitive, but faster, than both the gold standard PCR test and loop-mediated isothermal amplification (LAMP) tests which are currently used in hospital settings. The test does not require samples to be treated at high temperatures, and can be performed anywhere making it cheaper, more transportable, and easily carried out.

Dr Carter has worked with University of Birmingham Enterprise to file a patent application in Spring 2021 covering the method and its use in diagnostic equipment, seeking funding for the next step to test thousands of samples to confirm the findings before being adopted by the

NHS. The preprint paper describing the process lists Dr Carter as lead author. Dr Carter and the team are currently exploring how to make the test easier to deploy and use, and exploring its potential use for other diseases, including some cancers. The work has contributed to the understanding of COVID-19 testing and has developed a new testing solution improving upon current tools such as PCR and LAMP tests.

Key outputs and output indicators

KPI: Publications related to new technologies, materials, design & manufacturing processes - Carter, Jake G., et al. "Ultrarapid detection of SARS-CoV-2 RNA using a reverse transcription–free exponential amplification reaction, RTF-EXPAR." Proceedings of the National Academy of Sciences 118.35 (2021). Available at: https://www.pnas.org/doi/10.1073/pnas.2100347118

KPI - Data sources and solutions generated to address COVID-19 public health impact – the new test may contribute to more efficient testing approaches

G.10.3.Outcomes and impacts

The new testing technique is now being trialled by the NHS. So far, there has been no cross reaction with the majority of other respiratory pathogens and better sensitivity than PCR and loop-mediated isothermal amplification (LAMP) tests.

Dr Carter and their supervisors hope the new test will eventually help minimise the spread of COVID-19 in areas of high people-flow such as airports, restaurants, schools, workplaces, as well as protecting patients and staff in healthcare and hospital settings. It could also enable testing large crowds of people.

The team expects that, in the long-term, the use of the RTF-EXPAR technology will be extended for use with other RNA-based viruses and infectious agents, as well as other diseases, including cancer. Prof Andrew Beggs of Birmingham University's Institute of Cancer and Genomic Sciences evaluates diagnostic tests for the Department of Health and Social Care (DHSC) and is supporting Dr Carter to take the test through to the next stage.

Key outcome and impact indicators

KPI: new, adopted or improved innovation outputs – development of the 5-minute test

G.10.4.Impact pathways

Dr Carter's studentship was funded through the West Midlands DTP (doctoral training partnership). The two co-supervisors brought substantial experience to the BBSRC Midlands Integrative Bioscience Training Partnership. Along with several UKRI grants for their research, Prof Dafforn has received a BBSRC Enterprise Fellowship to spin out Linear Diagnostics which supported Dr Carter on a placement, contributing to their knowledge and skills on testing and how a test might be developed using the assays they worked on at Linear Diagnostics.

G.10.5.Sources

- Gateway to Research entry for Novel nucleic acid chemical modifications for the development of in vitro diagnostics using synthetic biology approaches. Available at: https://gtr.ukri.org/projects?ref=studentship-1915128#/tabOverview
- Carter, Jake G., et al. "Ultrarapid detection of SARS-CoV-2 RNA using a reverse transcription–free exponential amplification reaction, RTF-EXPAR." Proceedings of the National Academy of Sciences 118.35 (2021). Available at: https://www.pnas.org/doi/10.1073/pnas.2100347118
- New COVID-19 test gives positive result in just a few minutes (birmingham.ac.uk)

G.11.Short case study 11 - Understanding the symptoms and factors that determine long COVID-19

Award title	REACT Long COVID (REACT-LC) (MC_PC_20049)		
UKRI investment type	COVID-19 Long COVID (MRC/NIHR)		
Award holder (PI)	Prof Paul Elliott	**Institution/ organisation**	Imperial College London
Award size	£2,718,200	**Award duration**	28/02/2021 – 27/02/2024
Summary			
Part of the REACT programme, the REACT-Long COVID-19 study is one of the UK's major studies seeking to understand why some people suffer from long COVID-19, and others do not. Building on the research conducted in REACT-1 and 2, REACT-LC aims to identify the genetic, biological, social and environmental determinants of long COVID-19. While the main impacts have yet to materialise, early findings are already shedding light on the prevalence of long COVID-19 in the UK.			

G.11.1.Description of the award

It has been observed that, whilst some people experience no symptoms from COVID-19 or only for a short period of time, others can experience symptoms for several weeks or even months, referred to as 'long COVID'. Currently, there is little understanding of the underlying reasons for this and most research on the subject is focused on hospitalised patients.

The Real-time Assessment of Community Transmission Long COVID-19 (REACT-LC) study is investigating the sometimes-large differences in COVID-19 symptoms. The study is run by a team of 16 researchers from Imperial College London in partnership with the Queen Mary University of London, the Francis Crick Institute, Leiden University, Birmingham University and Newcastle University. REACT-LC is part of Imperial College London's larger REACT programme consisting of:

- **REACT-1** - measuring the prevalence of SARS-CoV-2 in the general population in England
- **REACT-2** - measuring the prevalence of antibodies to SARS-CoV-2 in a random sample of the adult population in England. The findings provided the Government with data on the unequal burden of COVID-19 and the impact of previous infection and vaccination
- **REACT-GE** - searches for biological 'signatures', such as molecules in the blood or gene variations, to help explain differences in the severity of illness across COVID-19 patients

REACT-LC adds to the body of work above and works with people who have had Long COVID-19 aiming to understand variations in their symptoms and experiences. The research will involve around 120k people that also took part in REACT-1 in a range of ongoing data collection activities including surveys, panels, and in-depth interviews to understand and track their health, symptoms, and experiences. This will help to develop and understand the genetic, biological, social and environmental signatures and pathways, and their inter-relationships, causing symptoms and may point to possible treatments. The main anticipated outcomes of the research therefore include the identification of symptoms of long COVID-19, an assessment of its prevalence, and the isolation the genomic, biological and socio-economic differences between participants who suffer from long COVID-19 and those who do not.

The study is delivered through five integrated work packages (WPs):

- WP1 will describe variations in long COVID-19 and develop patient reported outcomes
- WP2 will carry out detailed clinical phenotyping on a large sample (50% long COVID-19)

- WP2 data will be used in WP3 which includes 'multi-omic'[101] analysis
- WP4 will explore the social and environmental determinants of long COVID-19
- WP5 will feature data analysis and integration to identify genetic, biological, social and environmental determinants of long COVID-19

G.11.2.Outputs

In April 2021, a 'Let's Talk About Long COVID Research' public event[102] was held to kick-off the study and explain the main aims followed by a Q&A session where questions from the public with personal experience of or interest in Long COVID-19 were posed to the team. This contributed to improving the public understanding of COVID-19 and of the study itself.

As of March 2022, REACT-LC has identified 10k individuals who have tested positive for COVID-19, both with and without long COVID-19 symptoms, who will now be studied in terms of their biological makeup, their environment and any social factors that might affect the likelihood of experiencing Long COVID-19.[103] Initial findings suggest that the likelihood of experiencing long COVID-19 increases with age, with a 3.5% increase in likelihood per decade of life.[104] Data from approximately 500k individuals involved in the REACT-2 study were analysed within the REACT-LC study, leading to the finding that approximately one third of people COVID-19 reported symptoms for 12 weeks or more, which is considered as Long COVID-19. Based on this finding, the team estimates that over 2m adults in England may have experienced Long COVID-19. These findings were reported in a pre-print publication and contribute valuable insights towards understanding the impact of COVID-19 on public health as well as the economic recovery.

Key outputs and output indicators

KPI: Data, knowledge and understanding of COVID-19 for public health impact are generated rapidly – The project is helping to improve understanding of the prevalence of Long COVID-19 in the UK.

KPI: Communication materials – Imperial College London has published online articles communicating the purpose and early findings of the study.

KPI: Publications - Whitaker, M., Elliott, J., Chadeau-Hyam, M., Riley, S., Darzi, A., Cooke, G., ... & Elliott, P. (2021). Persistent symptoms following SARS-CoV-2 infection in a random community sample of 508,707 people. *MedRxiv*.

G.11.3.Outcomes and impacts

The study is set to complete in February 2024. Therefore, the main findings have yet to emerge. The data emerging from the REACT-LC study will be analysed to identify the factors and mechanisms that determine why only some people suffer from long COVID-19. This will help to develop and understand the various factors that differentiate between people who experience Long COVID-19 and those who do not. By the end of the study, the team aim to have identified the genetic, biological, social and environmental determinants of long COVID-19 with a view to identifying possible drug targets, as well as why some patients experience different symptoms compared to others. This is relevant to increasing the efficiency of clinical solutions to COVID-19 and may help to improve health outcomes for COVID-19 patients.

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[101] See: https://www.astrazeneca.com/r-d/our-technologies/multi-omics.html

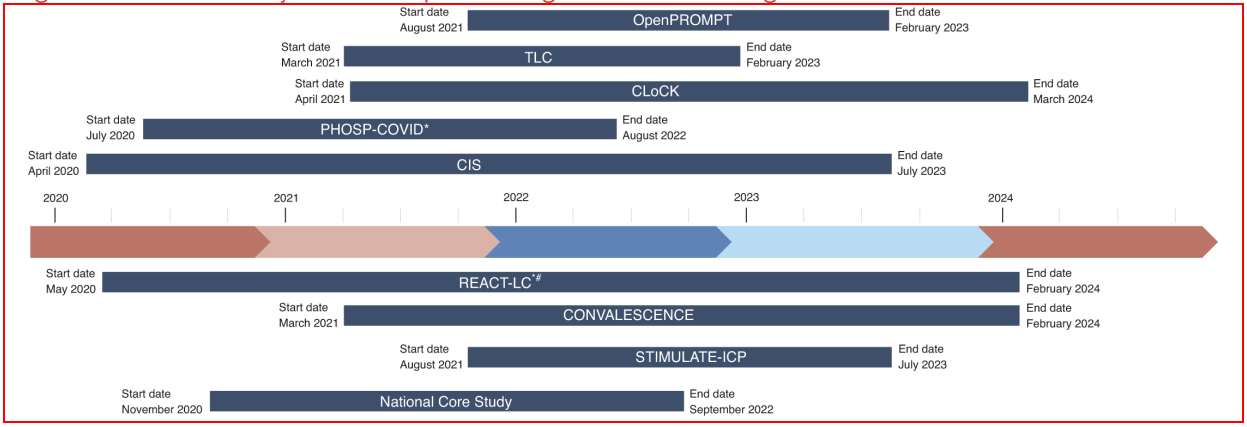
[102] See: https://www.voice-global.org/latest/2021/june/event-summary-let-s-talk-about-long-covid-research/

[103] See: https://pharmaceutical-journal.com/article/feature/opening-the-black-box-the-researchers-trying-to-find-treatments-for-long-covid

[104] See: https://www.nihr.ac.uk/news/up-to-one-in-three-people-who-have-had-covid-19-report-long-covid-symptoms/27979

There are some indications that the findings of the REACT-LC study will be useful for future research as other studies have already expressed interest in using the results. STIMULATE ICP[105], a package of NIHR-funded studies that includes a platform trial arm, is testing repurposed drugs in non-hospitalised patients who are referred to a long COVID-19 clinic. It expects to "*adaptively test more drugs as the evidence base builds when findings from studies such as REACT-LC become available and has structures in place to translate positive results to clinic in rapid time.*"[106] A recent Nature article[107] identified REACT-LC is one of the major epidemiological studies on long COVID-19 in the UK (see Figure 7). The article also reports that REACT-LC has been granted ethical approval for 20-year follow-up "*with plans highlighting how each study will evolve, ask new questions and seek further resources*".

Figure 7 Timeline of major funded epidemiological studies on long COVID in the UK



Source: Routen, A., O'Mahoney, L., Ayoubkhani, D., Banerjee, A., Brightling, C., Calvert, M., ... & Khunti, K. (2022). Understanding and tracking the impact of long COVID in the United Kingdom. Nature Medicine, 28(1), 11-15.

Key Outcomes and impact indicators

KPI: Improved public understanding of COVID-19 – The project involves a large number of individuals who have or had had COVID-19, and have been educated on the purpose and importance of research into the prevalence of Long COVID-19

G.11.4.Impact pathways

While the study will run for another two years, early findings already give an indication of the potential long-term impacts that it will contribute towards. The primary aim of the research is to identify the biological, environmental, and social factors that determine why some COVID-19 patients experience Long COVID-19 whereas others do not. These insights would have clear implications for the management of the impacts of the pandemic, both in terms of public health as well as economic. The underlying assumption, however, is that the causal factors for Long COVID-19 can indeed be identified conclusively. This further raises the importance of research openness and the sharing of findings. As mentioned previously, there are currently multiple ongoing studies on Long COVID-19 in the UK and to maximise the insights that can be

[105] Symptoms, Trajectory, Inequalities and Management: Understanding Long-COVID to Address and Transform Existing Integrated Care Pathways. See: https://www.stimulate-icp.org

[106] See: https://pharmaceutical-journal.com/article/feature/opening-the-black-box-the-researchers-trying-to-find-treatments-for-long-covid

[107] See: https://www.nature.com/articles/s41591-021-01591-4

gained from these, there is a strong case for ongoing knowledge sharing across studies and appropriate dissemination of findings.

G.11.5.Sources

- Voice Global. (2021). Event Summary: Let's Talk About Long COVID Research. Retrieved from: https://www.voice-global.org/latest/2021/june/event-summary-let-s-talk-about-long-covid-research/
- The Pharmaceutical Journal. (2022). Opening the black box: the researchers trying to find treatments for long COVID. Retrieved from: https://pharmaceutical-journal.com/article/feature/opening-the-black-box-the-researchers-trying-to-find-treatments-for-long-covid
- NIHR. (2021). Up to one in three people who have had COVID-19 report long COVID symptoms. Retrieved from: https://www.nihr.ac.uk/news/up-to-one-in-three-people-who-have-had-covid-19-report-long-covid-symptoms/27979
- Routen, A., O'Mahoney, L., Ayoubkhani, D., Banerjee, A., Brightling, C., Calvert, M., ... & Khunti, K. (2022). Understanding and tracking the impact of long COVID in the United Kingdom. Nature Medicine, 28(1), 11-15.
- Imperial College London. (2021). Over 2 million adults in England may have had long COVID - Imperial REACT. Retrieved from: https://www.imperial.ac.uk/news/224853/over-million-adults-england-have-long/
- Imperial College London. (2021). REACT study expanded to help better understand Long COVID. Retrieved from: https://www.imperial.ac.uk/news/215193/react-study-expanded-help-better-understand/

G.12. Short case study 12 - Near real-time domestic violence and abuse data in COVID-19 lockdowns

Award title	Responding to the Covid-19 domestic abuse crisis: developing a rapid police evidence base (ES/V007033/1)		
UKRI investment type	COVID-19 Agile Call (ESRC)		
Award holder (PI)	Dr Katrin Hohl	**Institution/ organisation**	City, University of London
Award size	£141,739	**Award duration**	06/2020 – 12/2021
Summary			
This award was a collaboration with the research team from City, University of London and a number of police forces in an effort to enhance the national preparedness for handling cases of Domestic violence and Abuse (DA) in the COVID-19 pandemic and its aftermath. The team used pooled case data from police forces to track patterns in the nature and levels of DA in relation to levels of restrictions in the form of lockdowns. The findings have informed police forces on the ground, but also both informed and sparked action from decision-makers in the police and the third sector.			

G.12.1. Description of the award

The start of the first nationwide lockdown in the UK, prompted by the rise of COVID-19 in March 2020, was met with a sharp increase in calls to the helplines of domestic abuse charities.[108] A surge in Domestic violence and Abuse (DA) cases was recorded worldwide in the week following the introduction of isolation requirements, as victims found themselves trapped with their abusers during lockdown.[109] Conversely, where the calls dropped, authorities feared that barriers to making the call safely had arisen due to the limitations to movement (e.g. making the call outside the home), or else that victims may have believed the services to be closed.[110] It became rapidly evident that the changed circumstances to safeguarding survivors of DA required new ways to assessing and approaching the situation.

The Responding to the COVID-19 domestic abuse crisis award aimed to provide a close to real-time evidence base to inform the police approach to the surge in DA triggered by the lockdowns resulted from COVID-19. The team aimed to answer questions about the impact of movement restrictions resulting from COVID-19 on DA, which may inform police risk assessment accuracy, victim safeguarding and criminal prosecution as the pandemic goes on.[111] The research team consisted of Dr Katrin Hohl as the Primary Investigator, and Dr Kelly Johnson as a Co-Investigator. The Home Office, the National Police Chiefs Council, and the College of Policing were included as partners and served as direct links to critical decision-makers.

The team made use of police case file information pooled from seven police forces to analyse data on DA, tracking changes in risk factors, frequency, nature and profile of reported DA cases. The data was subsequently compared to data about shifts in the restrictions imposed during lockdown, transitional phases and when restrictions were lifted. The quantitative approach was complemented with semi-structured phone interviews with police officers to identify emerging challenges and best practices in the frontline response to DA.

[108] https://www.bbc.co.uk/news/uk-53498675

[109] https://www.theguardian.com/society/2020/mar/28/lockdowns-world-rise-domestic-violence

[110] https://publications.parliament.uk/pa/cm5801/cmselect/cmhaff/321/32105.htm#_idTextAnchor000

[111] https://gtr.ukri.org/projects?ref=ES%2FV007033%2F1

G.12.2.Outputs

Among other complex effects, the team found that the pandemic keeps victims of DA in abusive relationships for longer, as the usual routes out are restricted during lockdown periods. The lockdown rules enabled the concealment and intensification of violence, coercion and control in some cases. The study also warned of a renewed surge in cases as the restrictions related to the second lockdown in the UK were eased.[112]

As with the acute need for solutions to the crisis, the team had undertaken research and communicated initial findings with rapidity. Drs Hohl and Johnson produced a briefing document of the first results and held their first webinar with the participating police forces within six weeks of the start of the award. In the same month, July 2020, they shared their findings thus far with the Home Office to bring evidence to inform a systemic response. Further webinars were prepared for participating police forces, the Chief Executive of Women's Aid Scotland and Girls Research Network in late 2020 and early 2021. Hohl and Johnson were also invited to present the findings at the National Police Chiefs Council (NPCC) National Domestic Abuse stakeholder meetings in September 2020, December 2020, April 2021 and September 2021.[113]

Dr Hohl presented at a ESRC-GSR Actionable Insights seminar in October 2021 which led to her presenting to the Ministry of Justice, as well as to the Ministry of Justice Silver Command meeting in November 2021 opened by the Lord Chancellor and Justice Secretary Dominic Raab.

The team has produced two reports of their findings related to the impacts of the pandemic on reported DA,[114] and the evidence base they have developed in response.[115] The grant report has been downloaded more than a hundred times between January and March 2022 from the Open Access site of City University. The authors also presented their findings in an online article commissioned by the Campaign for Social Science and republished by Women's Aid organisation.[116] Preliminary findings were presented at ESRC Festival of Social Science in 2020 and 2021. These dissemination efforts helped communicate the new knowledge to the public, decision-makers and the first responders.

Key outputs and output indicators

KPI: Publications – Several e.g. Johnson, K. and Hohl K. (2021) The impact of Covid-19 on Domestic Abuse Reported to the Police, and Policing Responses. Parliamentary Home Affairs Committee, Home Office Preparedness for Covid-19 (Coronavirus) Consultation Supplementary Call for Evidence Submission.

KPI: Timelines to first major outputs and impacts - first reports and dissemination exercises within two months of the start of the award

KPI: Communication materials - Hohl, K. & Johnson, K. (2021), A Crisis Exposed – How COVID-19 is impacting abuse reported to the police, Women's aid

G.12.3.Outcomes and impacts

The research team was approached by a representative of the Drive Project, a national project in the domestic abuse specialist sector aiming to develop a nation-wide system to address DA,

[112] https://www.womensaid.org.uk/how-covid-19-is-impacting-domestic-abuse-reported-to-the-police/

[113] Information from UKRI M&E survey rounds 1-3

[114] https://gtr.ukri.org/publication/overview?outcomeid=600edf52389620.50644286&projectref=ES/V007033/1

[115] https://openaccess.city.ac.uk/id/eprint/27279/

[116] https://www.womensaid.org.uk/how-covid-19-is-impacting-domestic-abuse-reported-to-the-police/

as a result of the webinar at the ESRC Festival of Social Science.[117] The findings were subsequently used in combination with a survey of domestic abuse perpetrators in relationships carried out by Drive. The findings from the two studies aligned in that the lifting of restrictions may result in an increased demand for support for DA victims. It reinforced the need for a better public understanding on the increased risk of DA linked to the changing rules of lockdown.[118]

Actions have been taken within police forces around the country to improve the management of DA cases in the pandemic context. The Police and Crime Commissioner's Office in Sussex, as a result of the award's findings, sent a request to the Home Office for an advance notification about the time of future lifting of lockdown restrictions to help prepare for increased demand for DA support.[119]

The findings have also been directly used by one English Constabulary with whom the team collaborated by informing the allocation of resources to process demand relating to DA and other safeguarding referrals. The findings have supported the case made for increased staffing to maintain an effective DA processing system within the constabulary. The team shared anonymised data sets of reported cases of DA as well as other findings and invitations to webinars with the seven police force units who provided the original data for maintained communication and up-to-date approaches to the levels of DA, and thus, well-being needs everywhere in the country.

The award has supported more effective management of the consequences of measures to combat COVID-19 at the governmental level. The research was used by the National Police Chiefs Council's Domestic abuse lead in their oral evidence to the Home Affairs Committee session on preparedness for COVID-19, including future outbreaks, in October 2020.[120]

Key outcome and impact indicators

KPI: Examples of improved management of COVID-19 pandemic – the award resulted in the increased preparedness for anticipated surges of domestic abuse cases within the police

KPI: Speed at which results were produced from awards – findings were used as evidence in the Home Affairs Committee session on COVID-19 preparedness in October 2020, four months into the award

KPI: Examples of knowledge / understanding mobilised to inform policy decisions - Johnson and Hohl (2021) Parliamentary Home Affairs Committee Home Office Preparedness for Covid-19 (Coronavirus) Consultation: Supplementary Call for Evidence Submission - The Impact of Covid-19 on Domestic Abuse Reported to the Police, and Policing Responses

G.12.4.Impact pathways

The research partners in numerous Police forces and constabularies, as well as the College of Policing and the Home Office, enabled the dissemination of results and recommendations to target, not only policy makers, but practitioners and spaces for training practitioners. Support from beyond the police forces, in turn, enabled the research team to attend the ESRC Festival of Social Science in November 2020 and November 2021. With 640 registered participants, the event attracted attention from important further connections, such as Drive.

[117] https://gtr.ukri.org/projects?ref=ES%2FV007033%2F1

[118] http://driveproject.org.uk/wp-content/uploads/2021/01/DP3_Drive-survey-of-people-using-abusive-behaviours_LC_180121-.pdf

[119] https://gtr.ukri.org/projects?ref=ES%2FV007033%2F1

[120] https://committees.parliament.uk/oralevidence/1097/pdf/

However, the award suffered from delays ranging from one to seven months, due to administrative hindrances around data sharing agreements, as the research relies on regular data updates from the seven partners in the police.

G.12.5.Sources

- Drive (2021), Survey of those who use abusive behaviour in relationships: Findings report, URL: http://driveproject.org.uk/wp-content/uploads/2021/01/DP3_Drive-survey-of-people-using-abusive-behaviours_LC_180121-.pdf
- Hohl, K. (2021), A Crisis Exposed: how COVID-19 is impacting domestic abuse reported to the police, *Women's aid*, URL: https://www.womensaid.org.uk/how-covid-19-is-impacting-domestic-abuse-reported-to-the-police/
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- House of Commons (2020), Home Affairs Committee Oral Evidence: Home Office Preparedness for Covid-19, URL: https://committees.parliament.uk/oralevidence/1097/pdf/

G.13.Short case study 13 - Coordinating and amplifying the Arts and Humanities Research response to COVID-19

Award title	The Pandemic and Beyond: The Arts and Humanities Contribution to Covid-19 Research and Recovery (AH/W000881/1)		
UKRI investment type	COVID-19 Agile Call (AHRC)		
Award holder (PI)	Prof Pascale Aebischer	**Institution/ organisation**	University of Exeter
Award size	£240,720	**Award duration**	15/02/2021 – 15/02/2023
Summary			
The award has enabled the University of Exeter team to work with 77 projects in the arts and humanities which examine the effects of COVID-19 in areas such as law, wellbeing, communication and in the creative industries. The collective work has been pulled together into a virtual Hub, The Pandemic and Beyond, in which projects curated by the team are amplified in various forms of multimedia. Showcased projects and their findings have informed policymaking and demonstrated the valuable and unique contribution arts and humanities have made to addressing the legal, ethical, cultural, social and mental health impacts of the pandemic.			

G.13.1.Description of the award

The COVID-19 pandemic has considerably disrupted the arts and culture sector in the UK and internationally. The halting of revenues, routines and relationships in the sector has, however, simultaneously highlighted the human need for connection, culture and inspiration.[121]

To address the new 'normal', the creative sector and researchers in arts and humanities have had to look for ways to adapt. AHRC has reacted rapidly by funding a range of projects under its COVID-19 R&I portfolio. The Pandemic and Beyond award is inherently interwoven into that portfolio. It has enabled the team to create a virtual hub for researchers, decision-makers and user-groups to understand the impacts of COVID-19 on culture, the arts, society as well as law and health. The hub brings together 77 UKRI-funded research teams exploring these areas, and acts as a meeting point for research teams, end-users and decision-makers alike.

The second purpose of the hub is to illuminate the contribution of arts and humanities in addressing the COVID-19 pandemic. Its aim is to showcase the ways in which these disciplines help solve problems associated with the pandemic using a multiplicity of approaches in a diverse range of areas. The team facilitates the collaboration of complementary projects and focused exchanges of impact plans, helping to share expertise between projects. The team supports AHRC in identifying research gaps and strengthening future crisis response calls.

Research teams curated by the awarded projects are categorised under the following clusters:

- Knowing the Pandemic: Communication, Information and Experience
- Ethics, Law and Governance
- Bridging Distance in the Creative Industries
- Coping Creatively: Arts, Health and Wellbeing

The project is led by Professor Pascale Aebischer at the University of Exeter with four Co-Investigators: Drs Fitzgerald, Tischler, Hartley and Morrison from University of Exeter.

[121] https://www.britishcouncil.org/research-policy-insight/research-series/impact-covid-19-arts

G.13.2.Outputs

The team conducted a qualitative empirical analysis to monitor the performance of the projects, which included an analysis of public-facing documents of the various projects the award brought in one place, discussions with key informants and five stakeholder workshops with representation from 58 of the projects. The researchers shared information about their work, new knowledge and their contributions to the overall response. The team made their results, including opportunities and challenges associated with each of the clusters, available as a public update on Arts and Humanities R&I on the Pandemic and Beyond platform.[122]

The knowledge generated from the various projects and their impacts have been curated and formulated into public communication pieces using various mediums from film to podcast episodes in their virtual hub.[123] These outputs include 19 podcast episodes and blog posts starting from May 2021, in which the research teams bring forth new knowledge on ways in which arts and humanities support the addressing of, and recovery from COVID-19. Topics in these communication resources range from ritual and religion through the pandemic to online conversation surrounding the pandemic, trust in public health and the spread of misinformation. On the Hub's website, the team produced a mission statement in which they discuss the many forms of impact of the pandemic and describe the task of coordinating the approach of arts and humanities research to it.[124]

The team developed a policy portal which divides projects into nine policy areas and hosts the up-to-date policy briefs and resources of 50 projects. One brief focuses on the Mental Health Impact of Restricted Access to Arts and Culture, showing clear benefits to wellbeing of regular arts/cultural engagement, which recommends maintaining alternative/hybrid provision of arts and cultural activity[125]. There are three public-facing policy engagement events that have been co-hosted with Policy@Exeter and policy consultants Culture Commons. These have showcased 19 projects, with attendees including Medical Services Directors and R&D managers from major NHS Foundation Trusts, policy advisors from DHSC and directors from the DWP, patient advocates and many other policy and decision makers. Finally, a blog post was developed documenting the team's submission to the consultation on the Draft Terms of Reference for the Public Inquiry into COVID-19,[126] the result of a meta-analysis and ethics review, commissioned by the team with the UK Ethics Accelerator project.

Key outputs and output indicators

KPI: Publications - Aebischer, P. et al (2021), The arts and humanities contribution to COVID-19 research and recovery: a snapshot, *The Pandemic and Beyond*

KPI: Communication materials generated - Pandemic and Beyond [podcast] (2022), Episode 12: Digital Performance Beyond the Pandemic, **URL:** https://anchor.fm/pandemicandbeyond/episodes/Pandemic-and-Beyond-Episode-12-Digital-Performance-Beyond-the-Pandemic-e1b4nf8

[122] https://pandemicandbeyond.exeter.ac.uk/blog/the-arts-and-humanities-contribution-to-covid-19-research-and-recovery-a-snapshot/

[123] https://pandemicandbeyond.exeter.ac.uk/media/

[124] https://pandemicandbeyond.exeter.ac.uk/blog/the-pandemic-and-beyond-the-arts-and-humanities-contribution-to-covid-19-research-and-recovery/

[125] https://pandemicandbeyond.exeter.ac.uk/wp-content/uploads/2022/01/CARE_Billington_Policy_Brief_Jan21.pdf

[126] https://pandemicandbeyond.exeter.ac.uk/blog/pandemic-beyond-response-to-draft-terms-of-reference-for-the-uk-covid-19-inquiry/

G.13.3.Outcomes and impacts

The project services other projects and increases their visibility, therefore acting as an impact enabler. Projects and their findings disseminated by the Hub have been used as evidence in the Boundless Creativity Report, a policy paper by the AHRC in collaboration with DCMS. The report is the first comprehensive analysis of the impact of COVID-19 on arts and humanities and innovations developed in response. It outlines the route to recovery and growth of the cultural sectors in the UK.[127] The project's work features prominently in the forthcoming POST Note on The Impact of Digital Technology on Arts and Culture in the UK, which includes 11 references to Pandemic and Beyond projects. By amplifying the voices of the discipline and the community, the award has particularly increased the openness of research, and enabled making an evidence-based case for public investment in Arts and Humanities R&I.[128]

Key outcomes and outcome indicators

KPI: Practices related to open research (in general) and research focused on societal challenges – 70+ AHRI-funded research projects (including project reports, websites and policy briefs) collated in a centralised space and categorised by core themes, URL: https://pandemicandbeyond.exeter.ac.uk/projects/

KPI: Examples of knowledge / understanding mobilised to inform policy decisions – a project brought in and showcased by the award, a digital toolkit for small to mid-scale theatres, was used as a case study in the Boundless Creativity Report, exemplifying the broadening of access to digital platforms

G.13.4.Impact pathways

The Pandemic and Beyond award, along with the Hub it created, provide a beacon to amplify the importance of Arts and Humanities research in and on the COVID-19 pandemic. Coordinating research and enabling interactions between research teams through nine Knowledge Exchange Workshops as well as creating training opportunities in policy and media engagement and running a range of multimedia communication activities, the award has brought considerable visibility to other projects. As a result, the Hub has helped enhance the public understanding of the human and socio-cultural implications of the pandemic and its featured projects informed the AHRC Boundless Creativity campaign. The support of the hub has accelerated the capture of data and development of knowledge informing the pandemic response on countless topics via the webinars (as a way of evidencing the track-through from projects to decisionmakers via hub events), and this way reduces negative societal impacts of COVID-19 and develops a society resilient to public health challenges.

The main hurdles in the realisation of the award aims concern issues around data sharing agreements, tight resource for the size of the portfolio and the need to provide basic policy and media training for research teams, as well as individual support for the writing of policy briefing papers. As the project objective is to coordinate and amplify the work of other research teams, issues with sharing agreements and GDPR initially prevented the sharing of important information, not only pertaining to presenting curated project findings, but also to enabling the research team to understand the projects with which they work.

[127] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005410/Boundless_Creativity_v1.pdf

[128] https://www.ukri.org/news/ahrc-report-sets-course-for-cultural-sector-recovery/

G.13.5.Sources

- Aebischer, P. & Nicholas, R. (2022), Policy Brief: Digital Theatre Transformation: A case study and digital toolkit for small to mid-scale theatres in England, URL: https://pandemicandbeyond.exeter.ac.uk/wp-content/uploads/2022/02/PB_Policy_Brief_DTT_Aebischer.pdf
- Pandemic and Beyond (2021), The Pandemic and Beyond: the arts and humanities contribution to COVID-19 Research and Recovery [blog post], URL: https://pandemicandbeyond.exeter.ac.uk/blog/the-pandemic-and-beyond-the-arts-and-humanities-contribution-to-covid-19-research-and-recovery/
- Pandemic and Beyond online hub: https://pandemicandbeyond.exeter.ac.uk/
- UKRI-AHRC (2021), Boundless Creativity Report: Culture in a time of COVID-19, URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005410/Boundless_Creativity_v1.pdf

G.14. Short case study 14 - Unlocking the secrets of sewage to detect local COVID-19 outbreaks

Award title	Use of wastewater analysis to evaluate the incidence of coronavirus (SARS-CoV-2) in the UK population (NE/V004883/1)		
UKRI investment type	UKRI COVID-19 Urgent Grant (NERC)		
Award holder (PI)	Prof Davey Jones	**Institution/ organisation**	Bangor University
Award size	Initially £52,235 + £197,108 uplift	**Award duration**	15/04/2020 – 14/03/2021
Summary			
Nasal and throat swab testing for the virus that causes COVID-19 is reliant on self-reporting and the individual deciding to do a test in response to symptoms. A team from Bangor University discovered that tracing COVID-19 in local sewage systems could provide an early warning of local COVID-19 peaks. The work has led to multiple larger programmes of work to test wastewater for COVID-19 as well as leading to a national wastewater surveillance programme being rolled out nationwide. There have been multiple instances where insights from the award have fed into national policymaking decisions, such as lockdown restrictions in Wales.			

G.14.1. Description of the award

COVID-19 can spread rapidly through groups of individuals, creating local outbreaks which put immense pressure on healthcare systems. But symptoms can take up to one to two weeks to be detectable and at least 20% of the population show no symptoms when infected, making it almost impossible to detect and respond quickly to local outbreaks. Effective monitoring of this pathogen is vital to estimate the amount of infection circulating in the human population, and to inform the design of measures for controlling the spread of disease. However, individual tests are not enough to estimate population level incidence.

The SARS-CoV-2 virus that causes COVID-19 is shed in respiratory droplets but also in faeces. A team of researchers led by Prof Davey Jones at Bangor University partnered with Dŵr Cymru (Welsh Water) and United Utilities Group plc to test the incidence of COVID-19 in the population via urban wastewater. The aims of this NERC Urgency award were to: (1) use wastewater to provide near real-time information on the incidence of SARS-CoV-2 within the UK population; (2) monitor changes in COVID-19 levels in the UK population, compared to conventional reporting metrics; (3) identify similarities in the abundance of COVID-19 in the major urban centres; (4) demonstrate the use of wastewater for virus surveillance and; (5) provide stakeholders (e.g. governments) with critical information and tools to be able to respond and adapt to current and potential future disease epidemics.

The team measured incidence of the virus found in wastewater at several key cities in England (e.g. Manchester, Liverpool) and 44 sites in Wales, the latter covering 80% of the population. Samples from wastewater were automatically taken every 20 minutes, to show COVID-19 rates within communities. Both inflow and outflow were measured to assess if wastewater treatment affects viral loading and to make sure that SARS-CoV-2 was being effectively removed by wastewater treatment.

The award joined two others as part of a consortium in NERC's urgency portfolio with the Joint Biosecurity Centre, water companies, the Environment Agency, and Office of National Statistics, who are adopting wastewater detection as part of the COVID-19 Alert System. The other two awards investigate whether the virus remains effective through the wastewater

treatment process and if it can pass from the wastewater treatment works to receiving waters and thus be distributed further in the environment via rodents for example.[129]

G.14.2.Outputs

The team developed, tested and implemented the wastewater detection system. They found that coronavirus RNA fragments in wastewater reveal when and where a spike is happening, even from asymptomatic carriers, where conventional testing might miss an outbreak. This provided data on the epidemiology of COVID-19 as well as how lockdowns influenced transmission rates during the October 2020 firebreak lockdown in England and Wales.

The results were then used to set up the national wastewater surveillance programme rolled out nationwide from June 2020. They were also used by NHS Test and Trace to enable rapid action against local outbreaks. The monitoring activity itself was found to be cost-effective, anonymous and non-invasive for the population surveyed. By October 2020, testing was taking place at more than 90 UK wastewater treatment sites. The team also found a way to identify new COVID-19 variants in wastewater samples and contributed to the government's efforts on controlling the variants' spread. The team also submitted evidence to SAGE in November 2020 on the use of wastewater detection systems for the pandemic in all four UK nations.[130]

The collaboration with Dŵr Cymru (Welsh Water) led to data and knowledge sharing on water quality issues in the Conwy catchment area, producing joint datasets. The partnership with United Utilities Group PLC involved sample analysis for SARS-CoV-2, which led to regular reports to DHSC. A further collaboration with the UK Health Security Agency (UKHSA) on other viral pathogens of public health interest[131] leveraged £225k in addition to UKRI funds.

Prof Jones gave radio and TV interviews to disseminate the work, along with ten academic journal articles to share technical results with other researchers. This award provided sufficient confidence in the approach for the Joint Biosecurity Centre to develop this wastewater monitoring approach.

Key outputs and output indicators

KPI: Number of publications: Ten academic journal articles e.g. Jones DL (2020) Shedding of SARS-CoV-2 in feces and urine and its potential role in person-to-person transmission and the environment-based spread of COVID-19. in *The Science of the total environment*

KPI: Data sources and solutions generated to address COVID-19 public health impact – significant epidemiology data on COVID-19 incidence. Including 'Wastewater COVID-19 Monitoring in the UK: Summary for SAGE – 19/11/20' document

KPI: Time elapse between grants and data and knowledge generated, and comparison with other grants (UKRI) – able to produce results much faster than other previous grants

G.14.3.Outcomes and impacts

The method was key to the early detection of the Omicron wave in Wales and is able to monitor future variants as it has now been rolled out across Wales.[132] The surveillance methodology is now used for national surveillance in all four UK nations. Welsh Health Minister Eluned Morgan

[129] NE/M009106/1, NE/V004883/1 and NE/V010441/1

[130] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/940919/S0908_Wastewater_C19_monitoring_SAGE.pdf

[131] UKRI M&E survey data

[132] https://gov.wales/wastewater-programme-expanded-across-wales

said the widespread monitoring for Covid would give authorities "*a better sense of what genuinely is going on within our communities*", which would allow informed decisions to be made on potential responses.[133] The award has clearly contributed to the improved management of the pandemic by capturing time-critical data in mid-2020.

Prof Jones, alongside Cardiff University, received £4.2m of further funding from the Welsh Government in Autumn 2020 to establish the Wales Environmental Wastewater Analysis and Surveillance for Health (WEWASH)[134] project to continue monitoring COVID-19 in wastewater across Wales.[135] The team provided an early warning system for spikes in COVID-19 cases, which helped assess the effectiveness of the Welsh Firebreak lockdown in October 2020. The team found that the lockdown reduced COVID-19 cases at first but did not help keep cases low post-lockdown. The team reports its findings weekly to the Welsh Government COVID-19 Technical Advisory Group.[136] The research was endorsed by the Welsh Health and Social Services Minister and Chief Scientific Adviser for Health[132] after the work of the original award led to an expansion of the wastewater monitoring programme from 20 to 44 sites in Wales in February 2022.

Key outcome and impact indicators

Additional funding of £500k from the Welsh Government to expand the wastewater testing programme across Wales and £225k from UK-HSA

KPI: Improved management of COVID-19 pandemic, including evidence-based public heath advice – multiple examples of advice to SAGE, DHSC and Welsh Government

KPI: Time-critical data – wastewater data rapidly collected to inform policy decisions

G.14.4.Impact pathways

The results of the award were rapidly produced. The solution, methodology and subsequent advice to policymakers were achieved within three months of the award starting, and academic publications within six months. This reportedly happened significantly faster than in the PIs previous awards. However, the award was somewhat hampered during the application process as the time between application and notification, then the time to award start was perceived to be slow. However, the team received excellent guidance and links to research users and policymakers from UKRI staff, both during the application stage and the award.

The award drew on prior expertise and resource from testing for influenza in wastewater, as well as colleagues from the Joint Biosecurity Centre and the UK Centre for Ecology and Hydrology, which was conducting similar research under the NERC urgency portfolio (N-WESP).[137]

[133] BBC (9 February 2022) Covid: Waste water testing could measure Wales' happiness. Available at: https://www.bbc.co.uk/news/uk-wales-60303322

[134] A collaboration between Bangor and Cardiff universities, Dŵr Cymru Welsh Water and Hafren Dyfrdwy. https://wastewatersurveillance.com/research/ . Centre for Environmental Biotechnology Project funded though the European Regional Development Fund (ERDF) by Welsh Government.

[135] https://www.cardiff.ac.uk/news/view/2489989-extension-of-the-wewash-project-to-continue-monitoring-levels-of-covid-19-in-wastewater-across-wales

[136] https://gov.wales/covid-19-situational-reports

[137] https://www.ukri.org/news/ukri-funded-research-supports-covid-19-sewage-tracking-system/

G.14.5.Sources

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- Bangor University (11 May 2020) What our sewage can reveal about covid-19 infection rates in the community. Available at: https://www.bangor.ac.uk/news/archive/what-our-sewage-can-reveal-about-covid-19-infection-rates-in-the-community-43628
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- Dancer SJ (2021) What is the risk of acquiring SARS-CoV-2 from the use of public toilets? in The Science of the total environment
- Farkas K (2021) Concentration and Quantification of SARS-CoV-2 RNA in Wastewater Using Polyethylene Glycol-Based Concentration and qRT-PCR. in Methods and protocols
- Farkas K (2020) Viral indicators for tracking domestic wastewater contamination in the aquatic environment. in Water research
- Farkas K (2021) Correction: Farkas et al. Concentration and Quantification of SARS-CoV-2 RNA in Wastewater Using Polyethylene Glycol-Based Concentration and qRT-PCR. Methods Protoc. 2021, 4, 17. in Methods and protocols
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- Jones DL (2020) Shedding of SARS-CoV-2 in feces and urine and its potential role in person-to-person transmission and the environment-based spread of COVID-19. in The Science of the total environment
- Polo D (2020) Making waves: Wastewater-based epidemiology for COVID-19 - approaches and challenges for surveillance and prediction. in Water research

G.15. Short case study 15 - Trailing a novel spectroscopic approach to virus identification

Award title	**VIPIRS - Virus Identification via Portable InfraRed Spectroscopy (EP/V026488/1)**		
UKRI investment type	COVID-19 Agile Call (EPSRC)		
Award holder (PI)	Prof Hui Wang	**Institution/ organisation**	University of Ulster (later QUB)
Award size	£410,730	**Award duration**	14/07/2020 – 13/01/2022 (delayed)
Summary			
The VIPIRS study leveraged machine learning techniques for COVID-19 virus identification using spectroscopy data. While still in progress, the study has already produced promising results with strong potential for the development of a virus detection tool that can be rapidly implemented in the field using low-cost equipment. The detection system has high relevance to COVID-19, enabling near-instant diagnosis, but also has the potential to be adapted to other respiratory viruses.			

G.15.1. Description of the award

Spectroscopy (a tool for studying the structures of atoms and molecules) is widely used in high performance instrumentation to identify chemical compounds and biological species, including bacteria and viruses. In the event of pandemics such as COVID-19, there is a need for relevant virus identification using low-cost instrumentation as it enables wider and more rapid deployment for diagnosis, prevention, and management. The problem with low-cost instrumentation, however, is that it typically yields relatively poor and noisy spectrum data.

Therefore, the aim of the VIPIRS award is to study the spectral characteristics of the SARS-CoV-2 virus and to investigate how low-quality spectral data produced by low-cost instrumentation can best be analysed. Based on this, spectral-data based virus detection models will be developed along with a virus detection solution that can be used 'in -situ' with relative ease. The solution will be able to extract spectral data from patient nasal samples and return a near-instant diagnosis within approximately one minute, based on the detection models that would run on a cloud-based service. If successful, it would enable rapid in-situ testing for COVID-19 and other related viruses at low cost, which would help to improve the management of the COVID-19 and future pandemics.

The VIPIRS study is carried out by the School of Computing and the School of Engineering at the University of Ulster in collaboration with the School of Medicine, Dentistry and Biomedical Sciences at Queen's University Belfast and the Belfast Health and Social Care Trust. The solution will be validated in real environments in collaboration with the Northern Ireland Regional Virology Lab (RVL). The award builds on past research by the School of Computing and School of Engineering at the University of Ulster which investigated how machine learning algorithms can be applied to spectra from low-cost near infra-red (NIR) spectrometers to extract identifiable patterns. Recently, for instance, the University's research has demonstrated that it is possible to use this approach to accurately differentiate between respiratory syncytial virus and Sendai virus.

G.15.2. Outputs

The award was scheduled to run until January 2022. However, some delays were experienced in the early phases due to the late discovery of virus biomarkers, which pushed back the remaining work.

To date, the award has met its first three milestones. As part of the first major milestone, a machine learning algorithm was developed to detect the presence of a target virus and differentiate between two different virus types. Crucially, this represented a proof of principle of the original concept and demonstrated the feasibility of detecting the presence of certain

virus types using low-cost portable instrumentation. That latter also meant that it would be suitable for subsequent widespread field deployment.

The second milestone was achieved partially after national COVID-19 restrictions caused some initial delays in securing the needed equipment for the works as well, culturing SARS-CoV-2 stocks as well as data collection. Initial analyses using traditional chemometric methods as opposed to machine learning algorithms produced results in line with the previous milestone. Further analyses using deep learning methods will be conducted as a next step.

For the third milestone, the virus detection system was optimised using deep learning, resulting in accuracy improvements that will be tested on SARS-CoV-2. The fourth and final milestone is still to be achieved for which the detection model will be tested in the field and will be released for larger scale testing and emergency deployment.

Some of the study's early findings have already been disseminated to the international academic community in the form of a presentation to the 2021 IEEE Sensors Conference. One research paper is currently under review and a second is in preparation.

Key outputs and output indicators

KPI: Rapid increase in medical capability/capacity to address COVID-19 – while the virus detection solution has not been finalised yet, it has strong potential to expand COVID-19 testing capacity through the use of low-cost instruments and the production of near-instant diagnoses.

KPI: Publications: Song, W., Wang, H., Rahman, E., Barabas, J., Huang, J., Power, U. F., ... & Maguire, P. Rapid Classification of Respiratory Syncytial Virus and Sendai Virus by a Low-cost and Portable Near-infrared Spectrometer. In *2021 IEEE Sensors* (pp. 1-4). IEEE.

- Forthcoming: Classification of respiratory syncytial virus and Sendai virus using portable near-infrared spectroscopy and convolutional neural network. *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*.
- To be submitted: "Detecting respiratory viruses using a portable NIR spectrometer – A data driven approach"

G.15.3.Outcomes and impacts

After initial experiments using respiratory viruses similar to SARS-CoV-2 yielded somewhat disappointing results, an alternative approach was used which was able to differentiate between spectra from respiratory syncytial virus (RSV) and Sendai virus (SEV) with an average accuracy of 85.5%. This represented a significant improvement to the baseline accuracy of 64% and was seen as a major breakthrough, achieving the original study objective.

In light of this breakthrough, there is a significant opportunity to accelerate avenues to exploitation. In particular, it may bring forward rapid and portable field testing using clinical samples such as nasal swabs which, when field testing is completed, will be considered for technology licensing. Investigators have also noted the potential for the solution to be adapted to respiratory virus detection more generally.

Overall, the award's results contribute to increasing the medical capability and capacity to address COVID-19 through increased UK testing capacity. This assumes, however, that there is still a need for rapid and in-situ COVID-19 testing when the award is completed. While widespread testing is winding down as part of the Government's "Living with Covid" plan[138], there is an ongoing need for testing amongst vulnerable groups as well as NHS staff that will continue to uphold the relevance of the award's research. Moreover, the solution's potential

[138] See: https://www.gov.uk/government/publications/covid-19-response-living-with-covid-19

applicability to other respiratory viruses mean that the type of solution developed in the award may be required in future.

G.15.4.Impact pathways

COVID-19 restrictions introduced several challenges to the study such as restricted access to experimental laboratories, researcher isolation, staff recruitment and retention, virus sample transportation, and equipment procurement and delivery. These challenges caused delays to the delivery of the award. The recruitment of staff was further complicated by the fact that a combination of relatively specialist skills in virus preparation, spectroscopy and spectral data analysis was required. Fortunately, the award was able to draw on two post-doctoral research assistants from a pre-existing partnership who reportedly provided excellent support in virus measurement and data analysis respectively. As mentioned previously, the late discovery of virus biomarkers caused further delays to the award and investigators noted that, in retrospect, this should have been prioritised to a greater extent as opposed to the auxiliary work.

Furthermore, IP issues delayed the organisation of a planned workshop on Detection Analytics and Virus Detection. The workshop would have involved four experts working on virus detection using spectroscopy. The objective was to develop collaborative links and establish an international network in this newly established field of real time spectral virus detection. This has limited the extent to which wider dissemination to the academic community could take place as well as the formation of research collaborations.

G.15.5.Sources

- Gateway to research data, retrieved from: https://gtr.ukri.org/projects?ref=EP%2FV026488%2F1
- COVID Agile call awardee survey rounds 1-4
- Song, W., Wang, H., Rahman, E., Barabas, J., Huang, J., Power, U. F., ... & Maguire, P. Rapid Classification of Respiratory Syncytial Virus and Sendai Virus by a Low-cost and Portable Near-infrared Spectrometer. In 2021 IEEE Sensors (pp. 1-4). IEEE.
- Forthcoming: Classification of respiratory syncytial virus and Sendai virus using portable near-infrared spectroscopy and convolutional neural network. Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy.
- To be submitted: "Detecting respiratory viruses using a portable NIR spectrometer – A data driven approach"

Appendix H Value for Money

As explained in the main body of the report, we have based our estimates on a review of academic literature and academic papers that provided robust modelling to two routes of impact: faster re-opening of schools and faster re-opening of the economy.

Table 12 to Table 14 below presents an overview of the papers reviewed and considered.

Also, we explain in the main report that we had explore a third route of impact ("sustaining R&D investment"). In this case, we were not able to establish an appropriate counterfactual scenario.

There are few studies assessing the impact of the Covid-19 crisis on the status of UKRI award holders. Moreover, the available evidence is qualitative in nature and does not allow us to stablish a counterfactual scenario that would allow us to describe the evolution of R&D investment among UKRI award holders in the absence of the pandemic.

A recent report that focuses on Innovate UK award holders conducted in February 2021 based on an on-line survey of 274 IUK award holders and 21 in-depth interviews found that around three quarters of firms said that their future plans for their R&D and innovation projects remained unchanged (Roper et al., 2021). Only a small proportion of firms (2 per cent) saw their project either stopping or being cancelled. The study also found that in order to sustain planned investments and timetables some firms have been forced to adopt riskier behaviours including operating at a loss or taking on work that they normally wouldn't have in order to maintain cash flow.

UKRI award holders responded to the pandemic with a range of different activities and behaviours and also relied on other funders, investors and lenders other than UKRI to sustain their R&D activities. This means it is difficult to assess how the UKRI response to Covid-19 contributed on its own to minimize the impacts of the pandemic (in line with the apparent minor effects of the pandemic on R&D suggested in Roper et al., (2021)).

As a potential approach to circumvent this 'identification' problem (that prevents us from disentangling the impact of new UKRI Covid-19 grants from the impact of the pandemic and from the award holders' own responses to the pandemic), we could have assumed that all the grants in the UKRI response to Covid-19 portfolio can be considered new grants that were created to support new award holders in new projects to deal with various aspects of the pandemic. Then, the 'treatment' scenario is one in which the mentioned grants are made available, while the control scenario is one with no UKRI response to Covid-19 funds. However, this assumption is too strong and not credible. No alternative options have been found in the literature and as such the estimates that emerge from imposing that assumption are not presented.

Table 12 Benefits associated with the faster reopening of the economy

Paper/Report	Authors	Findings	Methods	Notes	Caveats
International comparisons of GDP during the coronavirus (COVID-19) pandemic (2021)	ONS	Among G7 countries[1], the UK economy experienced the largest contraction in volume GDP over the first six months of 2020. The 8.6% shortfall[2] in volume GDP as of the end of Quarter 3 2020 relative to its pre-coronavirus level (this is the quarterly GDP estimates as of the end of Quarter 4 2019) is the largest of the G7 countries. Understanding the structural composition of the G7 economies provides some insight as to why the UK has experienced the largest economic impact from the pandemic. There have been larger declines in the volume of spending by households and government in the UK that explain its relative performance. Around three-quarters of this 8.6% shortfall in volume UK GDP is explained by the fall in household consumption expenditure and a further one-fifth by government consumption expenditure. The industrial compositions also explain the extent to which restrictions weigh on a country's GDP. For example, services output comprises 79% of UK GDP.	No clear methods section but it is mentioned that 'Estimates of the shortfall in GDP would be larger if based on where these economies would have expected to have been in the absence of the pandemic, rather than the level as of the end of Quarter 4 (Oct to Dec) 2019'	The Oxford COVID-19 Government Response Tracker (OxCGRT) reflects "the strictness of 'lockdown style' policies that primarily restrict people's behaviour". Relative to other G7 countries, the UK was one of the last countries to put such public health restrictions in place, in part reflecting the relative timing of the rise in infection rates. The restrictions have also been typically more stringent for the UK (in comparison with other G7 countries) and in place for a longer period of time. **It would require making a connection between UKRI research promoting lockdowns or reopening and how this relates to consumption (services, social consumption, government consumption (including health and education)), and mortality to make a**	It seems that the impact of the Covid-19 restrictions on GDP is not obtained relative to the trajectory in the absence of the pandemic.

Paper/Report	Authors	Findings	Methods	Notes	Caveats
				connection to GDP growth.	
Economic update: Strong recovery as economy opens up (2021)	Georgina Hutton	The reopening of non-essential retail (such as clothing and leisure stores) and outdoor hospitality businesses in April, led to a third consecutive month of growth in GDP. Monthly economic output was up 2.3% in April 2021 compared to March.	Inspection of observed trends using Markit's Purchasing Managers' Index (PMI) for both the services and manufacturing sectors, Gfk'sConsumer Confidence Index.	Here a change in GDP is attributed directly to reopening of the economy, the driver is growth in some services sectors	
Coronavirus and the impact on output in the UK economy: December 2020 (2021)	ONS	Monthly gross domestic product (GDP) increased by 1.2% during December 2020. In December 2020, services grew by 1.7% (a partial bounce back from the 3.1% fall seen in November 2020) following the easing of restrictions in many parts of the UK early in the month, while construction fell by 2.9%; production and manufacturing growth was more subdued at 0.2% and 0.3% respectively.	Growth figures were obtained using the Business Impact of Coronavirus (COVID-19) Survey	Here a change in GDP is attributed directly to reopening of the economy, the driver is growth in some services sectors	Services activity increased in the first half of December 2020 following the relaxation of business restrictions. However, restrictions were tightened again later in December 2020, which may affect the growth figures in that quarter of 2020.

Table 13 Benefits associated with the faster reopening of schools

Paper/Report	Authors	Findings	Methods	Notes	Caveats
Learning loss since lockdown: variation across the home nations (2021)	Lee Ellio, Major, Andrew Eyles, Stephen Machin	Disruption to schooling between March 2020 and April 2021 was unprecedented in its scale. 110 days lost in England); 119 days lost Northern Ireland; 119 days in Scotland; 124 days in Wales. These compare to a full year during normal times of 190 classroom days. Considering learning undertaken at home and in the classroom, pupils in England, Scotland, Wales, and Northern Ireland all experienced very large learning losses over the course of the year. On average, pupils in England lost 61 days of schooling. Larger average losses occurred in Scotland (64 days) and Wales (66 days), while pupils in Northern Ireland also lost 61 days.	The USoc data can be converted into measures of learning loss for individual pupils as they report whether children attend school and the number of hours per week they spend on schoolwork. These are converted into a measure where learning losses are defined as the percentage of normal schooling hours lost per day when compared with a 6-hour school day for 5 days a week. The daily estimates of learning loss can be combined with the attendance numbers in Figure 1 to obtain estimates of lost days of schooling in each school term.		There is no estimate of the loss in lifetime earnings
Coronavirus and the impact on measures of UK government education output : March 2020 to February 2021		Education output for Quarter 2 2020 in volume terms is now estimated to have fallen 36.7% and gross domestic product (GDP) 19.5%, a downwards revision of 13.6 and 0.5 percentage points respectively from the previous estimate.	Measures education output using a "sum of costs" approach: adding together the intermediate consumption, labour costs and depreciation of fixed assets associated with these activities. This covers the value of goods and services consumed in the production process as well as the costs of the factors of production. In		There is no estimate of the loss in lifetime earnings

Paper/Report	Authors	Findings	Methods	Notes	Caveats
			volume terms, the measurement of education output is based on cost-weighted activity indices. This involves gathering data on changes in the number of students in different educational settings (themselves intended as proxies for the number of hours of teaching provision) and weighting them together according to their relative unit costs of production. Increases in the number of students in a relatively high (low) weight activity consequently increase measured education output by a relatively large (small) amount.		
The Long-Term Distributional and Welfare Effects of Covid-19 School Closures (2021)		Average loss of schooling in the present discounted value of lifetime earnings of 2.1%, as well as welfare losses equivalent to about 1.2% of permanent consumption. When the learning losses are discounted. to the beginning of 2020 and aggregated across all school children impacted by the Covid-19 school closures, they amount to ca. 3% of 2019 US GDP.	Structural life-cycle model		The analyses use U.S. household micro data. Complex methodology: structural life-cycle model, however we could use some elasticities.
Lost Wages The COVID-19 Cost of School Closures (2020)	George Psacharopoulos Victoria Collis Harry Anthony Patrinos Emiliana Vegas	The estimated present value loss in earnings at the individual level is US$2,833 in low-income countries, US$6,777 in middle-income countries, and US$21,158 in high-income countries. At the global			

Paper/Report	Authors	Findings	Methods	Notes	Caveats
		level, this loss is US$11,117 at the individual level.			
The Economic Impacts of Learning Losses (2020)	Eric A. Hanushek Ludger Woessmann	Estimates of the present value of GDP lost over the remainder of the century are calculated assuming that just the grade 1-12 students who faced the initial disruption of schooling in 2020 are affected and that the education system returns to 2019 levels for all other past and future students. The economic losses from 1/3 year of learning correspond to an estimated economic downturn of USD2.15 trillion in UK.	Projections where present value of lost GDP is based on estimated difference in GDP for 80 years with lower achieving labour force expected from educational losses of one-third or two-thirds years compared to future GDP without learning loss. Future losses are discounted at 3 percent.	**Useful to estimate impacts of learning losses on GDP growth**	There is no estimate of the loss in lifetime earnings
Education recovery and resilience in England: Phase two report	Education Policy Institute	Based on **EPI analysis commissioned by the Department for Education (DfE),** the new report models the long-run impact of the pandemic on future earnings, finding that pupils are each likely lose at least £16,000 in earnings, rising to £46,000 in a worst-case scenario if the government fails to intervene. Losses to earnings would result in total lost national income running into the hundreds of billions – leading to substantial reductions in contributions to public services, and lower productivity and economic growth. An education recovery settlement of £13.5bn over three years will be required from the government to fully address learning losses and avoid cementing wide educational inequalities.	Simple calculations based on several assumptions -easy to replicate	**Useful to estimate impacts of learning losses on lifelong earnings**	

Paper/Report	Authors	Findings	Methods	Notes	Caveats
Simulating the Potential Impacts of COVID-19 School Closures on Schooling and Learning Outcomes: A Set of Global Estimates (2021)	Jo o Pedro Azevedo, Amer Hasan, Diana Goldemberg, Koen Geven, and Syedah Aroob Iqbal	Using data on 174 countries, the analysis finds that the global level of schooling and learning will fall substantially. School closures could result in a loss of between 0.3 and 1.1 years of schooling adjusted for quality, bringing down the effective years of basic schooling that students achieve during their lifetime from 7.8 years to between 6.7 and 7.5 years. Students from the current cohort could, on average, face a reduction of $366 to $1,776 in yearly earnings. In present value terms, this amounts to between $6,680 and $32,397 dollars in lost earnings over a typical student's lifetime. The loss in lifetime earnings in Europe and Central Asia ranges from $570 in the optimistic scenario to $3,003 in the very pessimistic scenario.		Interesting caveats section, some may apply to the previous paper too.	No specific estimates of lifetime earnings lost for UK

Table 14 Benefits associated with sustaining R&D investment

Paper/Report	Authors	Findings	Methods	Notes	Caveats
2021/22 budget allocations for UK Research and Innovation	UKRI	The Department for Business, Energy, and Industrial Strategy (BEIS) has confirmed an allocation of £7,908 million to UKRI for the financial year 2021-22. This figure was £7,154 million in 2018-19, £7,347 million in 2019-20, £8,611 million in 2020-21. Reductions relative to 2020-21 are on ODA, Science Infraestructure Capital and DfE Strategic Priorities Grant.			
The relationship between public and private R&D funding BEIS Research Paper Number 2020/010	Oxford Economics	The "leverage rate" indicates the impact of a 1 percent increase in public R&D investment on private R&D investment. We find that **a 1 percent increase in public R&D increases private R&D by between 0.23 percent and 0.38 percent within the same year.** By combining this finding with information on levels of public and private R&D support we are able to estimate the monetary impact of this leverage effect. We find that **each £1 of public R&D stimulates between £0.41 and £0.74 of private R&D within the same year.** Public R&D continues to influence levels of private spending in subsequent years. Our analysis suggests that the long-run impact of public R&D on private R&D is more than three times the short-run impact. The long-run leverage rate is estimated to be between 1.01 and 1.32, suggesting that each £1 of public R&D eventually stimulates between £1.96 and £2.34 of private R&D. Our research suggests that leverage begins within the year that the public investment occurs. The impact is most substantial in that first year and fades over time. Almost all of the effects materialise within around 15 years, and the majority of private investment is crowded in by the fifth year.	Approach seeks to identify a causal link to establish the extent to which public R&D leads to greater private R&D, the approach which enables us to assess the overall impact of public R&D support on levels of private R&D right across the economy. This means that we can estimate the impact of both "direct leverage" on those firms which receive support, and "indirect leverage" on firms which are not directly supported, but nonetheless increase their R&D investment.	**Seems the most useful paper so far, with additional references to previous macro and micro literature**	The results presented in this study are based on data stretching back over decades (as far back as the 1960s in some cases). Modelling of the relationships is also subject to data and econometric constraints. As such, there is no guarantee that the past experience reflected in our results will be repeated in future years. -Investment includes Indirect support for R&D in businesses (tax credits), out of scope for us.

Appendix I Bibliometric analysis - methods

I.1.1. Scope

Grants identified within the UKRI COVID-19 response (in the context of this study) were matched to their records in Gateway to Research (GtR). As shown in Table 16, 771 grants were matched, and 331 grants were unmatched. Most of unmatched grants (97%) correspond to repurposed grants. This is mainly because those grants received a new reference number that does not correspond to the identifiers available in GtR.

Publications from GtR/Researchfish were then added to the associated publication-grant links derived from Dimensions (provided they contained a DOI or pubmed ID).

Note that publications include journal articles, (parts of) books, monographs, pre-prints and proceedings.

Table 15 Matched and unmatched grants

UKRI Funder	Matched grants	Unmatched grants	All grants
Innovate UK	102	1	103
AHRC	81	0	81
BBSRC	39	1	40
EPSRC	100	0	100
ESRC	204	5	209
MRC	55	1	56
MRC/DHSC(NIHR)	1	0	1
NERC	16	0	16
STFC	2	0	2
UKRI and Wellcome	0	1	1
UKRI/DHSC(NIHR)	128	0	128
UKRI/MRC	1	0	1
AHRC (repurposed)	1	0	1
EPSRC (repurposed)	15	10	25
ESRC (repurposed)	20	23	43
MRC (repurposed)	6	283	289
NERC (repurposed)	0	6	6
Total	771	331	1,102

I.1.2. Identification strategy

To identify COVID-19 papers across a broad range of UKRI funded disciplines, the analysis has adopted a keyword search strategy that maximises the chance of finding COVID-19 research papers. We have identified publications that directly mentions the virus, taking into account

the different ways in which they could have done so. Covid-19 publications were identified using the following search string:

"2019-nCoV" OR "COVID-19" OR "SARS-CoV-2" OR "HCoV-2019" OR "hcov" OR "NCOVID-19" OR "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome corona virus 2" OR "coronavirus disease 2019" OR (("coronavirus" OR "corona virus") AND (Wuhan OR China OR novel)) OR "COVID"

This search was applied to the Dimensions full text search, and is designed to be as broad as possible net for Covid 19 research.

This identification strategy allows comparing the volume of Covid-19 publications emerging from UKRI's Covid-19 response with: (i) all Covid-19 publications emerging from all grants funded by UKRI, and (ii) all UK funded Covid-19 publications (i.e., publications that name a UK funder. By definition, each of these groups contain the prior one.

This approach does introduce some noise into the analysis, as it will pick up papers on the fringe of COVID-19 research, including mentions to COVID-19 in references. However, given the broad impact that COVID-19 has had on all areas of society and research, it was felt that a more inclusive approach was warranted.

I.1.3. Identifying UKRI papers

UKRI papers are identified, either via self-reporting in Researchfish (Gateway to Research,) or via mining of the acknowledgements or funding statements directly on papers.

I.1.4. Identifying UKRI COVID response papers

During the analysis, a number of papers were identified associated with UKRI Covid response grants that contained no language associated with COVID-19. These papers appear in the sample for a number of reasons. Firstly, a percentage of the UKRI COVID response repurposed existing grants, and these publications may have resulted from earlier cycles of the project. Secondly, whilst underlying technologies and approaches used to tackle COVID-19 may have been funded for their relevance to COVID-19, not all papers resulting from a project should be expected to mention the pandemic (although it would be expected that these papers mentioned COVID somewhere in the full text). Even though these papers might be COVID related, they have been left out of the analysis when comparing against other cohorts, as similar papers in broader cohorts cannot be detected.

I.1.5. Coverage of wikipedia and policy documents with benchmarks

To accurately compare policy and wikipedia mentions, against UKRI baselines (papers published in 2017-2019,) it was necessary to limit the comparisons to mentions that happened near the time of publications (900) days. Without this limitation, papers in the baseline set would have up to 5 years to accrue mentions, whereas the COVID-19 set a maximum of 2. This limitation results in baseline policy and wikipedia mentions that are more comparable to the COVID-19 set, but smaller than would be expected otherwise.

I.1.6. Normalisation by Research field

Results in this analysis have not been normalised by research field. Due to the recency of the publication timeline, there has not been enough time to establish reliable discipline specific benchmarks. Instead, to reflect discipline patterns, results are presented by funding council where appropriate. Aggregated data set comparisons are used here as a good first approximation, however they should be interpreted with caution, as differences in research composition of the underlying fields may influence the results.

Appendix J International funders' review

J.1. Findings from the international review of funders

J.1.1. Introduction

We reviewed six funders to learn about the impact of research supported by their COVID-19 response funding. We performed desk research and interviews, one with each funder, except for NSF, for whom we did not conduct an interview. We reviewed:

- The German Research Foundation, DFG
- The Dutch Research Council, NWO and its sister organisation for health research ZonMw
- The French National Research Agency, ANR
- The National Research Council of Canada, NRC
- The Japan Science and Technology Agency, JST
- The US National Science Foundation (NSF), USA

None of the reviewed funders have conducted impact evaluations of their COVID-19 response funding mechanisms. Therefore, the findings presented in this section build on funders' collected monitoring data and observations and self-assessment of the success of their response to the COVID-19 pandemic.

J.1.2. International funders' response to the pandemic – overview of measures

Table 16 lists the programmes the funders introduced in response to the pandemic and the key parameters of the programmes. The programmes vary in overall size (from €1.5m to $75m), award size, number of applications and supported projects. This overview provides context for the discussion on expected and achieved impact. Three funders (ANR, JST and NSF) mobilised pre-existing rapid response programmes (Flash, J-RAPID and RAPID, respectively). We split the programmes into two groups of programmes: those relying on peer review and those (at least partly) bypassing peer review. We also indicate the approximate length of review processes. This provides some background context for the discussion we present in section 1.6. on what these programme process elements meant for the impact achieved.

Table 16 Comparator funders' programmes – key facts at a glance

Programme (funder)	Approximate length of review process	Overall funding	Award size	Number of applications	Number of supported projects
Programmes relying on peer-review					
COVID-19 Focus Funding (DFG)	3 months	€32m	Up to €100k	396	112
Call for multidisciplinary research into epidemics and pandemics (DFG)	6-7 months	€66m	Up to €1m	270	51
J-RAPID (JST)	Few weeks	€4.1m	Up to €500k	23	11
CREST (JST)	2 months	€30m	Up to €1m	n/a	10

Programme (funder)	Approximate length of review process	Overall funding	Award size	Number of applications	Number of supported projects
ANR Flash programme (bypassed peer review for seed funding allocation)	2 days for seed funding 5 weeks for full funding	€17.6m	Up to €200k	259	106
ANR COVID-19 Research Action	Few weeks	€14.6m	Up to €150k	614	128
Covid-19 programme (ZonMw and NWO)	Peer-review duration few days	€170m	Up to €500k	1449 project ideas 555 full grant applications	8 incidental subsidies 300 second wave projects
Programmes bypassing peer-review					
Pandemic Challenge Programme (NRC)	A few weeks	€15m	Up to CAN$100k	n/a	50
RAPID (NSF)	n/a	$75m	Up to US$ 200k	Several thousands	Around 1000
Fast-track data (NWO)	Less than one week	€1.5m	Up to €50k	46	34

J.1.3. What international funders did to facilitate impact

Almost all consulted international funders reported having insufficient resources to either systematically and comprehensively monitor the outputs delivered by the research they funded or for systematic engagement and support of funded projects to facilitate greater impact. Where both systematic monitoring and impact facilitation did take place, they tended to focus on larger projects that are fewer in number, while there was considerably less monitoring or impact facilitation in programmes that fund many smaller projects (though these programmes might still have entailed significant overall investment).

Several funders pointed out that their main task is to ensure they fund high-quality research, while dissemination is the task of researchers. Therefore, they primarily relied on researchers' initiative to find the best ways of communicating findings to relevant users. However, funders did have specific mechanisms to facilitate impact.

Generally, research supported by funders that introduced targeted impact facilitation measures and supported the dissemination of findings has resulted in a higher percentage of publications with Wikipedia and policy mentions, as evidenced by Dimensions data.

In the following sections, we present more details on impact as evidenced by bibliometric data. In terms of funders' efforts to facilitate the impact, we observed the following:

- **Identifying and building links between government and business R&D efforts:** For example, to coordinate and support business R&D efforts in response to the pandemic, the Canadian NRC's Industrial Research Assistance Programme (IRAP) launched an initiative to invite small and medium-sized businesses to register their technology to assist Canada's COVID-19 response and participate in 23 virtual pitch sessions. In the sessions, companies presented their business, technology, and ideas to a panel of experts from federal and provincial governments. Overall, 76 companies presented their technologies and ideas for sanitisation, disease tracking, therapeutics, patient monitoring and more. This initiative

helped companies align their efforts to ongoing government activities, seek funding support from existing relevant funding programmes or secure NRC IRAP R&D funding. Ten companies secured funding as a result of the sessions. Three resulting technologies later received Health Canada certification and are now in use.

- **Working with national governments and government scientific advisory groups:** Several international funders were either members of scientific advisory groups advising the government, had members of these groups on their funding committees or established other forms of information exchange. This worked in two directions: first, it helped to direct research in areas where there were government needs. Second, it informed the government about the findings emerging from the funded research and, if necessary, established links between researchers and users in government.
    - For example, in France the National Agency for Research on AIDS and Viral Hepatitis-Emerging Infectious Diseases helped ANR to design the calls. In addition, the agency was represented on the government Analysis, Research and Expertise Committee and informed the committee members about the ongoing ANR-funded research, thus providing a link between government decision-makers and researchers.
    - Immediately after the researchers delivered results, the Dutch ZonMw shared the findings with the health authorities, and the authorities provided nationwide recommendations on the vaccination for the immune-compromised groups. ZonMw conducted systemic thematic reviews of the findings emerging from their funding portfolio and organised events for policy makers where several projects would present. Canada's NRC worked closely with health authorities and consulted the WHO blueprint to identify research needs. This helped to focus funding in areas where there is likely to be an impact.
- **Creating comprehensive and user-friendly databases of COVID-19 research:** For example, the US NSF supported the creation of the COVID-19 Information Commons (CIC), a public database facilitating knowledge sharing and collaboration across various COVID-19 research efforts. It contains detailed information about all NSF awarded RAPID projects. CIC also collected self-reported information from the projects via a voluntary survey. A webinar series was created, featuring talks by researchers from the NSF-funded COVID-19 RAPID research projects. The CIC effort demonstrated the benefits of bringing together information about a diverse set of COVID-related projects into a single place, thereby enabling interested users to search for information and efficiently discover linkages among diverse efforts. This helped foster the creation of a community and helped catalyse collaborations (National Science Foundation, 2022a).
- **Organising events, conferences, and press events to disseminate research findings and facilitate open sharing of research outputs:** Several funders chose to organise one or several large public events where researchers or the funder briefly presented key outcomes to a wider audience. This approach helped the funders to save resources and facilitate broad dissemination of research outputs and outcomes. For example, Germany's DFG organised a large digital conference inviting all projects (around 300) and high-level speakers like Sir Jeremy Farrar from Wellcome, who gave the keynote speech. The conference aimed to provide a platform to share ongoing research and emerging findings and look for potential interdisciplinary collaborations. France's ANR plans to organise a similar event in 2023. Japan's JST regularly hosted press conferences to inform reporters about outputs and outcomes of the research projects they funded.
- **Encouraging and supporting immediate open access to research publications relevant to the pandemic, and the use of preprints:** funders signalled to funded researchers that open access and preprints were encouraged, in order to enable a much more rapid and direct exchange of ideas and findings. Several funders signed on to a statement organised by

Wellcome and affirmed their commitment to sharing research data and findings relevant to the COVID-19 outbreak. The Dutch ZonMw applied several open science requirements in all its COVID-19 research programmes. The requirements included, for example, showing in the grant application the options for reusing data, preregistration of animal studies and developing and regularly updating a data management plan. ZonMw also asked to plan a budget for research data management, share research findings as soon as possible through open access publications and provide metadata as soon as possible. ZonMw also registered all research projects on the GLOPID-R research project tracker and the national Netherlands database (ZonMw, 2022b).

A.1.3. International funders' monitoring and evaluation efforts

All international funders have monitoring systems collecting information about the progress and key outputs delivered by the award holders. However, because in several programmes at least part of the projects is still ongoing, not all funders could share comprehensive and up-to-date summaries of monitoring data. Nevertheless, some funders have produced reports summarising some of it from different angles:

- Germany's DFG has published the statistics on applications received for its COVID-19 response funding analysing the themes of research proposals, demographics of applicants (gender, career stage, etc.), awards provided and the processes of processing the proposals (DFG, 2022)
- France's ANR has published a bibliometric analysis of publications linked to its funded research. It includes publication counts, thematic analysis, co-authorship, and types of journals where publications appear
- Canada's NRC has published a report listing outputs such as publications, new IP and outcomes such as new tools, vaccine candidates, networks, respirator samples tested, etc. The report also highlights the most impactful projects (NRC, 2021)

In contrast to UKRI, none of the reviewed international funders have so far started any comprehensive impact evaluations of their COVID-19 response funding. The funders mentioned reasons such as still ongoing research and limited funder capacity for evaluation. Also, several international funders focus primarily on scientific impact and use conventional bibliometrics-based measures and indicators to assess the impact of COVID-19 research. For example, ANR (France) concludes that the funding measures have achieved intended objectives based on the bibliometric analysis. Similarly, JST (Japan) judges the impact of its COVID-19 response funding research based on the counts and impact of scientific articles resulting from the projects. Although impact types than scientific impact are recognised, there is no systematic attempt to identify and quantify them.

Some funders rely on their monitoring data and make conclusions based on the comprehensive monitoring evidence. For its Pandemic Response Challenge Programme, Canada's NRC conducted close monitoring and project-end evaluation and is thus very aware of the outcomes and impact the projects have produced. Therefore, there is no need for additional impact evaluation. Impact evaluation of COVID-19 research will be part of NRC's routine evaluation of long-term outcomes (5-10 years after the funding) of the research they have funded to understand the commercial impact.

Some funders (the USA's NSF, Germany's DFG) plan to focus their evaluation efforts on the effect of the pandemic and rapid research funding on the research workforce. For example, the NSF intends to evaluate in what ways the COVID-19 pandemic influenced the participation of different groups in the NSF portfolio of programmes and activities, such as merit review. The NSF plans to examine whether and how the pandemic response funding measures contributed

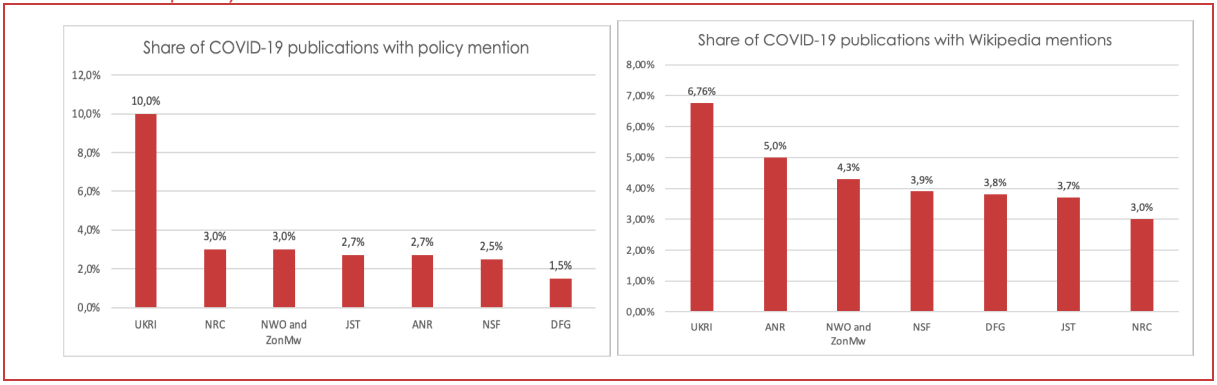
to the negative effects and how the funder can alter those in the future. The NSF evaluation plans are underpinned by concerns over the impacts of COVID-19-driven disruptions on the scientific enterprise and the careers of those most at risk (such as early career and women scientists). Pandemic disruptions seemed to have led to both negative and positive outcomes. For instance, the switch to virtual work disrupted in-person panels. It also opened the door for increasing reviewer diversity through remote panels by removing the barrier that travel may represent for some, such as scientists with caregiver responsibilities or underrepresented minorities with disabilities that make travelling difficult (NSF, 2022b). The planned evaluation will assess the above complexities in detail.

J.1.4. Impact highlights

International funders observed significant impact of their COVID-19 response research funding and its relevance in countries' overall response to the pandemic. In terms of scientific impact, bibliometric data from the Dimensions database shows that on average 86% of the outputs produced by research funded by the international funders COVID-19 response are cited.

The bibliometric data on the mentions of COVID-19 publications in Wikipedia and policy documents can illustrate trends of wider uptake (beyond scientific impact) of the research findings and relevance of the findings in policymaking. The data show that a relatively small share of overall COVID-19 publications are mentioned in the above sources (see Figure 8). UKRI-funded research publications are most frequently mentioned in Wikipedia and have the highest shares of policy mentions. The share of COVID-19 publications with policy mention for UKRI is an average of all councils, including MRC with the highest share (14,5%) and Innovate UK with the lowest share (3%).

Figure 8 Share of international funders COVID-19 response funded research publications with Wikipedia and policy mentions



Source: Dimensions

The bibliometric data can only provide an aggregate view but are limited in their ability to demonstrate the nature and significance of impact. All interviewed funders reported 'highlight' examples of research use by policymakers and other users. Several funders pointed to the long-term relevance of some of the findings, especially on topics such as virus transmission and overall pandemic preparedness. Figure 9 summarises some of the impact highlights for each funder.

Figure 9 Impact highlights at a glance

DFG (Germany)

DFG funds basic, curiosity-driven research. The importance of findings for the scientific community is the key expectation. Thus, for most DFG pandemic response funded projects, the outcomes and impact are yet to be achieved.

DFG **supported the team of researchers who developed BioNTech COVID-19 vaccine based on preliminary work originally carried out as part of DFG funded Collaborative Research Centre in Mainz**. This DFG-funded research is an example of the long-term benefits of basic research and demonstrates the value of basic research and the long-term role of DFG in funding such research. DFG pandemic response funding, although delivered through slightly accelerated processes, did not aim for immediate solutions. Instead, the funder's pandemic response follows its core mission of funding basic, potentially long-time horizon research.

ANR (France)

ANR supported projects resulted in **many scientific articles, including 65 (out of 321) in leading journals** such as Nature group, Science group, and Cell group journals. ANR also reports that outputs from several projects in epidemiology have produced notes to government decision-makers that subsequently **informed national pandemic control measures**.

For example, the EVALCOVID-19 project assessed the impact of pandemic control measures on people's mobility using real-time data from mobile phones. The results were used in a model to **assess the impact of lockdown** in the region Île-de-France. The model showed that lockdown made it possible to reduce the virus reproduction rate and slow the spread of the pandemic. The findings were discussed in the national COVID-19 Scientific Council report in November 2020.

SLAVACO project conducted population-wide surveys on **attitudes towards vaccination**. The project's findings were discussed by the national COVID-19 Scientific Council, the Vaccine Strategy Guidance Council, the Ministerial Taskforce for Vaccination against COVID-19 and the Technical Commission for Vaccines of the High Authority, **leading to modifications in communication about the vaccination.**

JST (Japan)

J-RAPID programme projects have resulted in several significant outputs. For example, a project in collaboration between the University of Yamanashi and the University of Notre Dame (USA) aimed to develop a **technology to monitor the spread of COVID-19 in wastewater**. The project's key output is a new method with a high detection sensitivity and a short detection time (90 minutes). The city of Yamanashi in Japan was involved in the project and helped test the new technology. As a result, **the city now uses it for virus detection**.

The **CREST programme** supported projects that are also starting to produce their first outputs. For example, one group has developed a new technique to identify viral RNA (ribonucleic acid) from SARS-CoV-2 at the single-molecule level and detect it within five minutes. This made it the **world's fastest (in 2021) coronavirus detection method**.

NRC (Canada)

NRCs Pandemic Response Challenge programme projects were critical in building Canada's capacity to **manufacture personal protective equipment** (PPE). The country's supply of PPE was low when the pandemic started and it depended on imports. To ensure the imported PPE was safe, the NRC established a testing lab, which evaluated around 5000 samples of PPE. This fed into decisions enabling the use of about 120 million PPE items. NRC's Metrology Research Centre also established a testing lab

network involving 40 private and provincially funded labs across the country, along with 12 new domestic PPE manufacturers, to further increase Canada's overall testing capacity.

Furthermore, NRC had a critical role in **strengthening the country's PPE production capacity to reduce the dependency on imported equipment**. The NRC IRAP programme supported several companies in reconfiguring existing manufacturing equipment to produce filters for masks and respirators.

The IRAP programme also supported the company LuminUltra which, with the help of the funding, re-focused its operations from wastewater testing for environmental contaminants to using its technology for public health purposes. As a result, **the company went on to produce 10 million test kits every week for detecting COVID-19 in wastewater for early detection of the new virus variants in Canada** (National Research Council Canada, 2022).

NRC research centres helped several manufacturing companies retool their operations to produce nasal swabs, **increasing Canada's capacity to produce two million swabs yearly**.

NRC funding was also crucial to support **vaccine production**. NRC IRAP invested more than $41m to advance early-stage R&D of seven Canadian vaccine candidates and seven therapeutic candidates to prevent and treat COVID-19. Another $113m will be awarded by 2023 to the most promising candidates.

NSF (USA)

NSF RAPID programme funded thousands of projects resulting in various outcomes. Some examples are the development of **self-sanitising medical facemasks**, research on how different temperatures, drying and other conditions affect the **virus's ability to survive** and research **on how water quality is affected by building-closures**. Researchers also developed online tools enabling **3D exploration of genomic variants of coronavirus** and analysed the **impact of lockdown strategies** in different countries. There is no robustly measured and publicly available information on the impact of the awards. However, in public communication, NSF emphasises that its investments in research related to the pandemic **produced actionable results** (NSF, 2022b).

NWO/ZonMw (Netherlands)

The results of ZonMw COVID-19 research programme projects on **vaccine efficacy in groups with compromised immune system** were passed on to executive agencies to inform policy and were **relevant for the national vaccination strategy**. The findings of these projects help patients, practitioners and policymakers to make the right decisions regarding the vaccination strategy. The results of these studies also fed into overall scientific knowledge on vaccination for groups with compromised immune system and thus have international relevance.

Several behavioural studies delivered evidence on adherence to pandemic control measures, attitudes towards vaccination, and the effectiveness of vaccination campaigns among low-income and immigrant communities. Health authorities used the findings to adjust vaccination campaigns.

As noted above, most funders primarily focus on monitoring scientific impact and use this impact type to judge the value of the research they have funded. There are several reasons for this. First, it results from the role some funders play in the R&I system of their country. For example, Germany's DFG primarily funds basic, curiosity-driven research and did not necessarily expect researchers to come up with immediate solutions for the pandemic. The importance of findings for the scientific community is the key expectation. Researchers can use DFG funding to establish contact and collaborate with research users, but it is not something the funder requires. To illustrate the point, DFG is proud to have supported the team of researchers who developed the BioNTech COVID-19 vaccine based on preliminary work initially carried out as part of DFG funded Collaborative Research Centre in Mainz. This DFG-funded

research is an example of the long-term benefits of basic research and is used as an argument to demonstrate the value of basic research and the type of funding DFG provides.

Second, scientific impact can be measured more straightforwardly. With well-established indicators and tools to account for scientific achievements (mostly publications-based), scientific impact is relatively easy to identify, quantify and showcase to decision-makers and society. The reviewed funders recognise and report other diverse and diffuse forms of research impact but also point to difficulties in capturing these because there is no agreed upon format for assessing non-scientific impact.

Finally, although all funders recognised the need for urgent research and findings, it appears that traditional research funders' role dominated expectations towards the impact of the pandemic response research. Notwithstanding overall trends to incentivise, measure and prize different types of impact, there is a strong presumption among several consulted funders that they should measure the impact primarily using well-established and recognised methods of identifying scientific impact. Linked to this is the presumption that researchers are primarily responsible for translating high-quality research into practical use.

While the overall focus was mainly on scientific impact, two funders (Canada's NRC and the Dutch ZonMw) also had clearly defined objectives of facilitating and demanding other types of impact. For example, NRC funds research at all technology readiness levels (TRLs); accordingly, its impact monitoring reaches beyond scientific impact. By closely monitoring project progress, the funder reports diverse use and applications of research results. The Dutch health research funder ZonMw very much focused on the practical use of the research and played an important convening role in ensuring synergies between research groups and almost immediately channelling the findings to the health authorities to inform, for example, the national vaccination strategy.

J.1.5. The role of COVID-19 response funding design and processes in achieving impact

All consulted international funders pointed out the relevance of funding design and processes in achieving the impact. Funders emphasised the role of appropriate funding portfolio, design and requirements of funding measures and funding allocation processes. We address each of these aspects below. The assessments below are based on the funders' informed observations of what use-oriented outcomes the research achieved, at what pace, whether the outcomes resulted in impact and what role the funding design and processes played. Each funder operates in a different context and introduced different response measures, therefore their experiences and assessment can inform discussion about potential funding modalities but cannot be used to draw comparisons and arrive at robust conclusions on what funding mechanisms produce more or faster impact.

J.1.5.1 Funding portfolio

Several reviewed funders pointed out that a two-fold funding portfolio helped to respond to the various needs that the research community and wider public had and thus helped fund research resulting in use-oriented outcomes: on one hand, immediate and rapid response instruments to support very urgent projects, on the other, a programme targeting issues emerging as the crisis unfolded. For example, the French ANR emphasised the diversity of funding instruments providing almost immediate seed funding and support for long-term projects which covered the diverse needs of the research community. Also, in terms of themes, ANR's COVID-19 response portfolio included calls on specific/pre-defined topics as well as more generic calls, thus allowing support for scientific dynamics and disciplinary and thematic diversity. Generic calls facilitated opportunities to conduct research on topics emerging as the pandemic unfolded (new virus variants, teleworking, mental health, inequalities, etc.). The

Dutch ZonMw reported similar observations. First, ZonMw identified immediate research needs and through accelerated processes funded specific consortia to deliver the specific findings. Then, ZonMw launched more generic calls and supported bottom-up projects addressing less urgent but still relevant topics.

All funders that used pre-existing and/or slightly adjusted funding mechanisms (Canada's NRC, Japan's JST and the French ANR) unanimously agreed that pre-existing rapid response mechanisms helped to respond fast and did deliver results. All three funders also plan to keep the mechanisms in their funding portfolio and use in response to future emergencies. That said, there is no particular evidence that pre-existing targeted rapid response measures necessarily produced faster or more impact. Other funders (the Dutch ZonMw, Germany's DFG) without pre-existing measures faced more difficult operational decisions and procedures when they introduced the response, but they nevertheless report success in terms of impact the research produced and the speed at which researchers produced outputs and outcomes.

J.1.5.2 Design and requirements of funding measures

Several COVID-19 response funding design elements and programme requirements facilitated impact achievement. The requirement to involve end-users, award duration and harmonisation requirements in health research were the key design elements that facilitated impact achievement and enhanced impact pace.

JST (Japan), ANR (France) and ZonMw (Netherlands) had a formal requirement for their COVID-19 response programmes to **include end-users in the formal project partnership from the start of the project**. The funders asked for a clear strategy of how end-users will be consulted or involved in research, testing, and use of intended outcomes. Reviewers used this information to assess the applications. Funders rejected funding applications that could not demonstrate end-user involvement. According to the funders, this resulted in projects that were clear about the research needs and potential users from the onset and contributed to generating user-oriented outcomes.

According to the consulted funders, **the speed at which researchers produced outputs, outcomes and impact largely depends on the duration of the awards**. Some programmes (JST CREST, DFG programmes) funded projects with an award duration of several years and these projects have not yet resulted in many outputs and outcomes. The funders were not particularly concerned about the immediate impact of the projects funded in these programmes. JST had another programme (J-RAPID) to address the urgent questions, while the CREST programme had longer impact timeframes. The two funders pointed out that some questions are relevant in the long term and are beyond the immediate response. They considered it important to fund research that looks at longer-term issues even in the overall context of urgency and emphasised that the pandemic is a moving target meaning that long-term questions and funding needs are as important as the ones faced when the pandemic started. These programmes also support low TRL or basic research, and the funders pointed out the value of high-quality basic research and their willingness to accept long waiting times.

Programmes aiming to deliver fast solutions and with shorter award duration have produced outputs and outcomes rapidly. For example, ANR observed that researchers generated published outputs from COVID-19 response funded research faster, setting the impact of COVID-19 response funding research apart from other funding measures. By December 2020, ANR had identified 80 publications and six patents linked to the COVID-19 response funding, which started in March and April 2020. Japan's JST-funded J-RAPID awards produced outputs and outcomes within the first months of funding. Similarly, public communication from the US

NSF points out that some of NSF's investments in research related to the pandemic produced actionable results within months, which corresponds to the objectives of the RAPID programme.

JST for their J-RAPID programme, as well as Canada's NRC and the Dutch ZonMw pointed to the importance of being clear with the expectations for rapid solutions. Having a short award duration also resulted in researchers considering these rules and adjusting research work accordingly, resulting in fast outcomes that were often used by policymakers, health authorities and others. However, there were also exceptions where researchers could not meet the pace of pandemic decision-making. For example, ZonMw reported that it was difficult for researchers conducting modelling studies to meet decision-makers' pace. The Netherlands Outbreak Management Team had to rely on internally developed models because the ones developed by researchers funded by ZonMw did not deliver the results when the decision makers needed them. ZonMw commented that the researchers only work to achieve rigorous results while government research teams tend to produce quick and potentially less well scrutinised results.

The Dutch health research funder ZonMw introduced a **harmonisation requirement** for researchers who delivered eight different studies on vaccination for patients with a compromised immune system. The requirement asked to work with jointly agreed protocols and measurement methods to ensure comparability of studies and findings. This requirement improved the usability of findings and faster translation into practical recommendations for the vaccination strategy and clinical practice. Furthermore, harmonisation also helped communicate recommendations to patients with different immune disorders but the same immune response. ZonMw will likely apply this requirement in future research programmes funding different projects on a similar topic. Although the situation and urgency were unique for this sub-programme, the researchers and the funder saw its use for arriving at more practical and applicable findings (ZonMw, 2022).

J.1.5.3 Funding allocation processes

The process review of UKRI's response to COVID-19 highlighted that several international funders reduced or bypassed peer review. Here we provide an analysis of whether these alternative approaches enabled quicker/better funding decisions leading to as great or greater impact on quicker timescales as evidenced by the monitoring efforts of the reviewed funders.

Three funders (France's ANR, Canada's NRC, the Dutch NWO) bypassed peer review for parts of their COVID-19 response – either for specific programmes (NWO, NRC) or select projects requiring urgent seed funding (ANR). NSF did this for its core COVID-19 response programme – RAPID (total investment of $75m). However, there is no publicly available information reflecting on the lessons of using this approach.

Given the urgency associated with the pandemic, funders concluded that bypassing peer review was the right approach. The funders could rapidly select high-quality research that delivered impact. For example, two days after receipt of the proposals (259 in total) for the Flash instrument, ANR selected 44 projects that received seed funding (€30k per project). ANR set up the seed fund to support projects assessed as urgent by its internal scientific committee. The selection of these projects bypassed traditional peer review. About one month later, ANR published the complete list of funded projects (in full amount and assessed by peers). Peer review-based evaluation concluded that most projects selected for the seed funding were of high quality (Agence Nationale de la Recherche, 2022b). According to ANR, the process helped 44 projects to start very fast and deliver the first outputs by mid-2020. ANR concluded that it could select high-quality projects without external evaluation. This does not mean that ANR considers external review unnecessary, but in situations requiring an urgent response, relying on funders' ability to make funding decisions appears feasible. In the Netherlands, NWO

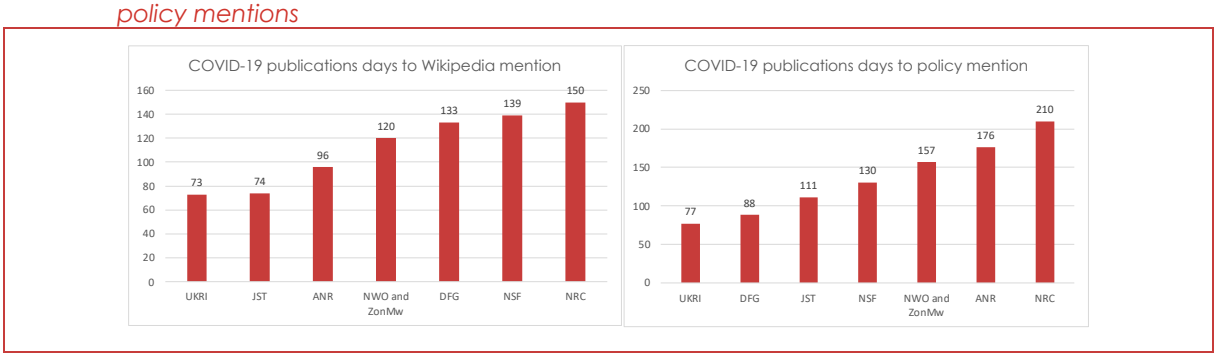
followed a similar approach within separate programmes. NWO used the Fast Track programme to award small (up to €50k) grants for urgent data collection and research and did not use peer review for this programme. If necessary, the projects later applied to other NWO or ZonMw programmes where funders relied on full peer review.

Canada's NRC bypassed formal peer review for selecting projects for funding to accelerate the process. Still, NRC used peer support during the implementation of the projects when projects funded within the Pandemic Challenge Programme could access external advisors to receive feedback and advice from peers and confirm they are progressing well. This process worked well and was one of the several funding design elements that enabled fast impact achievement. The successful projects' examples prove this, but comprehensive impact evaluation has not yet been performed. Initially, there were some concerns in NRC about the approach, but NRC Executive Committee was comfortable with it because of the need for speed that the situation required. Also, NRC was in close contact with health and other authorities, which provided significant input and gave NRC a solid situational awareness of what was needed which then helped to make funding decisions.

All-in-all international funders concluded that bypassing peer review did not result in supporting poor quality science (as evidenced by the monitoring of funded projects), and it did help to allocate the funding faster than in other funding programmes. In combination with other funding design and process elements, bypassing peer review helped achieve fast outcomes. However, there are also examples of funders and programmes in our review that followed full peer review in their rapid response mechanisms (JST J-RAPID programme and ZonMw COVID-19 programme), reporting fast progression of research to achieve outcomes. These two funders used other mechanisms to accelerate funding or facilitate impact achievement. JST placed high expectations on peers and knew they could rely on a fast response from the peer community. ZonMw optimised internal processes, provided shorter timelines for peer reviewers, closely monitored funded projects' outputs, and built links with potential users to facilitate impact.

According to bibliometric data, research outputs funded by accelerated programmes that bypassed peer review did not result in faster time to Wikipedia and policy mention of COVID-19 publications than research funded by other programmes without such modifications in review processes. Figure 10 shows that by this measure, research outputs resulting from programmes funded by funders that bypassed peer review (e.g., NSF, NRC, partly ANR) took more time to receive mentions in Wikipedia and policy. However, we must interpret these data cautiously as they are based on research articles. Researchers might have prioritised direct dissemination to research users, which is faster than indirect dissemination via journal article publication routes.

Figure 10 International funders COVID-19 response funded research publications days to Wikipedia and policy mentions



Source: Dimensions

There are several ways for funders to accelerate funding processes. NRC and ANR conclude that bypassing peer review does accelerate the funding process, and in the cases covered in this review it did not appear to entail risks of funding poor-quality research. Still, the contexts in which the international funders operate are too different to draw robust conclusions on whether the approach to award selection leads to faster and/or better outputs and outcomes. However, there is one lesson from the international funders' response to the COVID-19 pandemic and, indeed, previous experience with other emergencies, e.g. NSF using rapid response programmes. For relatively small awards to support immediate data collection and research as the crisis unfolds, bypassing peer review will make the awards available fast and on time (which can be crucial for their relevance) without significant risk for accountability.

J.1.6. Summary

Most international funders are still taking stock of the impact achieved by their COVID-19 response measures. The funders report several essential achievements, an overall positive assessment of the impact, and some lessons on how their funding design and processes worked to facilitate the impact.

International funders pointed to several funding design and process elements that facilitated impact. A funding portfolio that addresses different research needs in terms of when and what research is required helps to cover diverse research needs and enables impact on a range of issues emerging throughout the pandemic. The optimal emergency response funding portfolio comprises measures to address immediate and longer-term needs and pre-defined (e.g. by health authorities) generic funding calls. Pre-existing and established rapid response mechanisms also help to set up crisis responses faster and contribute to impact achievement.

Regarding instrument design and requirements, short award durations served as a stimulus for researchers to plan accordingly and enabled impact achievement in timelines relevant to the pandemic management. In addition, according to the international funders, the requirement to engage with end-users from the onset of the project contributed to the production of use-oriented outcomes.

Bypassing peer review helped several research funders to accelerate the funding process significantly and did not result in inappropriate funding choices. Some funders only used this approach to award funding for relatively small awards. However, the NSF RAPID programme is an important exception to this rule.

The context in which the COVID-19 response funding worked differs among the reviewed countries and funders. Consequently, comparing the impact of programmes following full peer review and those that bypassed it is difficult. However, the approach is feasible for programmes supporting urgent and small projects as it implies significant time savings and involves minimal risk.

Like UKRI, international funders saw it as their responsibility to be more active in facilitating research impact than research funders typically do. Our review identifies several measures the funders introduced to facilitate the impact, some of which are similar to what UKRI did. For example, working with national governments and governments' scientific advisory groups, organising events, conferences and press events to disseminate research findings, facilitating open sharing of research outputs, and encouraging and supporting immediate open access to research publications relevant to the pandemic and the use of preprints. Other funders potentially provide some inspiration for UKRI in their efforts to systemise information and make publicly available the findings of COVID-19 research and make targeted efforts to facilitate the usability of business R&D response. However, as UKRI, international funders struggled with making time and resources available, among other responsibilities, to engage in as much

convening work as would be desirable to maximise the impact of the research. Furthermore, some funders largely perceive it is primarily the researcher's responsibility to ensure the use of their findings.

UKRI leads in terms of impact evaluation of their COVID-19 response, especially in accounting for non-academic impact. None of the reviewed funders have conducted a comprehensive impact evaluation so far. However, some funders seem to be paying more substantial attention to the implications of the pandemic and pandemic response funding on the research community, especially the most vulnerable groups. Some of these evaluation questions outlined by international funders might also be relevant in the UK context.

J.1.7. Sources

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J.2. Funder information: French National Research Agency (ANR), France

Funder name	French National Research Agency (ANR)
Brief description	The French National Research Agency operates under the authority of the French Ministry of Higher Education, Research and Innovation. The agency funds project-based research in all disciplines to promote the development of basic and applied research, technological innovation, technology transfer and public-private partnerships. ANR organises competitive calls for proposals and selects projects for funding based on peer review in compliance with international standards. ANR's programmes are decided by the ministry and developed based on priorities defined in the National Research Strategy and in coordination with European and international research funding initiatives (Agence Nationale de la Recherche, 2022a).
Brief description of funder's response to COVID-19	From the beginning of the crisis, ANR has deployed a wide-ranging system to support the national research effort and contribute to the management of the COVID-19 pandemic. From February 2020, the ANR, in synergy with the Ministry of Higher Education, Research and Innovation, has implemented funding measures to support the production of knowledge, data collection or observations to help manage the pandemic. ANR mobilised pre-existing **Flash programme** and launched calls to allocate funding in a short time for immediate research needs. Flash programme supports projects which aim for rapid data collection, observations or research. The maximum funding amount was €200k. ANR launched the first Flash call on March 6, 2020. Two days after receipt of the proposals (259 in total), 44 projects benefited from a seed fund (€30k per project). ANR set up the seed fund to support projects assessed as urgent by the scientific committee of the ANR. The selection of these projects bypassed peer review. ANR published the complete list of funded projects (in full amount and assessed by peers) on April 9, i.e. five weeks after the publication of the call. Peer review based evaluation concluded that most projects selected for the seed funding were of high quality (Agence Nationale de la Recherche, 2022b). In April 2020, ANR launched another funding instrument **COVID-19 Research-Action** to support research aiming to provide answers to questions arising as the pandemic unfolds. The call supported projects aiming to deliver results within 3-12 months of project start. The maximum funding amount was €150k. The COVID-19 Research-Action call used the usual funding system adapted to an unprecedented pandemic situation and was continuously open, thus offering the research community the possibility of submitting projects for six months with ongoing evaluation. ANR organised 17 successive evaluation sessions between 2 June 2020 and 26 January 2021 (Agence Nationale de la Recherche, 2022b). Both programmes benefited from a co-financing contribution of €9.7m. The Foundation for Medical Research and six regions: Auvergne-Rhône-Alpes, Grand Est, Hauts-de-France, Occitanie, Pays de la Loire and Centre-Val de Loire teamed up with ANR to coordinate actions to support research on the COVID-19 pandemic. Finally, ANR organised several actions in collaboration with other international funders (e.g., JST, China NSFC) to support international research collaborations addressing pandemic related research questions. WHO and GLOPID-R recommendations formed the basis for the thematic focus of the Flash programme and COVID-19 Research-Action calls. Finally, ANR introduced a **COVID-19 priority** over the 2021 **Generic Call for Proposals** (a regular ANR funding instrument). This complemented the short-term projects funded by the Flash programme and COVID-19

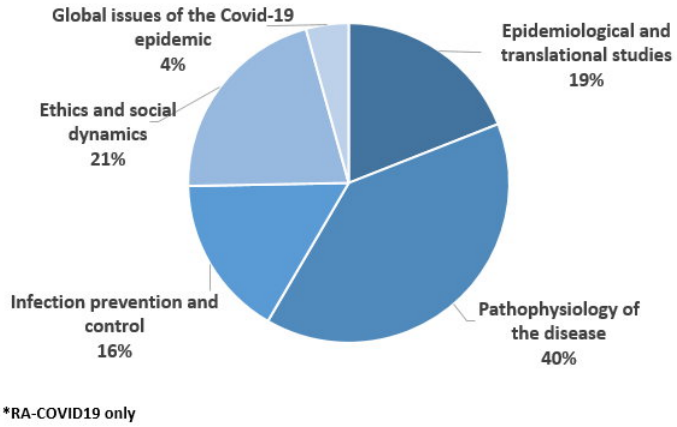
Funder name	French National Research Agency (ANR)
	Research Action calls. Generic call funded projects with a larger budget of €300k-€700k and allowed for the development of larger-scale research over 3-4 years.
Uptake of funder's response to COVID-19 funding instruments	The **Flash programme** awarded funding to 106 projects (259 applications) worth €17.6m. **COVID-19 Research Action programme** supported 128 projects (614 applications). The total awarded funding was €14.6m. In both programmes, private companies could lead or be project partners. Of all projects funded, 17 include a partnership with at least one company; four companies lead the projects (one in the field of diagnostic tests and three in therapeutic research). A total of 21 companies were involved (Agence Nationale de la Recherche, 2022b).

Funder's approach towards monitoring and evaluating the impact of the response to COVID-19 funding instruments
ANR requires the funded projects to submit short progress reports after three and six months of the project start and once the project is complete. ANR monitors the publications linked to their funded research every two months based on bibliographic searches on the Web of Science. ANR has published a report outlining the key statistics on the awards and bibliometric indicators on the COVID-19 response measures. In February 2023, ANR will also organise a large event taking stock of the achievements of the COVID-19 funding instruments. The funder has not scheduled any other evaluation activity.

Evidence on key outputs produced by the supported projects

The funded projects cover different areas that range from pathophysiological studies and knowledge from the biology of the SARS-CoV-2 virus to the characterization of the immune response of patients to diagnostic tests and antiviral molecules. ANR also funded epidemiological studies, modelling of virus dissemination, protection against infections, organization of hospital services and medical or scientific ethics. In social sciences ANR funded research focuses on behaviours, effects of the pandemic and the measures on the various populations, public policies, and economic and geopolitical impacts. Figure below shows the thematic breakdown of ANR funded research (Agence Nationale de la Recherche, 2022b).

Thematic breakdown of projects funded under the Flash and COVID-19 Research Action calls



*RA-COVID19 only

Source: https://anr.fr/en/latest-news/read/news/mobilisation-of-the-french-national-research-agency-for-covid-19-research-234-research-projects-fun/

Overall, ANR observed that published outputs from COVID-19 response funded research were generated faster than from other/usual funding instruments. By December 2020, ANR had identified 80 publications and six patents linked to the COVID-19 response funding. By October 2021, ANR had identified 321 publications and 17 patents; by June 2022, around 500 publications (from Web of Science) were linked to the COVID-19 response funding. About 96% of publications are open access. Most patents are in pathophysiology, infection prevention, and control and one in epidemiology (Agence Nationale de la Recherche, 2022b).

Of 279 funded projects, 68 produced publications in collaboration with researchers abroad. Of the 321 publications, 135 (42%) have at least one co-author with foreign affiliation. Collaborations are primarily with researchers in the United States and European countries (Italy, United Kingdom, Germany, Switzerland). 27 of the 135 co-authors have a dual affiliation in France and abroad.

Five ANR supported projects conducted clinical trials (Agence Nationale de la Recherche, 2022b).

ANR also reports that outputs from several projects in epidemiology have produced notes for government decision-makers. In addition, other projects have produced outputs and recommendations directly used by the COVID-19 Scientific Council, Ministerial Taskforce for the Vaccination, Ministry of Health, Public Health France, Parliament, regional health agencies and others (Agence Nationale de la Recherche, 2022b).

Evidence on key outcomes and impact of the supported projects
ANR has not conducted a comprehensive impact evaluation of the COVID-19 funding instruments. Therefore the funder could not provide quantitative impact measures but highlighted some important achievements. ANR believes the research has had a significant contribution in terms of new knowledge. The supported projects have resulted in many scientific articles, including 65 in leading journals such as Nature group, Science group, and Cell group journals. ANR also reports that outputs from several projects in epidemiology have produced notes to government decision-makers that subsequently informed national pandemic control measures (Agence Nationale de la Recherche, 2022b).

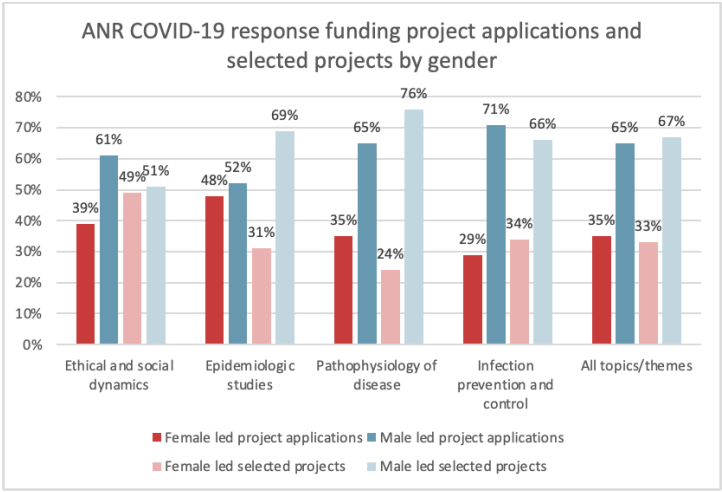
Impact enablers and challenges

The role of funder in facilitating the impact
Overall, ANR relied on researchers and their initiative to find the best ways of communicating the findings to the relevant users. However, there were specific mechanisms and actions that ANR took to facilitate scientific and other impacts. For example, the National Agency for Research on AIDS and Viral Hepatitis-Emerging Infectious Diseases helped ANR design the calls. It was also informed about the research that ANR funded. The agency was on the government Analysis, Research and Expertise Committee and informed the committee members about the ongoing ANR-funded research, thus providing a link between the government decision-makers and researchers. ANR also signed on to a statement organised by Wellcome and affirmed its commitment to sharing research data and findings relevant to the COVIID-19 outbreak. These provisions have been introduced in the various ANR COVID-19 calls.
The role of the design of funding instruments and/or funding processes
ANR concludes that the portfolio of instruments, the design of those instruments and modified funding processes helped to respond fast and facilitated the impact achievement. In particular, ANR emphasises the diversity of funding instruments providing almost immediate seed funding and support for short- and long-term projects that cover the research community's diverse needs. Regarding thematic, the ANR COVID-19 response portfolio included calls on specific/pre-defined topics and more generic calls, thus allowing support for scientific dynamics and disciplinary and thematic diversity. In addition, generic calls facilitated research opportunities on emerging issues as the pandemic unfolded (new virus variants, teleworking, mental health, inequalities, etc.). Regarding funding processes, ANR emphasised the value of continuously open calls/rolling applications. This helped manage the number of applications and provide flexibility to the research community. For the Flash instrument, ANR bypassed peer-review to select projects that had to start immediately and provided seed funding to these projects. As a result, ANR concluded that they could select high-quality projects quickly without external evaluation. This helped 44 projects to start very fast and deliver the first outputs in 2020. ANR also simplified some of the post-submission processes. For example, unlike usual, ANR had only one contact organisation and PI (even for collaborative projects), and they organised all administrative matters and payments through a single organisation. This procedure helped the projects to start and progress faster, and researchers got hold of funding more quickly. This helped to avoid any delays due to funding administration.
Other impact enablers
The willingness of several regions to complement the ANR funding with their funds allowed them to fund more projects. In addition, regions' involvement helped define specific research topics relevant to the respective local administrations.

Challenges

As identified by the ANR review of awards, the funder received more applications and funded more awards in all thematic areas that male applicants led. The funder observed that female researchers had more difficulties continuing work during the pandemic.

Gender distribution in ANR COVID-19 response funding applications and awards



Source: Agence Nationale de la Recherche (2022b). Premier rapport d'étape des actions et des projets financés. Available: https://anr.fr/fileadmin/documents/2022/ANR-Bilan-covid2019-01022022.pdf

Overall assessment and lessons for the future

What lessons does the evidence of impact bring for the future emergency response funding

Future emergency response largely depends on the type of crisis. For pandemics, the National Agency for Research on AIDS and Viral Hepatitis-Emerging Infectious Diseases will lead the response in France because, as a result of the COVID-19 pandemic, the agency has been given a broader mandate to coordinate the response (including research) to any pandemics.

For any other emergencies, ANR will likely utilise the Flash programme that existed before the COVID-19 pandemic and that ANR successfully mobilised to organise the response to COVID-19. ANR concluded that thanks to the new element of quick seed funding added to the Flash programme, they could select high-quality projects quickly without external evaluation (for the seed funding part of the Flash instrument). This does not mean that ANR considers external review unnecessary, but in situations requiring an urgent response, relying on funders' ability to make funding decisions appears feasible. It does not imply risks of funding poor-quality science.

Information sources and interviewees

Documents consulted

Agence Nationale de la Recherche (2022a). About us. Available: https://anr.fr/en/anrs-role-in-research/about-us/missions/

Agence Nationale de la Recherche (2022b). Premier rapport d'étape des actions et des projets financés. Available: https://anr.fr/fileadmin/documents/2022/ANR-Bilan-covid2019-01022022.pdf

Documents consulted
Interviewees
Prof Philippe Bouvet, Head of the Biology-Health Department, ANR.

J.3. Funder information: German Research Foundation, DFG

Funder name	**German Research Foundation, DFG**
Brief description	The German Research Foundation (DFG) is Germany's central, independent research funding organisation. It serves all science and humanities branches by funding basic, curiosity-driven research projects at universities and other research institutions. The DFG receives most of its funds from the federal government and the states, represented in all grants committees. The voting system and procedural regulations guarantee science-driven decisions. The main task of the DFG is to select the best projects by researchers at universities and research institutions on a competitive basis and finance these projects.
Brief description of funder's response to COVID-19	Objectives of the response DFG's mission for responding to Covid-19 was to monitor the overall basic research landscape and identify and fund potential research needs, giving special attention to interdisciplinary and transdisciplinary cooperation. DFG is an independent legal entity and could easily make decisions about the Covid-19 response independently. Funding instruments The **call for multidisciplinary research into epidemics and pandemics** was available for projects addressing the prevention, early detection, containment and investigation of the causes, impacts and management of epidemics and pandemics, taking the example of SARS-CoV-2 and other microorganisms and viruses that are pathogenic to humans. The DFG also introduced **the COVID-19 Focus Funding** instrument to allow researchers to address particularly urgent questions on the pandemic that need short-term answers. The Focus Funding instrument published thematic calls directed at all relevant disciplines, and the DFG Interdisciplinary Commission decided the call themes (DFG, 2020). DFG supported projects with a maximum duration of one year. Support was available for projects of the highest scientific quality, promising to contribute substantially to knowledge on the specific research question of the call. Proposals were short, a maximum of five pages. Researchers could propose pandemic-relevant questions also in other DFG funding programmes.
Uptake of funder's response to COVID-19 funding instruments	Over 2020 and 2021, DFG has invested around €90m in research in response to the pandemic through targeted funding instruments. About 43% of the awards were in life sciences, 32% in social sciences, and 13% in engineering. In addition, topic modelling conducted by DFG indicates that pandemic research is highly interdisciplinary. The **call for multidisciplinary research into epidemics and pandemics** received 270 proposals and supported 51 projects worth €32m. Seven **COVID-19 Focus Funding calls** received 396 applications and supported 112 projects with €15m. Across both funding instruments, social sciences and humanities were 37% of all represented disciplines.

	DFG did not provide follow-on funding within the two funding mechanisms but encouraged the researchers to apply to other/regular DFG funding programmes if they wanted to proceed with follow on research on topics started within the Focus funding or multidisciplinary research calls.

Funder's approach towards monitoring and evaluating the impact of the response to COVID-19 funding instruments

DFG does not typically closely monitor the progress of ongoing research projects, and this was also the case for the pandemic funding supported projects.
Given that most projects are still ongoing, DFG has not yet evaluated the impact of COVID-19 research. Still, the funder has published a report summarising the key statistics on the number of proposals received, demographics of submitting researchers (gender, career stage, etc.), awards provided, the processes of processing the proposals, and the implications for funding DFG provides for international collaborative research. In addition, the funder conducted topic modelling based on the text analysis of the submitted proposals (see a summary of key topics in the next section) (DFG, 2022).
The report shows that compared to usual, the age and gender distribution of the applicants for funding during the pandemic has slightly changed. In some age groups, the funder observed higher numbers of applications from men than from woman (DFG, 2022). In line with DFG standard procedure, DFG also plans to conduct a peer evaluation of the project's final reports. Peers then would provide written feedback to the PI's, which will also inform DFG and build their understanding of the achievements of the projects they have funded. At the time of writing, the DFG Commission for Pandemic Research is also preparing a paper summarising the lessons learned on the role of research during the pandemic. Some of the lessons we highlight in the concluding section of this summary.

Evidence on key outputs produced by the supported projects

DFG analysis of pandemic research proposals reveals the key research topics supported in the scope of COVID-19 funding measures (DFG, 2022):

Societal and political implications of the pandemic – impact on state institutions, public discourses, democratic processes. The role of social media, especially concerning (dis)information. Understanding the global effect of the pandemic

School closures and the effects of the closures is another key research area where DFG funded researchers have looked at the impact on certain types of schools, groups of students, age groups, the role of digitalisation

Research on non-pharmaceutical interventions to contain the pandemic focused on acceptance of the measures, social, economic and health consequences of the measures

The effects of the pandemic on mental and physical well-being and how different groups are affected

The effects of the pandemic on the health care system and medical care, prevention of other diseases, and impacts on chronically ill

Specific symptoms of COVID-19 and long-term effects like loss of smell and taste, causes and consequences of complications, duration, course and long-term consequences of illness

Viral reproduction and spread; identification of starting points for targeted immune or pharmacotherapy, diagnostics and the causes and consequences of viral mutations

Statistical, empirical and simulation-based modelling of the spread of the SARS-CoV-2 virus for the development of scenarios and prediction models for the temporal and spatial spread of the virus

Physics of movement of virus particles and environmental factors; the effect of protective measures and their effect under different conditions.

Evidence on key outcomes and impact of the supported projects

DFG funds basic, curiosity-driven research and does not necessarily expect the researchers to come up with quick solutions for the pandemic. The importance of findings for the scientific community is the key expectation. For most DFG pandemic response funded projects, the outcomes and impact are yet to be achieved. Researchers can use DFG funding to establish contact and collaborate with research users, but it's not something the funder requires to deliver.
To illustrate the point, DFG is proud to have supported the team of researchers who developed the BioNTech COVID-19 vaccine based on preliminary work initially carried out as part of DFG funded Collaborative Research Centre in Mainz. This DFG-funded research is an example of the long-term benefits of basic research and is used as an argument to demonstrate the value of basic research and the type of funding DFG provides.

Impact enablers and challenges

The role of funder in facilitating the impact

DFG's primary focus is basic, curiosity-driven research at the early stages; therefore, the funder does not take specific action to facilitate impact. In most cases, it is too early for the funder to do that. The funder is open to the possibility of no result.
To support the dissemination and facilitate knowledge sharing that might lead to impact, for the pandemic research projects, DFG did the following.
For the research funded by the COVID-19 response funding, DFG organised a large digital conference inviting all projects (around 300) and high-level speakers, for example, Sir Jeremy Farrar from Wellcome, who gave the keynote speech. The conference aimed to provide a platform to share ongoing research and emerging findings and look for potential interdisciplinary collaborations.
DFG also encouraged the award holders to publish pre-prints to disseminate the new knowledge to the wider community rapidly.

The role of the design of funding instruments and/or funding processes

During the first two years of the pandemic, DFG received more funding applications for the targeted pandemic response instruments and the regular funding calls than usual. However, despite the increase in demand and remote work, the funder managed to maintain the standard application processing timelines.
According to DFG, the rapid development and start of the projects caused some problems with finding research staff that would be able to start the work rapidly and work for a short period. This conflicts with the objectives of the rapid COVID-19 response mechanisms. Due to this problem, many projects started later than planned, which also affected the impact they could deliver.

Overall assessment and lessons for the future

What lessons does the evidence of impact bring for the future emergency response funding

DFG concludes that for them, it was challenging to introduce a rapid response to the pandemic. Although DFG significantly accelerated all processes, it was still not fast enough for the situation's urgency. However, DFG has not yet drawn clear conclusions on what this implies for the future. Likely, they would not use the instruments they did to respond to COVID-19 and would design a different type of rapid response measure. That goes along with the need to have sufficient staff to support the rollout of the rapid response measures, which was a challenge for DFG.
DFG coordinated Interdisciplinary Commission also observed that the research system could not respond rapidly because of the lack of flexibility among the research staff due to contractual arrangements and research staff structure. The funder and other stakeholders in Germany thus are discussing possible changes to the research staff roles to enable more flexibility in the future.
Finally, DFG emphasises that the pandemic is a moving target. Long-term funding needs are as important as the ones faced when the pandemic started. It was easy to identify urgent funding needs but transforming to what is next to come is more complicated.

Information sources and interviewees

Documents consulted
DFG (2022). Das DFG-Fordergeschehen im Kontext der COVID-19-Pandemie. Available: https://www.dfg.de/download/pdf/dfg_im_profil/geschaeftsstelle/publikationen/studien/bericht_foerdergeschehen_pandemie.pdf DFG (2020). Covid-19 Focus Funding in the Research Grants Programme. Available: https://www.dfg.de/en/research_funding/announcements_proposals/2020/info_wissenschaft_20_51/index.html
Interviewees
Dr Anne Brüggemann, Head of Social Sciences and Humanities Division; DFG coordinator for the Interdisciplinary Commission for Pandemic Research. Interview date: 03.06.2022.

J.4. Funder information: Japan Science and Technology Agency, JST

Funder name	Japan Science and Technology Agency, JST
Brief description	JST funds high impact strategic research. Strategic Basic Research Programmes are intended to advance basic research to achieve solutions for key issues Japan is facing. Fusion Oriented Research for disruptive Science and Technology programme supports ambitious transdisciplinary research beyond existing frameworks. JST funds also research-industry collaboration and technology transfer. In addition, JST fosters next generation talents in science and technology and provides information platforms and database services (JST, 2021).
Brief description of funder's response to COVID-19	JST's mission was to help researchers continue their research under new circumstances and fund nonmedical research for COVID-19, such as behavioural simulation, materials for sensors, detective devices, and social surveys for policy making and similar. In response to COVID-19, JST mobilised two key programmes – the international emergency programme **J-RAPID and the national programme CREST**. The international emergency program J-RAPID aims to respond quickly to emergency events, such as natural or anthropogenic disasters, and support research at the height of the crisis by mobilising national and international researchers. J-RAPID aims to play an initial response role by promptly supporting activities before ordinary projects are implemented by the national government, academic societies, or others. CREST is one of JST's major programmes for stimulating achievement in fundamental science and technology fields. JST launched a special COVID-19 call within the CREST programme. In 2020 one of the CREST programme themes was coping with the COVID-19 pandemic, and it quickly launched a special call for proposals. It supported interdisciplinary collaborations of researchers from a wide variety of research fields. It utilised and combined various types of nonmedical knowledge such as engineering, informatics and nanotechnology. The call aimed to minimise the impact of COVID-19 and create fundamental technologies to coexist with emerging or re-emerging infectious diseases, utilising a wide variety of science and technology to build a resilient society for the new normal with/post COVID-19.
Uptake of funder's response to COVID-19 funding instruments	The J-RAPID COVID-19 call received 23 proposals and supported 11 international research collaboration projects (3 with partners from the UK) on topics ranging from genome research to chemical engineering and social science research. CREST programme supported ten projects.

The impact of funder's response to COVID-19

Funder's approach towards monitoring and evaluating the impact of the response to COVID-19 funding instruments
JST monitors the J-RAPID programme supported projects (duration up to 1 year) by collecting information on the outputs, effects of the collaboration between different partners involved, prospects for future development and impact on society. CREST programme supported projects are long-term (3 years), and the programme's final evaluation will take place in 2023.
Evidence on key outputs produced by the supported projects
Overall, the J-RAPID programme supported 11 projects that have resulted in 42 scientific publications. J-RAPID programme supported projects have resulted in several significant outputs. For example, a project in collaboration between the University of Yamanashi and the University of Notre Dame **(USA)** aimed to develop a technology to monitor the spread of COVID-19 in wastewater. The project's key outputs are a new method with a high detection sensitivity and a short detection time (90 minutes). Another project delivered in partnership with researchers from Brazil, Canada, China, France, Japan and Mali aimed to develop a knowledge transfer strategy to share lessons learned between countries. The lessons learned focused on how public health organizations, hospitals, and their staff have operated in the respective countries to cope, adapt and transform during the various phases of the pandemic. The project delivered w**orkshops in each country** and **a final international workshop** in the summer/fall of 2021. The workshops brought together policy and decision makers, hospital and public health professionals, researchers, and civil society organizations to **collectively produce operational recommendations**. Also, CREST programme supported projects are starting to produce their first outputs. For example, one group has developed an innovative technique to identify viral RNA (ribonucleic acid) from SARS-CoV-2 at the single-molecule level and detect it within five minutes. This made it the world's fastest (in 2021) coronavirus detection method (JST, 2022).
Evidence on key outcomes and impact of the supported projects
JST does not support pure medical research because another funder, the Japan Agency for Medical Research and Development, is responsible for that field. Thus JST could not directly contribute to the development of COVID-19 vaccines or drugs. However, JST did fund digital technologies, engineering, social sciences, and humanities and could mobilise research projects that contributed to a comprehensive strategy to "detect", "clean", and "protect", enabling citizens to return to more normal social and economic activities as quickly as possible. Based on the monitoring reports provided by the supported projects and a review of published outputs, JST concludes that the projects have achieved significant scientific impact. For example, J-RAPID supported project between the University of Tokyo and the University of Glasgow analysed the molecular structure of the virus and mode of infection from wild animals to humans. The project discovered the protein associated with disease progression and expects to develop technologies that can prevent the transmission of any virus from wild animals to humans. The project has resulted in several publications in Nature and Cell. **Many projects had end users involved in the partnership. For example, the city of Yamanashi in Japan was involved in the project developing new techniques for monitoring and detecting the virus in wastewater and helped test the new technology. As a result, the city now uses it for virus detection.**

Impact enablers and challenges

The role of funder in facilitating the impact
JST did not have enough resources to disseminate information about each project's findings to diverse potential users. Therefore the funder regularly hosted press conferences to inform reporters about the outputs and outcomes of the research projects.

The role of the design of funding instruments and/or funding processes
JST had previously used the J-RAPID programme to fund rapid research in emergencies. Since the programme's introduction in 2011, this mechanism has helped to effectively and efficiently respond to various national/international emergency cases. Although the scale of the pandemic was even larger than in previous cases, it was relatively easy to adapt the J-RAPID programme for the global pandemic. Thus, JST knew the funding instrument works and would likely deliver the results. The programme's requirement to involve end-users from the start of the project helped to ensure that the technologies are developed for the needs of potential users and thus can quickly provide solutions to help to manage the response to the pandemic. Also, JST believes that the programme requirement for the project's duration (up to one year) also facilitates the generation of fast impact. When proposing a research project, researchers already estimate what they can achieve within this timeframe and plan accordingly. JST supported COVID-19 related non-medical research within the scope of its regular funding instrument, the CREST programme. The CREST programme had an established mechanism; the only significant difference from usual was the rapid introduction of the call and evaluation of the projects, which worked well. However, it was a challenge and an opportunity for JST, which had mainly handled natural sciences research, to involve social science/humanities disciplines effectively to contend with the pandemic that cannot be solved by natural sciences alone. The realities of the pandemic made JST accelerate the digitalisation process, which has led to process improvements for the research community benefiting from JST funding. JST continues to improve the digitalisation of everyday work, including online meetings, remote evaluation, and streamlining paperwork.

Overall assessment and lessons for the future

Overall assessment of the impact achieved
COVID-19 response funding instruments worked very well and were highly acclaimed by the JST's annual activities assessment by the government. As a result, JST plans to use the same J-RAPID response instrument in future emergencies.

Information sources and interviewees

Documents consulted
JST (2021). Japan Science and Technology Agency. Available: https://www.jst.go.jp/EN/about/pdf/outline_e.pdf JST (2022). Ultra-sensitive and world's fastest detection of new coronavirus. Available: https://www.jst.go.jp/EN/achievements/research/bt2022-02.html
Interviewees
Osamu Kobayashi, Director, Department of International Affairs, Japan Science and Technology Agency. Interview date: 22.06.2022.

J.5. Funder information: National Research Council Canada, NRC

Funder name	National Research Council Canada, NRC
Brief description	National Research Council Canada (NRC) is Canada's largest federal research and development organisation. It reports to Parliament through the Minister of Innovation, Science and Industry and is governed by a council of appointees drawn from its client community. NRC's mission is to "have an impact by advancing knowledge, applying leading-edge technologies, and working with other innovators to find creative, relevant and sustainable solutions to Canada's current and future economic, social and environmental challenges." (National Research Council Canada, 2021a). The NRC is made up of four R&D divisions and a horizontal digital research initiative. Under these divisions operate 14 integrated and consolidated research centres, each guided by advisory bodies composed of academic and industry leaders.
Brief description of funder's response to COVID-19	NRC's mission for responding to COVID-19 was to exploit and pivot NRC's activities and fund COVID-19 research to create solutions for the pandemic. NRC introduced the **Pandemic Response Challenge programme**, bringing together the best (NRC) Canadian and international researchers to fast-track R&D aimed at specific COVID-19 gaps and challenges identified by Canada's health experts. The programme was structured around four research pillars: rapid detection and diagnosis, therapeutics and vaccines, digital patient care and pandemic analytics and enabling adaptive responses. The programme ended in March 2022. NRC also invested in two large **infrastructure projects** to support Canada's biomanufacturing production capacity. The new Biologics Manufacturing Centre was completed in June 2021, only ten months after breaking ground. It will have a production capacity of approximately 4,000 litres a month, or two million vaccine doses per month. The Clinical Trial Material Facility will be built to manufacture vaccines for clinical trials and is scheduled to be complete in summer 2022. NRC's **Industrial Research Assistance Programme** (IRAP) collaborated with the Department of Industry, Science and Economic Development's (ISED) Innovative Solutions Challenge Programme and posted challenges seeking near-to-market solutions from small and medium-sized businesses (i.e. fewer than 500 staff). The programme provided funding to SMEs that require financial support to refine and sell their product or solution to meet COVID-19-related needs. IRAP also set up a new type of advisory service to help companies pivot to transform their operations to produce PPE or to shift from physical to virtual work. In addition, the programme provided webinars and direct consultations to thousands of businesses across Canada (National Research Council Canada, 2022). IRAP was also used to aid innovative firms not eligible for the regular Canada Emergency Wage Subsidy support. Finally, within the IRAP programme, NRC organised virtual pitch sessions where SMEs presented their ideas to the representatives of federal and provincial governments.
Uptake of funder's response to COVID-19 funding instruments	**Pandemic Response Challenge Programme** supported 50 R&D projects with $15m. NRC **IRAP** delivered nearly twice the funding (total of $11m) and support it would provide Canadian businesses in a typical year. The Innovative Solutions Challenge Programme supported 23 near-to-market projects. Since April 2020, NRC IRAP's Innovation Assistance Programme has provided $405.2m in wage subsidies (National Research Council Canada, 2022).

	IRAP programme organised 23 virtual pitch sessions where 76 SMEs presented their ideas to the representatives of federal and provincial governments (National Research Council Canada, 2022). IRAP programme provided COVID-19 advisory services (e.g., transforming manufacturing) to 2800 companies. A new online portal to accept applications, backed by a substantial web server upgrade, was key to ensuring NRC IRAP could keep pace with the unprecedented demand for its services.

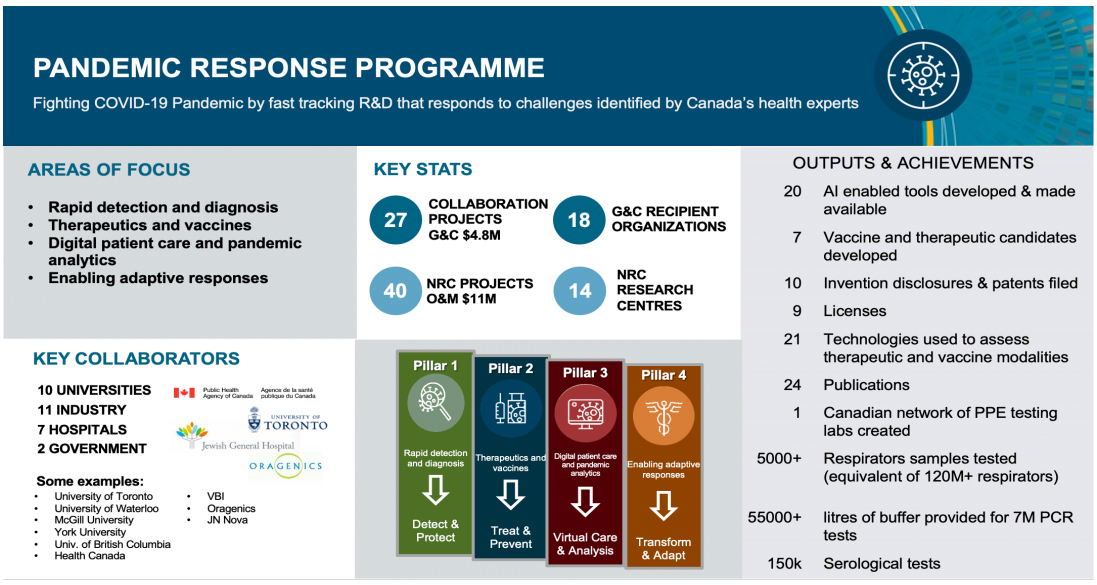
Funder's approach towards monitoring and evaluating the impact of the response to COVID-19 funding instruments

NRC evaluated each supported project in terms of its future after the Pandemic Challenge Programme. Some projects have achieved the intended objectives and ended as planned. Some projects will continue within other NRC Challenge Programmes because the technologies are applicable in other areas. These are mostly linked to digital health technologies where NRC has a separate Challenge Programme.
Because of close monitoring and end project evaluation, NRC is very well aware of the outcomes and impact the projects have produced. Therefore, there is no need for additional impact evaluation. However, NRC routinely monitors long-term outcomes (5-10 years after the funding) of the research they have funded to understand the commercial impact. Pandemic Challenge Programme funded research will also be subject to this assessment.

Evidence on key outputs produced by the supported projects

Figure below shows the key statistics and outputs of the Pandemic Response Challenge Programme. The programme areas focusing on detection and diagnosis and adaptive responses had some very practical outputs and outcomes, such as tested personal protective equipment (PPE) items and a new network of PPE testing labs; see details in the next section. The projects also resulted in novel IP. For example, researchers licensed a novel antigen for antigen testing. Other areas like therapeutics and digital patient care involved more basic research and lower TRLs, resulting in 24 scientific publications.

Overview of Pandemic Response Challenge Programme outputs



The NRC response programme focusing on SME and innovation support – IRAP - organised 23 virtual pitch sessions where 76 SMEs presented their ideas to the representatives of federal and provincial governments, resulting in 10 funded firms and three technologies went on to receive Health Canada certification (National Research Council Canada, 2022).
IRAP's Innovation Assistance Programme helped more than 2,200 businesses maintain operations and keep some 24,000 jobs on payroll (National Research Council Canada, 2022).

Evidence on key outcomes and impact of the supported projects

NRC is both a research funder and an organisation performing research (operates 14 research centres). Thus, NRC produced impact directly via research conducted at 14 centres and by providing funding via competitive funding programmes.

NRCs Pandemic Response Challenge programme projects were critical in building Canada's capacity to **manufacture personal protective equipment** (PPE). The country's supply of PPE was low when the pandemic started, and it depended on imports. To ensure the imported PPE is safe, NRC established a testing lab. The testing lab evaluated around 5000 samples of PPE, and this fed into decisions enabling the use of about 120 million PPE items. NRC's Metrology Research Centre also established a testing lab network involving 40 private and provincially funded labs across the country, along with 12 new domestic PPE manufacturers, to further increase Canada's overall testing capacity (National Research Council Canada, 2021b).

Furthermore, NRC had a critical role in strengthening the country's PPE production capacity to reduce the dependency on imported equipment. For example, the NRC IRAP programme supported several companies in reconfiguring existing manufacturing equipment to produce filters for masks and respirators. IRAP programme also funded other business R&D resulting in new products or services relevant to pandemic management. For example, the programme supported the company LuminUltra which, with the help of the funding, re-focused its operations from wastewater testing for environmental contaminants to using its technology for public health purposes. As a result, the company now produces 10 million test kits every week for detecting COVID-19 in wastewater for early detection of the new virus variants in Canada (National Research Council Canada, 2022).

IRAP also supported several other companies starting the **production of virus test kits**. In addition, NRC research centres helped several manufacturing companies retool their operations to produce nasal swabs increasing Canada's capacity to produce two million swabs yearly.

NRC funding was also crucial to support **vaccine production**. NRC IRAP invested more than $41m to advance early-stage R&D of seven Canadian vaccine candidates and seven therapeutic candidates to prevent and treat COVID-19. Another $113m will be awarded by 2023 to the most promising candidates. In addition, NRC IRAP provided $4.5m in funding to support the work of three Canadian biomanufacturing firms (National Research Council Canada, 2021b).

Impact enablers and challenges

The role of funder in facilitating the impact

NRC deliberately mobilised its networks and relationships throughout government and with industry and academia and played a substantial part in supporting other government departments such as the Public Health Agency of Canada and Innovation, Science and Economic Development Canada. Deliberate coordination of funding efforts was an important precondition for impact. Canada Research Coordinating committee provided federal level coordination of research response to Covid-19 between several research funding organisations. NRC's Pandemic Response Challenge Programme aimed to accelerate the development of technologies and focused on bridging the gaps between public research and private industry. NRC's Industrial Research Assistance Programme supported projects closer to the market.

NRC's IRAP programme launched an initiative to invite small and medium-sized businesses to register their technology to assist Canada's COVID-19 response and participate in virtual "pitch sessions" to present their business, technology, and ideas to a panel of experts from federal and provincial governments. NRC then invited small and medium-sized companies to pitch a panel of experts from federal and provincial governments on their technologies and ideas for sanitisation, disease tracking, therapeutics, patient monitoring and more. This initiative helped companies align their efforts to ongoing government activities, seek funding support from existing relevant funding programs or secure NRC IRAP R&D funding.

IRAP also set up a new advisory service to help companies pivot - to transform their operations to produce PPE or to shift from physical to virtual work - with webinars and direct consultations reaching thousands of businesses across Canada (National Research Council of Canada, 2021b).

The role of the design of funding instruments and/or funding processes
The pre-existing framework of the NRCs Challenge Programmes helped to decide and introduce pandemic response fast by utilising the already existing framework and adjusting the duration of the programme from seven years to two years. This overall set-up helped to make the funding available fast and helped to achieve the impact. Also, close work with health authorities and consulting the WHO blueprint to identify research needs helped to focus funding on areas with likely impact. To accelerate the start of the research, NRC bypassed peer review for its Pandemic Challenge Programme and instead offered real-time advisors to the teams delivering the research so that they could get feedback from peers to confirm they were doing the right thing. This process worked well and was one of the funding design elements that enabled fast impact achievement. Initially, there were some concerns in NRC about the approach, but NRC Executive Committee was comfortable with the approach because of the need for speed that the situation required. Also, as noted above, NRC was in close contact with health and other authorities, which provided significant input and gave NRC a solid situational awareness of what was needed, which helped to make funding decisions. Finally, the funder accepted that there were a lot of unknowns, was willing to take risks and accepted failure. For two high-risk projects that did not meet the initial milestones, NRC stopped the funding.

Overall assessment and lessons for the future

Overall assessment of the impact achieved
NRC reported being very satisfied with the design and processes of the COVID-19 response and the outcomes and impact achieved by the funded projects. The ability to use existing programme framework and adjust it to meet the urgency was among the main reasons for success.

Information sources and interviewees

Documents consulted
National Research Council Canada (2022). Biosurveillance for community-level virus detection. Available: https://nrc.canada.ca/en/stories/biosurveillance-community-level-virus-detection National Research Council Canada (2021a). About the NRC. Available: https://nrc.canada.ca/en/corporate/about-nrc National Research Council Canada (2021b). Response. Recovery. 2020-2021 Annual Report. Available: https://nrc.canada.ca/sites/default/files/2021-09/nrc-annual-report-2020-2021-e.pdf
Interviewees
Jean-Francois Houle, Vice-President, Pandemic Response Challenge Programme Andrew Procca, programme manager, Pandemic Response Challenge Programme Roscoe Klinck, Senior Policy Advisor, International Innovation Office

J.6. Funder information: National Science Foundation (NSF), USA

Funder name	National Science Foundation (NSF)
Brief description	The National Science Foundation (NSF) is an independent federal agency created by Congress. NSF is the only federal agency whose mission includes support for all fields of fundamental science and engineering, except for medical sciences. Providing grants for promising scientific research is NSF's primary business and a key element of its mission. In addition to funding research in the traditional academic areas, the NSF also supports high-risk research (National Science Foundation, 2021).
Brief description of funder's response to COVID-19	**RAPID programme** was the key NSF's pandemic response mechanism. NSF RAPID grants supported fast response research of up to $200,000. The duration of the supported projects was up to one year. Proposals for the RAPID instrument had to be short (maximum 2-5 pages) and justify why the proposed research is urgent. Proposals were reviewed and approved by NSF officers, rarely relying on external reviews. NSF received thousands of proposals for the RAPID grants. In addition to support for basic research across all disciplines, NSF operated SBIR/STTR programmes focusing on the translation of the research outcomes and supporting business R&D. **SBIR/STTR programme call addressing COVID-19 related research** supported proposals directly focusing on urgent research with a potential to provide solutions to pandemic related problems. Applicants had to submit a short (maximum 2000 words) project pitch, and NSF aimed to provide funding within six weeks after the receipt of the proposal.
Uptake of funder's response to COVID-19 funding instruments	According to the NSF awards database, NSF has funded about 1000 awards using the CARES Act Funding. The CARES Act implemented various programs to address issues related to the onset of the COVID-19 pandemic.

The impact of funder's response to COVID-19

Funder's approach towards monitoring and evaluating the impact of the response to COVID-19 funding instruments
NSFs Annual Evaluation Plan for year 2023 outlines the plan to evaluate in what ways did the COVID-19 pandemic influence the participation of different groups in the NSF portfolio of programmes and activities, such as merit review. The funder plans to examine whether and how the pandemic response funding measures contributed to the negative effects and how the funder can alter those in the future. NSF evaluation plans are driven by concerns over the impacts of COVID-19-driven disruptions on the scientific enterprise and the careers of those most at risk (such as early career and female scientists). Pandemic disruptions seemed to have led to both negative and positive outcomes. For instance, the switch to virtual work disrupted in-person panels. It also opened the door for increasing reviewer diversity through remote panels by removing the barrier that travel may represent for some, such as scientists with caregiver responsibilities or underrepresented minorities with disabilities that make travelling difficult (NSF, 2022b). The planned evaluation will assess the above complexities in detail.
Evidence on key outputs, outcomes and impact produced by the supported projects
NSF RAPID programme funded thousands of projects resulting in various outcomes. Some examples are the development of self-sanitising medical facemasks, research on how different temperatures, drying and other conditions affect the virus's ability to survive and research on how water quality is affected by building closures. Researchers also developed online tools enabling 3D exploration of genomic variants of coronavirus and analysed the impact of lockdown strategies in different

countries. Unfortunately, there is no robustly measured and publicly available information on the impact of the awards. However, in public communication, NSF emphasises that its investments in research related to the pandemic produced actionable results (NSF, 2022b).

Impact enablers and challenges

The role of funder in facilitating the impact
NSF supported the creation of COVID-19 Information Commons (CIC), a public database facilitating knowledge sharing and collaboration across various COVID-19 research efforts. It contains detailed information about all NSF awarded RAPID projects (Covid Information Commons, 2020). In October 2021, NSF provided extension funding ($2m) for the Information Commons project. The initial focus was on compiling publicly available information from all COVID-related projects funded by the various Directorates across NSF to create an easily searchable corpus. In addition to the publicly available information, the CIC collected self-reporting information from the projects via a voluntary survey (National Science Foundation, 2022a). A webinar series was created, featuring talks by researchers from the NSF-funded COVID-19 RAPID research projects. The CIC extension will extend this initial CIC effort also to include all projects funded by NSF related to the pandemic recovery phase. In addition, it will seek to include publicly available information on COVID-related efforts beyond those funded by the NSF. The initial CIC effort demonstrated the benefits of bringing information about a diverse set of COVID-related projects into a single place, enabling interested users to search for information and efficiently discover linkages among diverse efforts. This helped foster the creation of a community and helped catalyse collaborations (National Science Foundation, 2022a).
Other impact enablers
In its public communication, NSF emphasises its past investments in basic research and how it laid the groundwork for today's scientific advances in response to the pandemic (National Science Foundation, 2020a; National Science Foundation, 2020c).

Information sources and interviewees

Documents consulted
Covid Information Commons (2020). About the Covid information commons. Available: https://covidinfocommons.datascience.columbia.edu/content/about-cic National Science Foundation (2021a). About the National Science Foundation. Available: https://www.nsf.gov/about/#:~:text=The%20National%20Science%20Foundation%20(NSF,people%20to%20create%20knowledge%20that National Science Foundation (2022a). Award Abstract # 2139391. Available: https://www.nsf.gov/awardsearch/showAward?AWD_ID=2139391&HistoricalAwards=false National Science Foundation (2022b). National Science Foundation Annual Evaluation Plan. Available: https://www.nsf.gov/od/oia/eac/PDFs/NSF%20Annual%20Evaluation%20Plan%20FY2023%20Final.pdf National Science Foundation (2022c). U.S. National Science Foundation 2022-2026 Strategic Plan. Available: https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf

J.7. Funder information: Dutch Research Council, NWO and The Netherlands Organisation for Health Research and Development, ZonMw

Funder name	**Dutch Research Council, NWO** **The Netherlands Organisation for Health Research and Development, ZonMw**
Brief description	The Dutch Research Council (NWO) is a science funding body in the Netherlands, and its mission is to advance world-class scientific research. Each year, it invests almost €1b in curiosity-driven research related to societal challenges and research infrastructure. NWO focuses on all scientific disciplines and the entire knowledge chain, emphasising fundamental research (NWO, 2021). ZonMw funds health research and innovation throughout the entire knowledge chain, from fundamental research to implementation. ZonMw's main commissioning organisations are the Ministry of Health, Welfare and Sport and NWO.
Brief description of funder's response to COVID-19	NWO responded to COVID-19 by launching the **Corona: Fast-track Data call** to support immediate data collection possible only during the crisis and, together with its sister organisation, ZonMw, launched a more substantial **COVID-19 research programme**. ZonMw also started with the GO FAIR Foundation initiative, the 'Virus Outbreak Data Access Network' (VODAN). The purpose of this implementation network is to share data on the current outbreak of coronavirus in such a way that they become accessible to learning algorithms. NWO announced the **Corona: Fast-track Data call** for proposals in April 2020. The call for proposals focused on research conducted at the height of the corona crisis, specific research into issues other than medical and healthcare issues that arise in society during the crisis. This instrument was intended solely for research into issues arising in society during the corona crisis. The research had to be relevant to the learning capacity of society during the corona crisis or to the management of the crisis and - and required the gathering of real-time data that could only be collected during the crisis. Potential research topics included the fight against the pandemic, drug development, improvements in care, population behaviour and behavioural changes in the Netherlands, their impact on the spread of the virus, social and economic consequences and the impact of measures on the well-being of the Dutch population. Many projects were already in progress to gather essential information that could only be collected during the pandemic. This call was intended to support such existing projects, but researchers could also request funding for new projects (NWO, 2020). **COVID-19 programme** ZonMw had the lead role in implementing the COVID-19 research programme. The Ministry of Health funded the programme. NWO provided part of the programme's budget and was involved in the programme design, while ZonMw led the programme design and ensured the practical implementation of the programme. ZonMw implemented the programme in two waves. *The first wave COVID-19 incidental subsidies* The first wave COVID-19 programme supported eight critical projects with a total value of €5.5m. ZonMw organised the work of an expert panel that had the task to prioritise the most urgent, critical research subjects in the first stage of the pandemic. ZonMw did not organise an open call for proposals because of the urgency. Instead, based on the expert panel advice, specific research groups or principal investigators were asked to submit research proposals and received incidental subsidies. The funder

Funder name	Dutch Research Council, NWO The Netherlands Organisation for Health Research and Development, ZonMw
	used this very short and closed application procedure because of the need to act quickly. *Second wave Covid-19 programme* The second wave Covid-19 programme was partly organised as open competition and focused on research on the effects of the crisis and the measures taken against the pandemic. The programme supported three focus areas (ZonMw, 2020d): 1. Predictive diagnostics and treatment 2. Care and prevention 3. Societal dynamics. Bottom-up calls for proposals were published for all three focus areas. An additional call for proposals **for COVID-19 Science for professional practice** was published for small projects and studies with a maximum budget of €25,000. The call for proposals was intended for research realised by collaborations between scientific organisations and businesses, public organisations, administrative bodies or local governments. The scientific organisations applied on behalf of the collaboration.
Uptake of funder's response to COVID-19 funding instruments	**Corona Fast-Track Data** NWO provided €1.5m to fund 33 projects. **COVID-19 programme** The first wave Covid-19 programme supported eight critical projects with a total value of €5.5m. The programme's second wave funded almost 300 projects. **Two calls for smaller projects: COVID-19 Science for professional practice call** funded 56 projects and call for creative solutions funded 76 projects.

The impact of funder's response to COVID-19

Funder's approach towards monitoring and evaluating the impact of the response to COVID-19 funding instruments
ZonMw completed process evaluation after the first year of funding to assess how the funder's internal processes worked. The evaluation is only for internal use. Other evaluations looking at impact have not started yet.
Evidence on key outputs, outcomes and impact of the supported projects
According to ZonMw, the **First wave COVID-19 programme** consortia projects and the larger projects of the second wave COVID-19 programme produced the most significant impact. **An** example of impactful **p**rojects were projects on vaccine efficacy in groups with compromised immune system. Research results were passed on to executive agencies to be converted into policy quickly and were relevant for the national vaccination strategy. The findings of these projects help patients, practitioners and policymakers to make the right decisions regarding the vaccination strategy. The results of these studies also feed into overall scientific knowledge on vaccination for groups with compromised immune system and thus have international relevance. **Second wave COVID-19 programme** projects resulted in many practical outcomes. For example, several behavioural studies delivered evidence on adherence to pandemic control measures, attitudes towards vaccination, and the effectiveness of vaccination campaigns among low-income and immigrant communities. The **COVID-19 Science for professional practice call** funded 56 small projects. The results of these projects were grouped into three domains and published on the website to make the results available for a wider audience: **Wetenschap voor de Praktijk - ZonMw**. Another call for creative solutions funded 76 projects. These were grouped in several themes and are available on the website: **Projecten Creatieve oplossingen aanpak coronavirus (COVID-19) - ZonMw Digitale Publicaties**. Compared to large consortium studies, the funder had more difficulty following up with several small projects. Several projects produced outcomes with potential for practical use, for example, a tent to enable families to visit relatives in nursing homes. The solution was introduced in some nursing homes but not nationwide. About ten projects of this programme (with a small grant size of €25k) received follow-up funding from other ZonMw programmes to extend the initial work. ZonMw reported that the rapid funding enabled fast production of research outputs and outcomes, and the process was faster than usual. In the beginning every 2 months and later every 3 months an overview of (interim) results of all running and finalised projects was reported to the Ministry of Health to use for policy making. In most disciplines, this resulted in the fast uptake of research findings in policymaking. However, in some areas it was difficult to meet the rapidness required by decision makers. The Netherlands Outbreak Management Team met regularly and had to advice the Ministry of Health based on available results, while some thorough scientific evidence only became available later. **NWO Corona Fast-Track Data call** supported various data collection projects, using innovative data collection tools and resulting in different outputs. For example, Erasmus MC-Sophia Children's hospital and Tilburg University launched the Grow It! app to prevent psychological problems and obtain insight into young people's moods. Grow It! is a smartphone app, in the form of a game, that explicitly supports young people aged 12 to 25 years with their feelings of anxiety and stress during the coronavirus crisis. The data that young people entered provided a weekly update about their mood. The app is part of the project '*How do adolescents cope with the Corona-crisis: a smartphone study*'. Via the app, the researchers also obtained insight into children's emotions, formed profiles of people, and acquired insight into how their mood changes over time. Rotterdam City Council also supported the project. The NWO programme also supported projects that complemented and extended the data collection of existing longitudinal studies. For example, one project examined whether the COVID-19 pandemic leads to increased symptoms of depression and anxiety, especially in psychiatric patients. It utilised the availability of more than 3000 subjects from ongoing psychiatric cohort studies that have been well-characterised in multiple waves during the last decade. Psychiatric symptoms were re-assessed using consecutive online assessments (April-July 2020), allowing comparison with symptoms in periods before the COVID-19 pandemic (NWO, 2022).

Impact enablers and challenges

The role of funder in facilitating the impact
ZonMw had a significant role in coordinating the research results with the Dutch Ministry of Health, Welfare and Sport, the National Institute for Public Health and the Environment and the Health Council of the Netherlands (ZonMw, 2022a). Immediately after the researchers delivered the results, ZonMw shared the findings with the above institutions, and the institutions provided nationwide recommendations on the vaccination for the immune-compromised groups. For the Second wave COVID-19 programme, ZonMw organised a systemic review of findings, grouped thematically, and organised meetings to share the findings with relevant policy makers and other stakeholders. For example, ZonMw gathered all behavioural studies projects that delivered findings on this topic for an online meeting with the Ministry of Health, Welfare and Sport, where researchers presented the key findings. As a result of this, the ministry made changes to its vaccination campaign and other measures.
The role of the design of funding instruments and/or funding processes
To enable knowledge sharing and overarching research, the studies on the vaccine efficacy in groups with compromised immune system in the Netherlands worked based on jointly agreed protocols and measurement methods. ZonMw put forward this requirement, which strongly facilitated the comparability of findings and thus also the use. ZonMw also had a requirement detailed in the programme text and reporting requirements to seek project collaborators that could potentially be users of the research findings. ZonMw applied several open science requirements in all their COVID-19 research programmes. The requirements were, for example, showing in the grant application the options for reusing data, preregistration of animal studies, and developing and regularly updating data management plan. ZonMw also asked to plan a budget for research data management, share research findings as soon as possible through open access publications, and provide metadata as quickly as possible. ZonMw also registered all research projects on the GLOPID-R research project tracker and the national Netherlands database (ZonMw, 2022b).
Challenges
One of the challenges ZonMw faced was securing funding from the ministry to fund research on long COVID. The research community demanded this, and the funder had to reallocate funding from other priorities to cover this important subject. In the summer of 2022, relevant findings on long COVID are coming in. However, this is late, and in terms of impact, a large group of people are affected by long COVID living with limited knowledge on how to handle it.

Overall assessment and lessons for the future

What lessons does the evidence of impact bring for the future emergency response funding
The harmonisation requirement for researchers to work with jointly agreed protocols and measurement methods will likely be applied in future research programmes funded by ZonMw. Although the situation and urgency were unique for this sub-programme, the researchers and the funder saw its usefulness for arriving at more practical and applicable findings (ZonMw, 2022). The funder can play a large role in quick turnaround of results to policy makers to ensure implementation of results. The VODAN project and open science/open access policies have led to more openness and quick availability of data and results. Many more lessons will be made available after ZonMw will perform the impact evaluation. Results of the COVID-19 programme are being used to design a new programme on pandemic preparedness.

Information sources and interviewees

Documents consulted
NWO (2021). About NWO. Available: https://www.nwo.nl/en/about-nwo NWO (2022). The impact of COVID-19 on mental health in persons with and without psychiatric disorders: extension of ongoing large-scale cohort studies. Available: https://www.nwo.nl/projecten/44020009-0 ZonMw (2022a). COVID-19 vaccination for patients with a compromised immune system. Available: https://www.zonmw.nl/en/about-zonmw/coronavirus/covid-19-vaccination-for-patients-with-a-compromised-immune-system/ ZonMw (2022b). Open Science in COVID-19 research. Available: https://www.zonmw.nl/en/research-and-results/fair-data-and-data-management/open-science-in-covid-19-research/
Interviewees
Dr Suzanne Verver, Covid-19 senior research programme manager at ZonMw

Appendix K Survey of award holders

K.1. Sampling, launch and response rate details

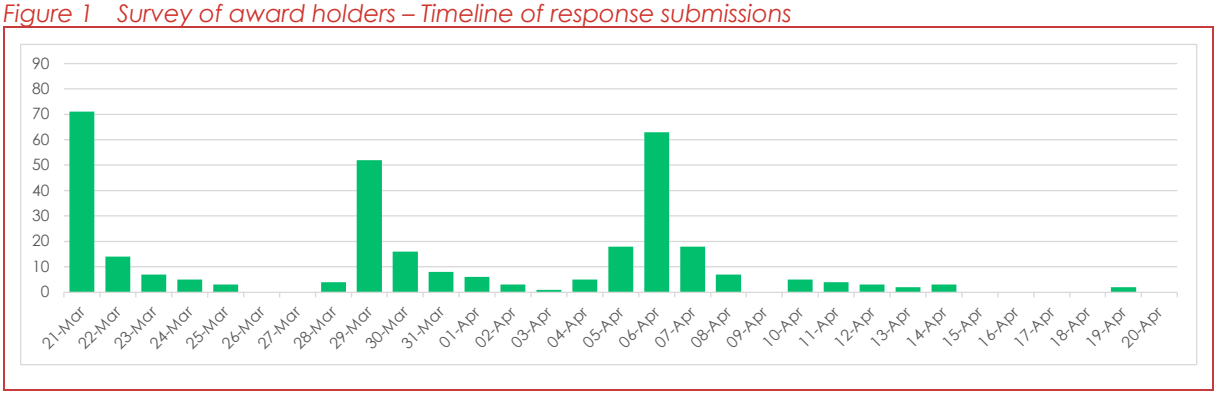
The survey data collection took place between the 21st of March and 20th of April 2022.

We note that our total population figure is smaller than the total number of awards stated in the introduction to our main report. The main reason is that it was agreed with UKRI not to survey those funded under the Africa Newton call (N=80). Secondly, we survey individuals rather than awards. Where an individual held multiple awards, we asked them to answer any award-specific questions in relation to their award of the largest financial value. This filtered out 38 awards specifically at InnovateUK and 27 further awards across other parts of the UKRI portfolio. Finally, some awards did not have a valid email address associated with them in the data we received. This applies to 28 InnovateUK awards, as well as to four others across other parts of UKRI.

Table 1 Survey of award holders – headline response rate

Survey of UKRI COVID-19 response award holders					
Total Population:	**692 (668)***	**Survey responses:**	**320**	**Response rate:**	**46.2%**
Population notes: Population includes all individuals who received awards (as lead investigator or equivalent) on the following UKRI COVID-response investments: The UKRI Agile Calls, long COVID-19 and Rapid Response Calls, Urgency Grants, COG-UK calls, Therapeutics Task Force, Unit/Centre Supplementary funding, GCRF/NF Agile awards, Global Effort on COVID-19, NCS, UK-India COVID-19 Partnership, UKRI Ideas to Address COVID-19 and other calls. 20 invitations bounced and 4 respondents had opted out of receiving surveys, so 668 could be invited to take the survey.		Response notes: Responses were collected between 21/03/2021 and 19/04/2022, Involving one initial invite and two reminders (see graph below). The population of respondents largely reflects the total population on all characteristics we are able to control for (see table below). The only caveat is that non-Innovate UK Agile call award holders are slightly overrepresented, whilst UKRI Ideas to Address COVID-19 award holders are slightly under-represented (also observed in the process evaluation survey). Aside from this caveat, this means that our survey data are likely strongly representative of the total population.		Response rate notes: For this population size, 248 responses would have been necessary to analyse for statistical significance at a confidence level of 95% and a confidence interval of 5. For a confidence interval of 4, 322 responses would have been necessary. Our response rate comfortably passes the former threshold and narrowly passes the latter. However, due to some respondents skipping questions, the latter is not fulfilled on every survey item presented in this report. This applies notably to the first part of the survey, which was not intended for all participants.	

Figure 1 Survey of award holders – Timeline of response submissions



Source: Surveymonkey.

Table 2 Survey of award holders – response rates in detail

	Total population (N = 692)		Response pool (n = 320)	
Funding instrument				
Agile Call	400	**57.8%**	213	**66.6%**
UKRI Ideas to Address COVID-19 - Innovate UK	88	**12.75**	17	**5.3%**
Rapid Response Calls	76	**11.0%**	32	**10.0%**
GCRF/NF Agile Awards	40	**5.8%**	20	**6.3%**
Global Effort on COVID-19	21	**3.0%**	8	**2.5%**
All others	67	**9.7%**	30	**9.4%**
Funder				
AHRC	80	**11.6%**	44	**13.8%**
BBSRC	38	**5.5%**	24	**7.5%**
EPSRC	59	**8.5%**	29	**9.1%**
ESRC	203	**29.3%**	104	**32.5%**
Innovate UK	88	**12.7%**	17	**5.3%**
MRC (Agile Call only)	46	**6.6%**	20	**6.3%**
NERC & STFC	17	**2.5%**	12	**3.7%**
UKRI (incl. UKRI/NIHR investments)	120	**17.3%**	49	**15.3%**

K.2. Raw survey data

Have you developed any data sources and/or solutions to understanding COVID-19 and its public health impact? (E.g. COVID-19 epidemiology, disease process, clinical trials, novel and/or existing vaccine and therapeutic candidates)

Answer Choices	Responses	
No	47.66%	51
Yes, and these have been disseminated to relevant user groups (please give detail in the box below)	32.71%	35
Yes, but not yet disseminated to relevant user groups (please give detail in the box below)	19.63%	21
If 'yes', please provide a short summary on to whom this has been disseminated and the impact of this if known / or a summary around plans for and/or barriers to dissemination		61
Answered		**107**
Skipped		**0**

Comments (90):

- Training / dissemination for practitioners
- Briefings to decision-makers
- OA resources/publications
- Adopted processes, solutions or products

Have you developed any data and/or knowledge that contribute towards managing and/or understanding the impact and challenges of measures to contain and/or respond to COVID-19? (E.g. knowledge and understanding of the impacts of lockdown and restrictions, inequality impacts, economic modelling of the damage of and recovery from COVID-19, sustainable sourcing of PPE)		
Answer Choices	Responses	
No	36.19%	38
Yes, and this has been disseminated to relevant user groups (please give detail in the box below)	34.29%	36
Yes, but not yet disseminated to relevant user groups (please give detail in the box below)	29.52%	31
If 'yes', please provide a short summary on to whom this has been disseminated and the impact of this if known / or a summary around plans for and/or barriers to dissemination		69
Answered		**105**
Skipped		**2**

Comments (69):

- Collected data tended to be pertaining to hospital admissions, primary data from healthcare professionals, and the impact of the pandemic and restrictions on more vulnerable groups (e.g., women, indigenous peoples)
- The generated understanding has been primarily fed to decision-makers in the UK and LMICs
- Publications were largely in process at the time of responding

Are you aware of any insights from your UKRI COVID-19 award being cited in any policy documents pertaining to the pandemic, its consequences or measures to contain and/or respond to it? (E.g. reports, legislation, practice guides and other documents from any arm of central government, devolved or regional administrations, NGOs, charities or international organisations)		
Answer Choices	Responses	
No	81.37%	83
Yes (please give detail in the box below)	18.63%	19
If 'yes', please provide weblinks (urls) or organisation and report titles, as convenient for you		32
Answered		**102**
Skipped		**5**

Comments:

- UK-based health policy documents were the most commonly documents where findings were cited
- Reports published by international organisations (e.g., WHO, Asian Development Bank)

Have you developed any technologies, materials, and/or design and manufacturing processes that contribute towards addressing the challenges presented by COVID-19 and/or measures to contain and/or respond to it? (E.g. solutions to PPE sustainability, infection control devices, and deep cleaning technologies and methodologies)		
Answer Choices	Responses	
No	61.32%	65
Yes, and these have been adopted (please give detail in the box below)	15.09%	16
Yes, but not yet adopted (please give detail in the box below)	23.58%	25
If yes, please provide a short summary on to whom this has been adopted and the impact of this or give a summary around plans for and/or barriers to adoption		43
Answered		**106**
Skipped		**1**

Comments (43):

- Approaches or methodologies used in other research projects
- Processes adopted by industry partners
- Processes in hospitals to increase efficiency and safety
- Tools designed to support coping among some groups of public (e.g., young people with mental health, families with coping a specific illness)

Has your work contributed to the increased efficiency and/or efficacy of clinical solutions to COVID-19? (E.g. treatments, vaccines, large scale vaccine and ventilator production)		
Answer Choices	Responses	
No	76.19%	80
Yes. Please give a short summary of the contribution(s):	23.81%	25
Answered		**105**
Skipped		**2**

Comments (25):

- Public health outcomes through education
- Rapid testing solutions and safety validations of products
- Improvements to PPE (e.g., communication methods, repeat-use of PPE)

Are there any significant impacts of your work on understanding or tackling COVID-19, its consequences or measures to contain and/or respond to it, that have not yet materialised but that you expect to occur in the foreseeable future?		
Answer Choices	Responses	
No	28.85%	30
Yes. Please give a short summary, including when the impact(s) might materialise:	71.15%	74
Answered		**104**
Skipped		**3**

Comments (74):

- Increased efficacy in diagnosing, prevention of transmission and improved understanding of vaccine effectiveness
- Support for affected communities (e.g., through better understanding of their predicament, digital solutions and educational materials and expected policies)
- Training materials for health care practitioners and relevant policy-makers – expected better healthcare outcomes

What has been the single most impactful result of your award? (We are particularly interested in any impact you have had outside of academia)	
Answered	**308**
Skipped	**11**

- Themes:
- 25% Guidance to policymakers/dissemination at government level
- 18% Contributions to treatment and prevention / increased understanding
- 12% Contributions to disciplines/new or enhanced research processes
- 7% Publications or a developed product
- 7% Increased collaboration with new partners
- 2% Dissemination of information or training materials
- 11% Other
- 18% Too early to say / impacts have not yet materialised

What is the most impactful example of communicating your research as part of this award to research users and practitioners?	
Answered	**297**
Skipped	**23**

Themes:

- 19% Media coverage

- 17% Communication or collaboration with decisionmakers
- 14% Publications (articles or textbooks)
- 13% Presentations (conferences), seminars, workshops or other events
- 11% Collaboration or training with industry/practitioners
- 5% Social media dissemination
- 4% Exhibitions
- 3% Public documents
- 1% Adoption of solutions
- 19% Too early to say

In relation to when you started your UKRI COVID-19 award, when did you achieve the following?															
	Within the first three months		Within the first 4-6 months		Within the first 7-9 months		Within the first 10-12 months		After more than 12 months		Not yet achieved, but expected in future		Don't know/not applicable		Total
First publication (e.g. article, pre-print, technical paper)	11.82 %	37	13.42 %	42	11.82 %	37	14.38 %	45	13.10 %	41	32.59 %	102	2.88%	9	313
First research tool, method, database or model produced	25.40 %	79	21.22 %	66	9.65%	30	9.32%	29	6.11%	19	6.43%	20	21.86 %	68	311
First product, process or solution created (e.g. medical intervention, creative output)	12.01 %	37	7.47%	23	11.04 %	34	4.87%	15	4.22%	13	10.71 %	33	49.68 %	153	308
First public communication of results / data shared	19.23 %	60	27.24 %	85	16.67 %	52	11.86 %	37	14.49 %	14	16.99 %	53	3.53%	11	312
First public engagement activity	26.37 %	82	22.83 %	71	14.47 %	45	7.40%	23	7.07%	22	13.18 %	41	8.68%	27	311
First advice given to policymakers (within or outside UK government)	16.08 %	50	15.11 %	47	12.22 %	38	11.25 %	35	8.36%	26	16.72 %	52	20.26 %	63	311
Answered															**311**
Skipped															**7**

How does the speed at which you were able to produce research findings and outcomes from your UKRI COVID-19 award compare with your general experience of other awards you have held in the past (from UKRI and/or other funders)?														
	Significantly slower than in previous research and/or innovation awards		Slightly slower than in previous research and/or innovation awards		Same speed as in previous research and/or innovation awards		Slightly faster than in previous research and/or innovation awards		Significantly faster than in previous research and/or innovation awards		Not applicable (this was my first ever research and/or innovation award)		Total	Weighted Average
1	6.11%	19	8.68%	27	12.86%	40	24.12%	75	41.16%	128	7.07%	22	311	3.93
Answered														**313**
Skipped														**9**

Did you draw on (or make use of) any of the following that enhanced your ability to deliver your proposal and/or deliver your award successfully and at pace?		
Answer Choices	Responses	
Pre-existing partnerships and/or networks (e.g. easy to mobilise a team to respond and deliver the work)	86.46%	265
Pre-existing awards (e.g. building on a set of existing results and capabilities to deliver impact quickly)	44.79%	143
Pre-existing data sharing facilities (e.g. to quickly access data for use in your award)	19.79%	67
Pre-existing research infrastructures (e.g. leveraging existing assets rather than developing completely new facilities or equipment)	54.17%	155
Please briefly describe the most significant example of the above that helped you deliver at pace:		237
Answered		**300**
Skipped		**20**

Comments (237):

- Existing key partnerships, teams and networks for fast accesses, pre-existing trust within project and with stakeholders
- Existing infrastructure (e.g., protocols) though multiple aligned this with existing partnerships too
- Pre-existing data sets, data-sharing agreements or facilities which significantly expedited the access to relevant data
- Access to key facilities through pre-existing connections

From your perspective at the start of your award, please assess on a scale of 1-10 the likelihood of your award achieving its main anticipated outcomes, where '1' means 'extremely unlikely' and '10' means 'extremely likely', followed by rankings of how this generally compared with any previous UKRI and non-UKRI awards you have held (if applicable).																						
	1		2		3		4		5		6		7		8		9		10		Do not know/Not applicable		Total
At the start of your COVID-19	0.00%	0	0.00%	0	1.01%	3	2.36%	7	5.74%	17	8.78%	26	11.82%	35	29.39%	87	16.89%	50	21.96%	65	2.03%	6	296

UKRI award																							
At the start of other previous UKRI funded awards	0.33%	1	0.00%	0	0.00%	0	0.33%	1	4.89%	15	5.86%	18	12.38%	38	22.48%	69	10.10%	31	12.38%	38	31.27%	96	307
At the start of previous awards from other funders	0.33%	1	0.00%	0	0.65%	2	0.98%	3	5.54%	17	7.17%	22	15.96%	49	27.04%	83	13.03%	40	14.66%	45	14.66%	45	307
																					Answered		**311**
																					Skipped		**9**

To what extent did any of the following aspects present challenges to your ability to achieve and/or extend your intended impacts (so far)?										
	Not a challenge		Minor challenge		Major challenge		Don't know/not applicable		Total	Weighted Average
Time between your application submission and award notification	38.89%	119	34.31%	105	25.49%	78	1.31%	4	306	1.7
Time between your award notification and award start	38.96%	120	32.79%	101	26.30%	81	1.95%	6	308	1.87
Permitted duration of your award	21.50%	66	34.20%	105	42.35%	130	1.95%	6	307	2.33
Requirement to demonstrate impact faster than typical UKRI awards	26.56%	81	46.89%	143	11.48%	35	5.25%	16	305	2
Support available from UKRI (e.g. in responding to questions or requests)	54.22%	167	20.78%	64	12.01%	37	12.99%	40	308	1.82
National COVID-19 restrictions (e.g. lockdowns)	19.48%	60	39.61%	122	32.79%	101	1.62%	5	308	2.21

Securing approvals for your work (e.g. ethics)	37.34%	115	37.99%	117	18.83%	58	5.84%	18	308	2.08
Securing additional resources to enhance your work's impact now and in the future	20.26%	62	36.27%	111	33.33%	102	10.13%	31	306	2.47
Other major challenge (please specify if applicable):									117	
Answered										**308**
Skipped										**12**

Comments (117):

- Supply chain issues with sourcing critical materials or components (at times due to the pandemic or Brexit)
- Other disruptions caused by the pandemic (particularly related to staffing, disruptions to scheduling and field work due to restrictions)
- Administrative/ governance issues (e.g., delays in ethical approvals, cuts in funding)

Please note whether UKRI staff or representatives undertook any of the following support activities in relation to your award. Please tick all that apply.		
Answer Choices	Responses	
UKRI staff or representatives provided guidance at the application stage (e.g. clarifying priority topics or expected outcomes)	33.45%	98
UKRI staff or representatives introduced or connected me to potential consortium partners or co-investigators at the application stage to potentially create a joint application	6.14%	18
UKRI staff or representatives introduced or connected me to potential users of my eventual award results at the application stage (e.g. to better frame my research plan in relation to user needs)	4.78%	14
UKRI staff or representatives introduced or connected me to potential users of my award results during the lifetime of my award (e.g. to share results or build relationships)	15.70%	46
UKRI staff or representatives introduced or connected me to other researchers working on related topics during the lifetime of my award (e.g. for coordination or collaboration purposes)	25.94%	76
UKRI staff or representatives introduced or connected me to research centres or research infrastructures, either at application stage or during the lifetime of my award	9.90%	29
For any of the above purposes, UKRI staff or representatives introduced or connected me to individuals in central government, government ministries (e.g. BEIS, DfT, DHSC) or government advisory groups (e.g. SAGE), or equivalents in the devolved administrations	10.58%	31
To my knowledge, UKRI did not undertake any of the above activities in relation to my award	43.69%	128
Did UKRI staff or representatives provide any other enabling or convening support not mentioned above?		129
Answered		**293**
Skipped		**27**

Comments:

- Intermediary support (e.g., leasing with the media, disseminating to other organisations)
- Proactive presence and advice at various parts of the process and with miscellaneous changes (e.g., expedited approvals, disruptions in secondment)
- Promotion of awards and results (e.g., via Pandemic and Beyond)
- No-cost extensions

With hindsight, is there anything that UKRI could have done differently to enhance your award and optimise its ability to address the challenges presented by COVID-19 and its consequences?	
Answered	**238**
Skipped	**91**

Comments:
• 39 awardees (16%): Allowed more flexibility in award timeline – a fair few awardees commented on ideally needing follow-on funding or an extension to their deadlines. Some mentioned that, as the pandemic is a chronic state (also limiting researchers' capacity), a 12-month award may not have been sufficient. Many also reported unhelpful inflexibility in award start dates which may not have allowed for sufficient time to set up. • 40 awardees (17%): Sometimes coupled with the above point, researchers commented on delays in communications on UKRI's side. This was particularly prevalent regarding delays between application submission and the notification of the award, and between the notification and sending an official letter in which the total funding was confirmed. Delays between award notification had led to the loss of researchers who had to take on other projects. Delays between the notification and the official letter would also be paired with the inflexible deadlines (awards to commence within one month of notification) rendering some researchers forced to start prior to learning their funding amount. Some researchers commented on long response times to basic queries such as those about deadline extensions. • 27 awardees: (11%): Increase clarity – some awardees reported a lack of clarity with, or full understanding of the review processes, application criterion or conditions for extension. Further guidance had been requested by some without receiving it. Some respondents also indicated that they were not aware that UKRI could offer the forms of support listed in Q8, and that they could have benefitted from them had they known. Some confusion over the point of contact was reported too, where one had not been named, or the share of responsibilities between more than one organisational structure was not communicated. • 49 awardees (21%): General support or facilitative action, e.g. making introductions, connecting to policymakers, facilities or relevant networks, getting additional support with ethical approvals or technology exploitation. A few mentioned having requested these things to no avail. Some reported wishing for UKRI to have organised networking or training events during the lifetime of the award. UKRI influence was also asked for, in supporting responses from organisations faster (to Pete: e.g. DHSC, SAGE). Some reported little response in requests to support. • 10 awardees (4%): Wished for fewer reporting requirements, or otherwise a reduced administrative burden or other bureaucracy considering the urgency of the nature of these calls. This included both, details in application process (e.g. requirement of the pdf and JeS application, having to attend interviews) and reporting during the timeline of the award (some described the process as onerous for, for instance, having to answer the same questions every time, or that awardees could time their reporting/surveys to achieving results)

If you could design and deliver your award all over again, is there anything you would do differently to further enhance the impact of your award?	
Answered	**225**
Skipped	**95**
Comments:	
• 47 awardees (21%): would have strived to optimise the available time to suit their needs. This would have taken place by being more insistent on applying for extensions, pushing back when UKRI asked for a shorted project, or allocating the award in a way that allowed for certain key investigators more time • 23 awardees (10%): reported that they would have requested for more funding, secured additional funding from elsewhere or budgeted their award differently to re-prioritise certain activities (or had they been aware of sudden changes to funding). This additional funding could be performance-related based on demonstrable impact. Some awardees would have spent additional resources on dissemination and other impact activities. • 18 awardees (8%): would have made more efforts to forge links with certain groups, whether research or industrial partners, policymakers, right contractors, or pressed UKRI more for obtaining access to relevant events or networks for the same. • 16 awardees (7%): referenced more specific strategic actions, such as in hindsight preparing legal agreements where delays took place, anticipating the future demand of their solutions (e.g. post COVID), focused on outputs with non-academic stakeholders, or identified better avenues for dissemination (over the traditional publishing route for fast dissemination)	

- 15 awardees (7%): spoke about alternative recruitment or hiring decisions for the research team. Some had been affected by the lockdown, others would have preferred FTE RAs rather than part-time, or started the hiring earlier. A few reported that they would have recruited specific managers for dissemination.

If you could design and deliver your award all over again, is there anything you would do differently to further enhance the impact of your award?	
Answered	**152**
Skipped	**168**

Comments:

Enabling:

- Some researchers (about 25% of the positive comments) commended the fast turnaround of funding decisions, which in turn enabled fast results. Even as the review process was not considered, some awardees reported positively about the rapid production of results and the scheme design seemingly intended to produce impact. A few awardees also reported an enabling sense of making a critical difference during the pandemic.
- Other positive themes included lessened bureaucracy, and the overall sense of smooth progress leaving awardees to focus on doing core work. Another common theme were particularly capable research teams and organisational partnerships working seamlessly and bringing together interdisciplinary expertise and effective implementation. Awardees who were able to make use of personal contacts also reported these working out well.

Hindering:

- While well-working partnerships were reportedly among the most valuable enablers, poor communication, differences of interest and lacking capabilities between partners proved to be a barrier in the process. Reportedly, this was especially the case with data sharing agreements in which disruptions would cause significant delays. Other problems with poorly functioning partnerships included mismatching practices, clashing policies, lack of appropriate partners and the general lack of willingness or capacity to work together effectively.
- COVID-19 was also a common barrier. In one awardee's words "researchers working on the pandemic also work in the pandemic", which showed in reports of team members or their family falling ill and having to isolate, as well as data collection and dissemination being constrained by remote work. A few awardees also reported a high turnaround in admin turnover and mental health challenges mainly caused by the pandemic. A few awardees mentioned the fact that the landscape and situation was constantly shifting, and that the adaptation to it was made more challenging by rigid regulatory processes (e.g., unpredictable restrictions and testing requirements). Some also reported a sense of urgency due to the state of emergency in which BAU regulatory processes (e.g., writing applications) sat poorly.
- In the same vein, many awardees also mentioned the inflexible lifetime of their awards as a barrier, sometimes paired with the frequent reporting requirements and insufficient funds (and the need to seek additional funding to ensure impact activities). In cases where ODA funding was used, cuts to the funding caused major disruptions and uncertainty.

Please feel free to share any further thoughts or reflections you may have on factors enabling and/or hindering the impacts of your award.	
Answered	**139**
Skipped	**181**

Comments:

- The final reflections consisted largely of positive notions of different elements of the award. Approximately 25% of the comments reported satisfaction with the timely response and/or a good level of support from the UKRI (three awardees specifically raising Pandemic and Beyond project as a valuable source of support). While challenges were mentioned, there was a general consensus regarding the importance and relevance of these calls.
- Some awardees spoke of good practices (e.g., bringing together interdisciplinary teams) and a momentum of rapid delivery which they would like to see continue. In a similar vein, some concerns were voiced about the continuation of rapid support if the interest drops and priority funding ceases, while the COVID-19-related problems continue on.
- Negative elements were also included. While most of the awardees reported general satisfaction with UKRI support, some did mention a lack of responsiveness or coordination. Some expressed and regret over the lack of opportunities for post-award extension. approximately a third of the awardees mentioned the overall challenge of the award even if they reported it to be worthwhile. About five awardees mentioned the frequency of reporting and survey-filling, noting that their time could be spent better in the core tasks.

Appendix L Interviews

L.1. Phase 1 interviews – award holders

Interviews took place over the course of six weeks from the beginning of April 2022, until mid-May 2022. 52 potential interviewees were contacted, with 26 interviewees scheduled and conducted, leading to a response rate of 50%.

L.1.1. List of interviewees

Name	Research organisation	Funding instrument and funder	Award reference	Interview date and time	Interviewer
Aaron Williamon	Royal College of Music	COVID-19 Agile Call for R&I (AHRC)	AH/P005888/1	29/04/2022 - 13:00	Billy Bryan
Adrian Muwonge	University of Edinburgh	Global Effort on COVID-19 (UKRI/DHSC(NIHR))	MR/V034952/1	27/04/2022 - 10:30	Antonio Neto
Berthold Gottgens	University of Cambridge	COVID-19 Urgency Grants (MRC)	MR/W014556/1	06/04/2022 - 10:30	Marisa Amato
Christopher Smith	London School of Hygiene & Tropical Medicine	Global Effort on COVID-19 (UKRI/DHSC(NIHR))	MR/V033530/1	10/05/2022 - 10:00	Costanza Tiriduzzi
Darach Neeson	PHION THERAPEUTICS LTD	Research Grant (Innovate UK)	82601	11/05/2022 - 16:00	Laura Sutinen
David Livingston	SODIKI LIMITED	UKRI Ideas to address COVID-19 – Innovate UK de minimis Aug 2020 (Innovate UK)	86459	09/05/2022 - 10:00	Laura Sutinen
Interviewee has requested to remain anonymous	Anonymous	GCRF/NF Agile awards (EPSRC)	Anonymous	04/05/2022 - 10:30	Costanza Tiriduzzi
Irene Hardill	Northumbria University	COVID-19 Agile Call for R&I (ESRC)	ES/V015281/1	03/05/2022 - 10:00	Cristina Rosemberg
James McLaughlan	University of Leeds	COVID-19 Agile Call for R&I (EPSRC)	EP/V043714/1	21/04/2022 - 14:00	Julie D'hont
Jo Knight	Lancaster University	COVID-19 Rapid Response Open Call (UKRI/DHSC(NIHR))	MR/V028502/1	04/05/2022 - 15:30	Laura Sutinen
John Edmunds	London School of Hygiene & Tropical Medicine	COVID-19 Rapid Response Call 2 (UKRI/DHSC(NIHR))	MC_PC_19065	03/05/2022 - 10:30	Laura Sutinen
Kenneth Bailliie	Public Health England/ CoG-UK Chair, UoCambridge	GenOMICC (UKRI)	MC_PC_20004	13/05/2022 - 13:00	Ruth Dixon
Liat Levita	University of Sheffield	COVID-19 Urgency Grants (ESRC)	ES/W003333/1	06/05/2022 - 15:30	Michael Crompton

Name	Research organisation	Funding instrument and funder	Award reference	Interview date and time	Interviewer
Mark Green	University of Liverpool	Fellowship (UKRI/DHSC(NIHR))	MR/W021242/1	05/05/2022 - 13:00	Ruth Dixon
Marshall Tulloch-Reid	The University of the West Indies, Jamaica	Global Effort on COVID-19 (UKRI/DHSC(NIHR))	MR/V03698X/1	09/05/2022 - 16:00	Laura Sutinen
Martie van Tongeren	The University of Manchester	COVID-19 Rapid Response Call 2 (UKRI/DHSC(NIHR))	MC_PC_19083	16/05/2022 - 13:30	Laura Sutinen
Matthew Reason	York St John University	COVID-19 Agile Call for R&I (AHRC)	AH/V011405/1	03/05/2022 - 15:00	Costanza Tiriduzzi
Miles Carroll	Public Health England	COVID-19 Rapid Response Call 2 (UKRI/DHSC(NIHR))	MC_PC_19080	05/05/2022 - 10:00	Antonio Neto
Min Kwan Kim	University of Southampton	COVID-19 Agile Call for R&I (EPSRC)	EP/V051679/1	20/04/2022 - 15:00	Laura Sutinen
Patrick Chinnery	University of Cambridge	(UKRI)	UK-CTAP	06/05/2022 - 12:30	Ruth Dixon
Peter Lloyd-Sherlock	University of East Anglia	GCRF/NF Agile awards (EPSRC)	EP/V043110/1	03/05/2022 - 13:00	Marisa Amato
Simon James Gibbons	King's College London	COVID-19 Agile Call for R&I (ESRC)	ES/W001950/1	03/05/2022 - 10:00	Laura Sutinen
Stephanie Snow	The University of Manchester	COVID-19 Agile Call for R&I (AHRC)	AH/V00879X/1	28/04/2022 - 15:30	Laura Sutinen
Tom Wilkinson	NIHR Southampton Biomedical Research Centre	(UKRI)	ACCORD	25/04/2022 - 15:00	Billy Bryan
Trisha Greenhalgh	University of Oxford	COVID-19 Agile Call for R&I (ESRC)	ES/V010069/1	22/04/2022 - 15:30	Laura Sutinen
Ultan Power	Queen's University of Belfast	COVID-19 Rapid Response Call 1 (UKRI/DHSC(NIHR))	MC_PC_19057	21/04/2022 - 15:30	Billy Bryan

L.1.2. Interview tool

3865 – Impact Evaluation of UKRI's R&I Response to COVID-19

Awardee interview topic guide

Name	**[please include Prof/Sir/etc if applicable]**		
Institution/organisation			
Award title and ID	[Full award title (Grant ID)]		
UKRI investment type	[Funding scheme name, e.g. NIHR/MRC Rapid Response, (Council, eg ESRC)]		
Award size	£	**Award duration**	Xx/xx/202x – xx/xx/202x
Interview date/time	[format: dd/mm/yyyy; tt:tt]		
Interviewer			
Special notes	[optional]		

Preliminary points to share with interviewees:

- Thank you for your participation!
- This impact evaluation has been commissioned by UKRI and is being carried out by Technopolis. This is a follow-up of the process evaluation we conducted for UKRI in 2021, if you also participated in that we thank you! We are now primarily concerned with outcomes and impacts, though the processes principally conducive to impacts are in scope
- No attributable quotes will be used from these interviews. However, we ask permission to note the names of all our interviewees in the method annex to our final report
- Interviewees have the right to withdraw their participation at anytime
- In case interviewees ask about why we have their contact details: In accordance with UK data protection legislation, the lawful basis for sharing your contact details with the supplier is Public Task in line with UKRI's official function. For further information please see the Je-S T&Cs, and for information how UKRI processes your information the UKRI Privacy Notice.'

Instructions for interviewers:

- Please complete all the details about the interviewee at the top of this page
- Study the interviewee's survey response (if they responded - thank them if they did) and identify any interesting themes to explore in this interview. This guide covers a range of topics but you should focus on the questions that will help you explore their survey answers in more detail
- This interview tool contains 11 headline questions, each of which has several possible prompts. All are ultimately interesting for our study. However, you are not expected to ask every prompt to every interviewee!

- Every interview should however cover most or all of the headline questions
- Please develop an understanding of each interviewee's award and competition call via the portfolio data and documents we hold. Also spend 5 minutes looking up the interviewee online to double check their organisation and any very recent COVID-19 related work
- Please add your interview notes under each of the headline questions. Do not add separate notes under each sub-question bullet point
- Interview notes should be detailed, but do not have to be a verbatim transcription. Please use whatever convention suits you best to efficiently and effectively convey the information gained from the interview under each question heading
- Please place completed versions of this interview form in the designated SharePoint folder, always using the file name convention '3865 – Interview – [First name] [Surname]'
- **Questions**

(Main questions are numbered; possible prompts/follow-ups in bullet points)

- Why did you decide to apply for a UKRI COVID-19 response award?
  - As possible follow ups, you can ask how they became aware of UKRI's funding call
  - To what extent was their project aligned with UKRI / the government's priorities (this will mainly apply to the agile call) – or were they even aware of these?
- Please can you briefly describe your UKRI COVID-19 award and your role in it?

[note to interviewers: you could potentially get this information prior to the interview from our documentation, and just quickly check it with the interviewee]

- What were the most important results from your COVID-19 award and what was / will be their impact?

[note to interviewers: when listening to their response make sure you're clear which area(s) their impact falls into. E.g. you might ask "would you say that broadly means you were able to increase the efficiency of clinical solutions to COVID-19?"]

The impact areas are:

  - Data sources and/or solutions to understanding COVID-19 and its public health impact
  - Data and/or knowledge that contribute towards managing and/or understanding the impact and challenges of measures to contain and/or respond to COVID-19
  - Influence on or fed into policymaking decisions. Being cited in any policy documents pertaining to the pandemic, its consequences or measures to contain / respond to it
  - Technologies, materials, and/or design and manufacturing processes that contribute towards addressing the challenges presented by COVID-19 and/or measures to contain and/or respond to it
  - Increased efficiency and/or efficacy of clinical solutions to COVID-19
  - Time-critical data & resources captured during the pandemic to inform research of and response to future pandemic or public health threats
- What in particular affected how quickly you were able to produce results? What factors helped, and what got in the way?
- Can you highlight any particular barriers you faced in terms your award being able to achieve its intended impacts and helping to address COVID-19 and its consequences?
- Conversely, were there any enabling factors that helped you achieve such impacts?

- To what extent would you have been able to achieve those impacts at the speed you did without UKRI's funding?
  - More broadly, what would have happened if the UKRI funding had not been available? Would your project have gone ahead at all?
  - What other funding would/could you have accessed?
  - If so, how would the speed have differed?
- Besides funding, did UKRI support your COVID-19 award in any way, during the application stage, delivery or (if applicable) post-award? If so, how?
  - (e.g. helping connect you to collaborators, amplifying your results)
- Did you access or did you work build on any pre-existing UKRI funded awards, facilities or services? How did this support your COVID-19 work?
- What could UKRI have done / done more of to support you in achieving your results?
- We would like to talk about some broader perspectives, if you have a view: Firstly, in your perception, did COVID-19 lead to any shifts in research culture (temporary or permanent) compared to business-as-usual, for example around open access, open research, equality/diversity and inclusion, or focus of research topics on societal challenges? Any examples?

[note to interviewers: Open research means openness throughout the research cycle, through collaborative working and sharing and making research methodology, software, code and equipment freely available, along with instructions for using it. This often translates to making publications and data 'open access']

- Secondly, do you think that the UKRI response to COVID-19 has led, or might lead, to any lessons learned on effective approaches to rapidly addressing societal challenges / emergencies through research and innovation?
- Thirdly, to what extent do you agree that the UKRI response has led to an increased preparedness of society and economy to public health challenges?
- Are there any further points pertaining to your award or UKRI's COVID-19 response we haven't covered that you feel are relevant and would like to share? Or are there any questions we should have asked but did not?

A.1.4. Summary findings

1. *Why did you decide to apply for a UKRI COVID-19 response award?*

Main themes

- Just over a quarter of interviewees stated they applied for a UKRI COVID-19 award, out of a sense of duty to, or through an opportunity to help during a national crisis. Just under a quarter stated they were responding to the need for research on COVID-19
- Just over a quarter of interviewees stated they applied for a UKIR COVID-19 award due to the opportunity for funding during the pandemic. Just under a quarter responded that the UKRI COVID-19 award gave them an opportunity to extend research they had already started

2. *Please can you briefly describe your UKRI COVID-19 award and your role in it?*

Main themes

- Care/vulnerable communities /mental health /psychological impact
- A quarter of interviewees projects involved research in the targeted at care work, vulnerable communities, mental health, and the psychological impact of COVID-19.
- COVID-19 treatment / management /understanding
- Just under half of interviewees projects involved research targeted at COVID-10 treatment, management, and increased understanding.

3. *What were the most important results from your COVID-19 award and what was / will be their impact?*

Main themes

- Contribution to public knowledge
- Over half of interviewees stated that their work has contributed to an increase in public knowledge. This includes producing work used by further researchers, publication of research papers, increase in skills of facilitators and practitioners, guiding messages to stakeholders and capturing of evidence to disseminate further to charities.
- Contribution to management and containment of COVID-19
- Over half of interviewees stated their work contributed to the management and containment of COVID-19. This includes contributing to increased understanding of the virus and its impact, improved technology, novel results about drugs and vaccines and their role in managing the pandemic and decreasing mortality rates.
- Contribution to public policy
- Just under a fifth of interviewees stated their work directly influenced policy makers, either through publication of results in policy papers or deliverance of results to public briefing meetings at government departments.

4. *What in particular affected how quickly you were able to produce results? What factors helped, and what got in the way?*

Main themes

- Data and sampling access

- Just under half of all interviewees stated they faced difficulty around data and sampling. Difficulty accessing data, through data sharing agreements and general form filling and bureaucracy, as well as data quality more generally. Supply chain issues were also mentioned.
- Application and funding delays
- Just under half of interviewees stated they faced issues with application and funding delays. Interviewees mentioned long delays between application and receiving funding, as well as difficulties gaining necessary ethical approval from the relevant authorities and comities, in time. A small number of interviewees stated that their funds were frozen for a lengthily period, which hindered progress, and caused reputational damage to their them and their work.

5. *Can you highlight any particular barriers you faced in terms your award being able to achieve its intended impacts and helping to address COVID-19 and its consequences?*

Main themes

- Application and funding delays
- Just under a quarter of interviewees stated that the time between application submission and award notification, as well as issues of bureaucracy were barriers to their awards achieving their intended impact.
- Institutional barriers
- Just under a fifth of interviewees stated that institutional barriers such as university systems for finance management, or lack of committees to deal with authorisations caused delays in their project achieving its intended impact.

6. *Conversely, were there any enabling factors that helped you achieve such impacts?*

Main themes

- Pre-existing relationships
- Just under half of interviewees stated that pre-existing relationships were the strongest enabling factor in their work achieving its intended impact. Interviewees noted that these relationships enabled closed and increased collaborations, easier dissemination of findings and for their project to "get going" more generally.

7. *To what extent would you have been able to achieve those impacts at the speed you did without UKRI's funding?*

Main themes

- Project would not have been possible
- Over half of interviewees stated strongly that their project would simply not have been possible to carry out without UKRI funding.
- Project would have been smaller in scale
- Just under half of interviewees stated that their projects would still have been possible, but would have been smaller in scale and would not have achieved as much as it had, without UKIR funding.

8. *Besides funding, did UKRI support your COVID-19 award in any way, during the application stage, delivery or (if applicable) post-award? If so, how?*

Main themes

- UKRI provided no additional support
- Just under half of interviewees stated that UKRI provided no additional support to their project.
- Significant support
- Just over a quarter of interviewees stated that UKRI provided significant support to their project. Interviewees noted that this took the form of quick responses to questions, steering the scope of projects, networking and partnership opportunities, and regular meetings with UKRI project coordinators.
- Pandemic and beyond project
- Just under a fifth of interviewees mentioned that UKRI helped them through the funding of the Pandemic and Beyond project.

9. *We would like to talk about some broader perspectives, if you have a view: Firstly, in your perception, did COVID-19 lead to any shifts in research culture (temporary or permanent) compared to business-as-usual, for example around open access, open research, or focus of research topics on societal challenges? Any examples?*

Main themes

- Open access, data access and sharing
- Just under half of interviewees stated that there is an increased imperative, and increased speed in publishing open access articles and open data sets as well as sharing results more widely.
- Increase in cross disciplinary and research collaboration more generally
- Just over a quarter of interviewees stated that thee was increased cross-disciplinary research and increase collaborations more generally.
- Social equity
- A quarter of interviewees stated that there had been an increased awareness of issues surrounding social equity, inclusivity and structural inequalities, particularly catalysed after the protests surrounding the death of George Flyod.
- Move online
- Just under a quarter of interviewees stated that the move to working online, decreased costs, enabled wider stakeholder engagement, was more convenient and time saving, and enabled access to meetings which would have otherwise not been possible to attend.
- Speedier research culture/ application culture
- Just under a quarter of interviewees stated that there was a speedier research culture, either through speedier progress of particular disciplines, efficiency in decision making, speedier application processes, speedier response rates and quicker passing of regulations.

10. *Secondly, do you think that the UKRI response to COVID-19 has led, or might lead, to any lessons learned on effective approaches to rapidly addressing societal challenges / emergencies through research and innovation?*

Main themes

- Speedier research culture/ application culture
- Just under half of interviewees stated that the UKRI response to COVID-19 has led or might lead to a speedier research and application culture. Of note was the immediacy and time scale of the awards led to more focus and a simplification of decision-making processes. regulation speed and increase efficiency were also noted. Finally, the possibility of speeding up the bid writing process, the review process, whilst maintaining standards and transparency, and an agile infrastructure and research culture were also noted.
- Increase in cross disciplinary and research collaboration more generally
- Just under a fifth of interviewees mentioned an increase in interdisciplinary work and an increase in data sharing practices.

11. *Thirdly, to what extent do you agree that the UKRI response has led to an increased preparedness of society and economy to public health challenges? / [Any other comments]*

Main themes

- Interviewees agreed to a varied extent that UKRI's response led to an increased preparedness of society and economy to public health challenges. Just under a fifth stated that UKRI awards led to better approached to acute situations. Just under a fifth stated there was increased awareness of the consequences of a pandemic and how the issue can be solved by R&D, as well as an increased awareness of societal impact of research. Other points raised included an increase in working smartly with data, a quicker and more responsive research culture as well as a suggestion for pre-crisis funding, in order to be better prepared

12. *Are there any further points pertaining to your award or UKRI's COVID-19 response we haven't covered that you feel are relevant and would like to share? Or are there any questions we should have asked but did not?*

Main themes

- Just under a quarter of interviewees suggested an extension on grants as well as flexibility for further funding
- Just under a quarter of interviewees suggested a reflection on the relationship between policy and research
- Just under a quarter of interviewees suggested keeping the culture of responsive funding

L.2. Phase 2 interviews – science and innovation experts

Interviews took place over the course of six weeks from the beginning of July 2022, until mid-August 2022. 24 potential interviewees were contacted, with 15 interviewees scheduled and conducted, leading to a response rate of 62.5%.

L.2.1. List of interviewees

Name	Organisation	Role	Interview date and time	Interviewer
Alan Penn	Department for Levelling up	Chief Scientific Advisor	27/07/2022; 11:30	Cristina Rosenberg
Andrew Curran	Health and Safety Executive	Chief Scientific Advisor and Director of Research	15/07/2022; 12:30	Peter Varnai
Anne Johnson	Academy of medical sciences	President	29/07/2022; 12:00	Ruth Dixon
David Busse	Government Office for Science	Senior Policy Advisor	27/07/2022; 11:30 (interviewed with Laura Eden)	Ruth Dixon
Eleanor Riley	London School of Hygiene and Tropical Medicine	UKRI Covid-19 Task Force member	03/08/2022; 11:00	Ruth Dixon
Ilina Singh	University of Oxford	UKRI Covid-19 Task Force member	08/08/2022; 13:00	Cristina Rosenberg
Kieran Walshe	University of Manchester	UKRI Covid-19 Task Force member	01/08/2022; 14:00 (interviewed with Rob Orford)	Peter Kolarz
Laura Eden	Government Office for Science	Deputy Director, Covid Enquiry and Transparency previously Deputy Director, Covid Strategy and Delivery	27/07/22; 11:30 (interviewed with David Busse)	Ruth Dixon
Lucy Chappell	Department of Health and Social Care	Chief Scientific Advisor	09/08/2022; 15:00	Peter Kolarz
Michael Batley	Department of Health and Social Care	Deputy Director of Research Programmes	15/05/2022; 14:00	Ruth Dixon
Paul Monks	Department for Business, Energy & Industrial Strategy	Chief Scientific Advisor	28/07/2022; 11:30	Cristina Rosenberg
Phil Blythe	Newcastle University, formerly at the Department for Transport until June 2021	Chief Science Advisor until June 2021	26/07/2022; 15:00	Peter Kolarz
Rob Orford	National Health Service Wales	Health Chief Scientific Advisor, Welsh Government	01/08/2022, 14:00 (interviewed with Kieran Walshe)	Peter Kolarz
Sarah Sharples	Department of Transport	Chief Scientific Advisor	11/07/2022; 14:30	Cristina Rosenberg
Stephen Powis	National Health Service	National Medical Director for NHS England	01/08/2022; 12.30	Ruth Dixon

L.2.2. Interview tool

3865 – UKRI COVID-19 Impact evaluation

Phase 2 expert interview topic guide

Name	**[please include Prof/Sir/etc if applicable]**
Institution/organisation	
Role	
Interview date/time	[format: dd/mm/yyyy; tt:tt]
Interviewer	
Special notes	[optional]

Preliminary points to share with interviewees:

- Thank you for your participation!
- This impact evaluation has been commissioned by UKRI and is being carried out by Technopolis. This is a follow-up of the process evaluation we conducted for UKRI in 2021
- No attributable quotes will be used from these interviews. However, we ask permission to note the names of all our interviewees in the method annex to our final report
- Interviewees have the right to withdraw their participation at anytime

Instructions for interviewers:

- Please complete all the details about the interviewee at the top of this page
- **Study the interviewee's background. What does their organisation do and what was their remit during the COVID-19 pandemic? Are there any major known impacts of UKRI-funded research to which they are known to be connected? Identify any interesting themes to explore in this interview through this prior research**
- This interview tool contains 8 headline questions. Unless there is a good reason to skip individual questions (e.g. if the interviewee makes clear early on that they cannot comment on an up-coming questions), we aim to ask all question to all interviewees
- Please note that the individuals to be interviewed in this WP are likely to be extremely busy. We absolutely need to ensure we do not exceed 30 minutes per interview, unless an interviewee explicitly says they can make more time if needed
- Please add your interview notes under each of the headline questions
- Interview notes should be detailed, but do not have to be a verbatim transcription. Please use whatever convention suits you best to efficiently and effectively convey the information gained from the interview under each question heading

Please place completed versions of this interview form in the designated SharePoint folder, always using the file name convention '3865 – Interview – [First name] [Surname]'

Interview questions

- From your perspective, what were your expectations from UKRI in a national emergency like COVID-19?
- Overall, were your expectations of UKRI met? Why/why not?
- Can you comment on the capacity of your organisation (and potentially, of other research users) to source and use research-based evidence during the COVID-19 pandemic? Were there any factors that made it easier or harder to source and use research-based evidence?
  - [Modified version for interviewees who did not represent user-organisations (e.g. funders): Can you comment on the capacity of research users to source and use research-based evidence during the COVID-19 pandemic? Were there any factors that made it easier or harder to source and use research-based evidence?]
- Concretely, what were the main ways in which your organisation made use of UKRI-funded research and what were the main impacts that resulted from this?
  - [Modified version for interviewees who did not represent user-organisations (e.g. funders): Concretely, what in your view were the main ways in which non-academic organisations made use of UKRI-funded research and what were the main impacts that resulted from this?]
- Can you consider a counter-factual? What would have happened if the UKRI-funded research had not been available to you/your organisation?
  - [Modified version for interviewees who did not represent user-organisations (e.g. funders): Can you consider a counter-factual? What would have happened if the UKRI-funded research had not been available to user organisations?]
- Can you comment on the significance of UKRI-funded research during the COVID-19 pandemic in comparison to other funders (e.g. philanthropic funders such as Wellcome, private industry R&D, international funders)? Were there differences in terms of quality, speed, access or relevance between UKRI-funded work and work funded by others?
- Are there any lessons to be learned for UKRI? Are there things you feel should be done very differently in possible future societal emergencies?
- Do you have any other thoughts on UKRI's R&I response to COVID-19 that we have not covered yet?

L.2.3. Summary findings

From your perspective, what were your expectations from UKRI in a national emergency like COVID-19?

Main themes

Main expectations of the consulted R&I experts were about the UKRI's role as a central agency in research. This included the expectation to coordinate a collective response rapidly (8 interviewees, 53%), to mobilise funds or experts effectively (7 interviewees, 47%), and to be able to prioritise needs correctly (e.g., focus on needs-based research over blue-skies) (7 interviewees, 47%).

Less common aspects concerned elements like efficient communication (1 consultee), and the sole prioritisation of medical research (two consultees reported expecting a complete

prioritisation of medical research, two consultees emphasised the importance to additionally fund economic and social research).

Overall, were your expectations of UKRI met? Why/why not?

Main themes

Overall, experts inclined to answer yes: six interviewees reported explicitly that their expectations were either met or exceeded (40%). One consultee reported feeling disappointed (6%). The most common justification for satisfaction was the perceived rapidity at which the response progressed (50%). Other positive comments concerned successful joint work with NIHR (33%). Four consultees (27%) named previous UKRI investments (e.g., resources and networks) as critical enablers for fast-paced action.

Elements which had not met expectations included mainly delays (either at the start or shortly after, reported by 27%) and problems with mismatching priorities (33%). These included a perceived lack of focus on end-users and a lack of practical research awarded.

Three experts (20%) reported dissatisfaction with the engagement from UKRI. Specifically, these concerned the coordination with core projects and dissemination of information among researchers. Finally, problems with data access were named by two experts (13%).

Can you comment on the capacity of your organisation (and potentially, of other research users) to source and use research-based evidence during the COVID-19 pandemic? Were there any factors that made it easier or harder to source and use research-based evidence?

Main themes

Nearly half of interviewees (7 consultees) reported having (acquired) a dedicated individual or unit for sourcing or translating evidence into useful information. These individuals or teams were placed to obtain data early on in the process (e.g., pre-print stage), to make use of technical data, or to assess existing evidence for its usefulness. Six consultees reported an increase in capacity to access and use evidence in more general terms.

Approximately 25% of interviewees reported challenges pertaining to a specific area or source of data. These topics included hospital-acquired infections and implications of the COVID-19 virus to public transport.

About 25% of the interviewees addressed the role of researchers and research organisations (ROs) in sourcing information. Most of these consultees reported that researchers and ROs had stepped up to provide evidence and guidance. One R&I expert reported feeling that the pressing questions were not receiving answers from research, however, but also felt that key researchers struggled with their capacity.

Slightly fewer than half of the consultees felt that the efforts to combat the pandemic had created a precursory for all future needs for exceptional measures. This said, one expert expressed that the collective coordination of efforts is not a viable model for research in non-emergency periods. Important lessons and examples of good practice concerned interconnectedness and pre-planning to understand where particular data was needed most urgently.

Do you think there were any factors that made it easier or harder for them to source and use research-based evidence?

Main themes

Enablers and barriers to sourcing and using evidence were generally related to collaboration, sharing and transparency. (Of the five experts who answered this question) two experts named administrative limitations, especially pertaining to data sharing agreements and pre-existing MoUs. A culture of ownership and a lack of transparency were also described as inhibiting factors to effective collaboration. Additionally, one interviewee named cohort-based collaborations as an enabler in effective data sourcing and use.

Concretely, what were the main ways in which your organisation made use of UKRI-funded research and what were the main impacts that resulted from this?

Main themes

Concrete examples of uses of UKRI-funded research consisted largely of security policies and guidelines. Research on transmissibility was reported to enable a safe return to public transportation and to inform workplace safety. Additionally, three interviewees reported having used the provided evidence constantly in policy-crafting or in an advisory capacity without further elaboration. One R&I expert also reported a large amount of their work on medical solutions to have resulted from UKRI-supplied evidence. This work, in turn, was reported to have transformed the impact of the pandemic internationally. Finally, one interviewee reported that the rapid release of evidence (e.g., through pre-prints or press releases) enabled the vaccine task force to begin investing far sooner than normally.

Three R&I experts emphasised research across the UK, rather than that of the UKRI alone. Two consultees reported uncertainty about what parts of used evidence came from UKRI-funded projects and what did not. Again, two highlighted the role of SAGE in locating and feeding relevant information in the right places. One of those felt that the UKRI could consider taking on a function similar to that deployed by SAGE (directing questions to relevant evidence if it existed).

Can you consider a counter-factual? What would have happened if the UKRI-funded research had not been available to you/your organisation?

Main themes

The most common counterfactual examples concerned the speed of countering COVID-19 in the UK as well as the soundness of research. Six experts (40%) expected delays to have occurred at various stages of the research process and in the return to normalcy in the absence of the UKRI. One expert rationalised this to stem from the absence of the existing infrastructure and investment by the UKRI. Five interviewees (33%) suspected the quality and scope of resulting research to not have been as high. Examples of these limitations concerned the lack of peer reviewers in the process as well as zoonosis (the potential for COVID-19 to mutate in other species before infecting humans again), which may have not been addressed elsewhere. Two interviewees also expected the NCSs to not have progressed as efficiently without the UKRI input.

Three interviewees reported expecting other sources of funding (governmental or commercial) to become available in the absence of the UKRI. All three also expected the response to not have been as efficient without the UKRI's central coordination. Two experts thought that the

UK would have had to rely on research from elsewhere. One of them remarked that this scenario would have left populations in the UK underrepresented.

Can you comment on the significance of UKRI-funded research during the COVID-19 pandemic in comparison to other funders (e.g. philanthropic funders such as Wellcome, private industry R&D, international funders)? Were there differences in terms of quality, speed, access or relevance between UKRI-funded work and work funded by others?

Main themes

Seven R&I experts reported not having a decent view of other funders, or of who had funded what (47%). This was due to the UKRI's central role, and the overall number of awards funded in response to COVID-19. Additionally, two consultees maintained that the most important work was funded collaboratively across multiple funders.

Another common conclusion was that the UKRI was likely best connected for maximising the outputs of research (25%). The reasons for this were the historic connections to research and policymaking forged by the UKRI. These connections enabled a particularly efficient pivoting to respond to COVID-19 coherently and a rapid translation of findings into policy. Some R&I experts remarked on the capability of GO-Science to expedite impacts through connections, but the agreement was that the UKRI was better placed for this.

Additionally, about 20% of the consultees considered the UKRI to have most potential for impact in the pandemic context due to its government-backed status. This enabled a degree of stability not possible for all funders, and protected the response from economic, commercial or political biases.

Are there any lessons to be learned for UKRI? Are there things you feel should be done very differently in possible future societal emergencies?

Main themes

A good amount of the suggested lessons from the interviewees concerned different aspects of governance. These included investments towards an infrastructure with the capacity for coordinating all aspects of research to address one large problem, (and this way grow more mindful of duplication, 20%), building a better system for data sharing (13%) and clarifying the conditions around funding (13%).

In addition, while the orchestrated approach to COVID-19 was generally agreed upon, three experts considered its impacts on EDI. Reported risks involved awarding based on personal connections or the prominence of the researcher, rather than the credibility of the proposal. This in turn could feed into existing issues around EDI. The recommendation was to invest time in considering the shadow casted by such variations to competitive funding.

Finally, four experts voiced an increased need for problem-based, interdisciplinarity and applied sciences. Not only does this cover approaching a pandemic from a non-medical perspective, but actively engaging end-users and industry in the development of solutions to maximise the identification of gaps.

Appendix M List of documents

UKRI provided 512 individual sources of information, which we indexed, summarised and analysed as part of the process and impact evaluations.

Table 17 Sources of information by programme

Programme	No. of sources
UKRI Agile R&I Call	290
ACCORD	89
Case study background	30
Vaccine Manufacturing Innovation Centre	18
DHSC UKRI Rapid Response Initiative	15
GCRF and Newton Fund	14
Innovate UK response	11
GenOMICC Consortium	7
National Core Studies	7
MRC response to Covid-19	5
External communications	4
Global Effort on COVID-19 (GECO)	4
Whole Genome Sequence Alliance	4
COVID-19 GENOMICS UK (COG-UK)	3
RECOVERY	3
ED&I Data	2
TRANSITION	2
Portfolio grant data	2
COG, ACCORD, RECOVERY, GenOMICC	1
STFC grant information	1
Total	**512**

Table 18 Indexed sources of information used in the evaluation

#	Programme/scheme/group	Source
1	Portfolio grant data	Feb22_UKRICovidAwards.xlsx
2	Portfolio grant data	Jan22_UKRICovidAwards.xlsx
3	STFC grant information	STFC_Covid19 research activity 15Oct21.xlsx
4	COG, ACCORD, RECOVERY, GenOMICC	Key contacts COG UK ACCORD RECOVERY GenOMICC.xlsx
5	DHSC UKRI Rapid Response Initiative	Copy of Copy of DHSC-UKRI Covid Awards_v2.0_vFINAL.xlsx
6	DHSC UKRI Rapid Response Initiative	2019-nCoV Rapid Response Form_vFINAL.docx
7	DHSC UKRI Rapid Response Initiative	Archived UKRI NIHR Rapid Response Call Text Web Address.docx

#	Programme/scheme/group	Source
8	DHSC UKRI Rapid Response Initiative	COVID-19 call 2 panel brief_v2.7.docx
9	DHSC UKRI Rapid Response Initiative	COVID-19 RR panel membership.pdf
10	DHSC UKRI Rapid Response Initiative	nCov Application Processing Guidance.docx
11	DHSC UKRI Rapid Response Initiative	nCoV call text vFINAL4.docx
12	DHSC UKRI Rapid Response Initiative	Presentation_vJP3.pptx
13	DHSC UKRI Rapid Response Initiative	Process Flow Diagram_v2.pdf
14	DHSC UKRI Rapid Response Initiative	COVID-19 Rapid Response Form_v4.0.docx
15	DHSC UKRI Rapid Response Initiative	Call Text_v1.1.pdf
16	DHSC UKRI Rapid Response Initiative	Archived UKRI NIHR Rolling Call Text Web Address.docx
17	DHSC UKRI Rapid Response Initiative	survey text.docx
18	DHSC UKRI Rapid Response Initiative	JAN 22 COVID-19 progress update submissions.xlsx
19	DHSC UKRI Rapid Response Initiative	draft letter to communicate with PIs about survey v.4.docx
20	COVID-19 GENOMICS UK (COG-UK)	Re OFFICIAL RE Genomics consortium.msg
21	COVID-19 GENOMICS UK (COG-UK)	Email from SMW re COG-UK support.msg
22	COVID-19 GENOMICS UK (COG-UK)	200314_COG-UK_final.docx
23	ACCORD (ACcelerating COVID-19 dRug Development)	ACCORD Exec Group Terms of Reference v2.0 May 20.docx
24	ACCORD (ACcelerating COVID-19 dRug Development)	ACCORD Govt Announcement.html
25	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 01Jul20.pdf
26	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 01Jun20.pdf
27	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 02Jul20.pdf
28	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 02Jun20.pdf
29	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 03Aug20.pdf
30	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 03Jul20.pdf
31	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 03Jun20.pdf
32	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 04Jun20.pdf
33	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 05Jun20.pdf
34	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 06Jul20.pdf
35	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 07Jul20.pdf
36	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 08Jul20.pdf
37	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 08Jun20.pdf
38	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 09Jul20.pdf
39	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 09Jun20.pdf
40	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 10Jul20.pdf
41	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 10Jun20.pdf
42	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 11Jun20.pdf
43	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 12Jun20.pdf
44	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 13Jul20.pdf
45	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 15Jun20.pdf
46	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 15May20.pdf

#	Programme/scheme/group	Source
47	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 16Jun20.pdf
48	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 17Jun20.pdf
49	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 18Jun20.pdf
50	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 18May20.pdf
51	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 19Jun20.pdf
52	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 19May20 V2.pdf
53	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 19May20.pdf
54	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 20Jul20.pdf
55	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 20May20.pdf
56	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 21May20.pdf
57	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 22Jun20.pdf
58	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 23Jun20.pdf
59	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 24Jun20.pdf
60	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 25Jun20.pdf
61	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 26Jun20.pdf
62	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 27Jul20.pdf
63	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 27May20.pdf
64	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 28May20.pdf
65	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 29Jun20.pdf
66	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 29May20.pdf
67	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD 30Jun20.pdf
68	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 1May20.pdf
69	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 4May20.pdf
70	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 5May20.pdf
71	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 6May20 for ExecGp.pdf
72	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 6May20.pdf
73	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 7May20.pdf
74	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 11May20 9am for Exec Gp.pdf
75	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 11May20 9am.pdf
76	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental treatments ACCORD dated 13May20.pdf
77	ACCORD (ACcelerating COVID-19 dRug Development)	Status Report PhII Experimental Treatments dated 12May20.pdf
78	ACCORD (ACcelerating COVID-19 dRug Development)	Temperature Chart PhII Experimental treatments ACCORD dated 30Apr20.pdf
79	ACCORD (ACcelerating COVID-19 dRug Development)	RE_ COMMISSION_ Delivery plan updates & scores.msg
80	ACCORD (ACcelerating COVID-19 dRug Development)	11-05-2020 5.A Treatments DRAFT_GB.docx
81	ACCORD (ACcelerating COVID-19 dRug Development)	5.B Treatments - Commission 03-05-2020 RC_GB.docx
82	ACCORD (ACcelerating COVID-19 dRug Development)	Fwd_ Updated Delivery plans_ 5A Treatments.msg
83	ACCORD (ACcelerating COVID-19 dRug Development)	5.A Treatments.docx
84	ACCORD (ACcelerating COVID-19 dRug Development)	Trial to Delivery Process Map 290520.xlsx
85	ACCORD (ACcelerating COVID-19 dRug Development)	Milestone Guidance.pdf

#	Programme/scheme/group	Source
86	ACCORD (ACcelerating COVID-19 dRug Development)	FW_ Treatments_ Weekly Reporting.msg
87	ACCORD (ACcelerating COVID-19 dRug Development)	FW_ Reporting Next Week_ Treaments.msg
88	ACCORD (ACcelerating COVID-19 dRug Development)	Devolution Checklist.docx
89	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments_20020601.docx
90	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments Milestones.xlsx
91	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments 010620.docx
92	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments 010620_ACCORD Update.docx
93	ACCORD (ACcelerating COVID-19 dRug Development)	01-06-20 5A Treatments.docx
94	ACCORD (ACcelerating COVID-19 dRug Development)	RE_ Reporting Next Week_ Treaments.msg
95	ACCORD (ACcelerating COVID-19 dRug Development)	FW_ Reporting Next Week_ Treatments.msg
96	ACCORD (ACcelerating COVID-19 dRug Development)	100620 - Risk management.docx
97	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments Milestones (1).xlsx
98	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments Delivery Plan 080620 v2.docx
99	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments 010620_ACCORD Update (1).docx
100	ACCORD (ACcelerating COVID-19 dRug Development)	Trial to Delivery Process Map 100620.xlsx
101	ACCORD (ACcelerating COVID-19 dRug Development)	FW_ Reporting Next Week_ Treatments (1).msg
102	ACCORD (ACcelerating COVID-19 dRug Development)	120620 v2 5A Treatments Milestones MM.xlsx
103	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments Milestones MM.xlsx
104	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatments Delivery Plan 150620.docx
105	ACCORD (ACcelerating COVID-19 dRug Development)	Paper D - Summary of DHSC COVID-19 Scenarios 200617 Official Sensitive.docx
106	ACCORD (ACcelerating COVID-19 dRug Development)	Paper C Note on second wave 200617 Official Sensitive.docx
107	ACCORD (ACcelerating COVID-19 dRug Development)	High Level Risk Register.xlsx
108	ACCORD (ACcelerating COVID-19 dRug Development)	FW_ Reporting Next Week_ Treatments (2).msg
109	ACCORD (ACcelerating COVID-19 dRug Development)	Delivery Plan Addendum – Scenario planning.docx
110	ACCORD (ACcelerating COVID-19 dRug Development)	5A Treatment Delivery Plan.docx
111	ACCORD (ACcelerating COVID-19 dRug Development)	5A 120620 v2 Treatments Milestones MM (1).xlsx
112	RECOVERY	Formal letter on UK C-TAP.pdf
113	RECOVERY	FINAL - DHSC-MRC MOU RECOVERY Phase II Therapeutic Trials reconfiguration mrc.docx
114	RECOVERY	CT CTAP 2.2.21.pdf
115	TRANSITION	Phase 2 refocus June 2020.docx
116	TRANSITION	2020-06-29 UKRI COVID-19 ACCORD - RECOVERY refocus_Final (002).docx
117	Global Effort on COVID-19 (GECO)	Global Effort on COVID-19 (GECO) Health Research - Call Specification.pdf
118	Global Effort on COVID-19 (GECO)	GECO_ProcessFlow.pdf
119	Global Effort on COVID-19 (GECO)	GECO List of award holders.xlsx
120	Global Effort on COVID-19 (GECO)	GECO for COVID ExCo.docx
121	GenOMICC Consortium	RE Progress update from Genomics England and COVID-Human Response Programme.msg
122	GenOMICC Consortium	RE GenOMICC-Genomics England Partnership Response Submitted.msg
123	GenOMICC Consortium	RE GenOMICC-Genomics England Partnership Response Submitted Reply.msg
124	GenOMICC Consortium	FW Update.msg

#	Programme/scheme/group	Source
125	GenOMICC Consortium	FW Progress update from Genomics England and COVID-Human Response Programme.msg
126	GenOMICC Consortium	COVID-19 UK Host Genomics Proposal_FINAL.docx
127	GenOMICC Consortium	COVID-19 UK Host Genomics and Trials Proposal.ppt
128	MRC response to Covid-19	MRC-COVID-19-response-interim-report-V2.pdf
129	MRC response to Covid-19	Monitoring and Evaluation of the RRI_fv.pdf
130	MRC response to Covid-19	Explanatory note for MRC documents.docx
131	MRC response to Covid-19	ANNEX 4.2.docx
132	MRC response to Covid-19	ANNEX 4.1.docx
133	External comms	UK funders learn from COVID-19 'white-water ride'.html
134	External comms	RS COVID submission.pdf
135	External comms	Fiona M Watt_ Covid-19—a new disease has forced a rethink of how we fund medical research - The BMJ.html
136	External comms	MRC C19 interim report May 2021 - for UKRI internal v.1.docx
137	UKRI Agile R&I Call	2020-04-08_UKRI C-19 Agile Responsive Fund_FULL Business Case_1.2
138	UKRI Agile R&I Call	UKRI Post Agile Call Urgency Route.docx
139	UKRI Agile R&I Call	UKRI grant repurposing.docx
140	UKRI Agile R&I Call	UKRI Agile COVID-19 Application Instructions.docx
141	UKRI Agile R&I Call	UKRI Agile Call Application Form v3.docx
142	UKRI Agile R&I Call	UKRI Agile Call Application Form v2.docx
143	UKRI Agile R&I Call	UKRI Agile Call Application Form v1.docx
144	UKRI Agile R&I Call	COVID-19 Proposal Form - research - Phase 2 v1.docx
145	UKRI Agile R&I Call	Applicant Instructions Je-S Phase 2.docx
146	UKRI Agile R&I Call	UKRI Agile Call Phase 2 Process Evolution - Detailed - 090720.vsdx
147	UKRI Agile R&I Call	UKRI Agile Call Phase 1 Process.vsdx
148	UKRI Agile R&I Call	Live Project Funding List Data Tracker data entry flow diagram.pptx
149	UKRI Agile R&I Call	CV19CG Minutes 01 December_final.docx
150	UKRI Agile R&I Call	CV19CG Minutes 2 June.docx
151	UKRI Agile R&I Call	CV19CG Minutes 3 November .docx
152	UKRI Agile R&I Call	CV19CG Minutes 5 May .docx
153	UKRI Agile R&I Call	CV19CG Minutes 06 April 2021.docx
154	UKRI Agile R&I Call	CV19CG Minutes 06 October.docx
155	UKRI Agile R&I Call	CV19CG Minutes 07 April .docx
156	UKRI Agile R&I Call	CV19CG Minutes 7 July .docx
157	UKRI Agile R&I Call	CV19CG Minutes 08 September.docx
158	UKRI Agile R&I Call	CV19CG Minutes 09 February 21.docx
159	UKRI Agile R&I Call	CV19CG Minutes 9 June.docx
160	UKRI Agile R&I Call	CV19CG Minutes 09 March 2021.docx
161	UKRI Agile R&I Call	CV19CG Minutes 11 August.docx
162	UKRI Agile R&I Call	CV19CG Minutes 12 January 21.docx
163	UKRI Agile R&I Call	CV19CG Minutes 12 May.docx

#	Programme/scheme/group	Source
164	UKRI Agile R&I Call	CV19CG Minutes 14 April .docx
165	UKRI Agile R&I Call	CV19CG Minutes 15 December.docx
166	UKRI Agile R&I Call	CV19CG Minutes 15 July .docx
167	UKRI Agile R&I Call	CV19CG Minutes 16 June.docx
168	UKRI Agile R&I Call	CV19CG Minutes 17 November_final.docx
169	UKRI Agile R&I Call	CV19CG Minutes 19 May.docx
170	UKRI Agile R&I Call	CV19CG Minutes 20 April 2021.docx
171	UKRI Agile R&I Call	CV19CG Minutes 20 October.docx
172	UKRI Agile R&I Call	CV19CG Minutes 21 April .docx
173	UKRI Agile R&I Call	CV19CG Minutes 21st July.docx
174	UKRI Agile R&I Call	CV19CG Minutes 22 September.docx
175	UKRI Agile R&I Call	CV19CG Minutes 23 February 2021.docx
176	UKRI Agile R&I Call	CV19CG Minutes 23 June.docx
177	UKRI Agile R&I Call	CV19CG Minutes 23 March 2021.docx
178	UKRI Agile R&I Call	CV19CG Minutes 25 August .docx
179	UKRI Agile R&I Call	CV19CG Minutes 26 January 21.docx
180	UKRI Agile R&I Call	CV19CG Minutes 27 March.docx
181	UKRI Agile R&I Call	CV19CG Minutes 27 May.docx
182	UKRI Agile R&I Call	CV19CG Minutes 28 April.docx
183	UKRI Agile R&I Call	CV19CG Minutes 28 July.docx
184	UKRI Agile R&I Call	CV19CG Minutes 29 June .docx
185	UKRI Agile R&I Call	CV19CG Minutes 31 March.docx
186	UKRI Agile R&I Call	DRAFT CV19CG Minutes 26 January 21.docx
187	UKRI Agile R&I Call	International Update for COVID 19 Coordination Grp - 1 December 2020.docx
188	UKRI Agile R&I Call	090421_UKRICOVID19_Taskforce_TOR.docx
189	UKRI Agile R&I Call	140420_UKRICOVID19_taskforce_Inivitationtojoin_v4.docx
190	UKRI Agile R&I Call	141020_UKRICOVID19_Taskforce_TOR.pdf
191	UKRI Agile R&I Call	150121_R&Itaskforce_membership.docx
192	UKRI Agile R&I Call	220421_UKRICOVID19_Taskforce_TOR.docx
193	UKRI Agile R&I Call	240920_UKRICOVID19_taskforce_Inivitationtojoin_.docx
194	UKRI Agile R&I Call	270121_UKRICOVID19_taskforce_Inivitationtojoin_.docx
195	UKRI Agile R&I Call	20201204_UKRI COVID-19 portfolio analysis-Open Call-DHSC-CD.pptx
196	UKRI Agile R&I Call	ExternalTaskforce_Correspondancetracker.xlsx
197	UKRI Agile R&I Call	RE_ UKRI COVID-19 Research and Innovation Taskforce - Projects for comment .msg
198	UKRI Agile R&I Call	UKRI_COVID19_R&I_Taskforce_ToR.pdf
199	UKRI Agile R&I Call	Vaccine trust-hesitancy contacts.xlsx
200	UKRI Agile R&I Call	FW_ FAO_ James Cooper - Brief on UKRI's COVID-19 Research and Innovation call .msg
201	UKRI Agile R&I Call	Annex B2_230920_RItaskforce_minutes.docx
202	UKRI Agile R&I Call	Annex B1_150920_R&Itaskforce_minutes_final.docx

#	Programme/scheme/group	Source
203	UKRI Agile R&I Call	Annex A2_150920_UKRI_COVID19_Portfolioanalysis.docx
204	UKRI Agile R&I Call	Annex A1_150920_UKRI COVID-19 portfolio analysis-Open Call-DHSC.pdf
205	UKRI Agile R&I Call	Annex A_COVID-19 Research List 1005.xlsx
206	UKRI Agile R&I Call	AnnexD150620_SAGEprioritysresearchquestions_V2.docx
207	UKRI Agile R&I Call	AnnexC_170620_SAGEPriorityConsortium.xlsx
208	UKRI Agile R&I Call	AnnexB_Social science COVID activity 20200615 FINAL.pdf
209	UKRI Agile R&I Call	AnnexB_15062020_UKRI_COVID19_Portfolioanalysis.docx
210	UKRI Agile R&I Call	AnnexA_170620_UKRI_R&Iprojectlist.xlsx
211	UKRI Agile R&I Call	1806_UKRI CEO_Briefing_R&ICOVID19_Final.docx
212	UKRI Agile R&I Call	1706_UKRI CEO_Briefing_COVID19_.docx
213	UKRI Agile R&I Call	Annex B_Project List 20 May UKRI_DHSC funding call.xlsx
214	UKRI Agile R&I Call	Annex A_Project List 20 May Open Call.xlsx
215	UKRI Agile R&I Call	2020-05-12_UKRI CEO_Briefing_COVID19_ResearchandInnovationcall.docx
216	UKRI Agile R&I Call	2020-05-12_UKRI CEO_Briefing_COVID19_ResearchandInnovationcall_Final .docx
217	UKRI Agile R&I Call	Researchquestions - LIVE.ias.docx
218	UKRI Agile R&I Call	RE_ UKRI COVID-19 research and innovation taskforce - research questions.msg
219	UKRI Agile R&I Call	Re_ UKRI COVID-19 research and innovation taskforce - research questions_SM.msg
220	UKRI Agile R&I Call	RE_ UKRI COVID-19 research and innovation taskforce - research questions_RK.msg
221	UKRI Agile R&I Call	RE_ UKRI COVID-19 research and innovation taskforce - research questions_NJ.msg
222	UKRI Agile R&I Call	Re_ UKRI COVID-19 research and innovation taskforce - research questions_IS.msg
223	UKRI Agile R&I Call	Re_ UKRI COVID-19 research and innovation taskforce - research questions_DC.msg
224	UKRI Agile R&I Call	List of immunology questions.msg
225	UKRI Agile R&I Call	SM_Re UKRI taskforce - Research questions for COVID-19.msg
226	UKRI Agile R&I Call	RL_Re UKRI taskforce - Research questions for COVID-19.msg
227	UKRI Agile R&I Call	Re_ UKRI taskforce - Research questions for COVID-191.msg
228	UKRI Agile R&I Call	RE_ UKRI taskforce - Research questions for COVID-19.msg
229	UKRI Agile R&I Call	PR_Re_ UKRI taskforce - Research questions for COVID-19-IS.msg
230	UKRI Agile R&I Call	DC_Re UKRI taskforce - Research questions for COVID-19.msg
231	UKRI Agile R&I Call	270420_Researchquestions.docx
232	UKRI Agile R&I Call	RL_Re_ UKRI COVID-19 R&I - Research Priorities for Gender Impacts of COVID-19 (2).msg
233	UKRI Agile R&I Call	prRE_ UKRI COVID-19 R&I - Research Priorities for Gender Impacts of COVID-19 (1).msg
234	UKRI Agile R&I Call	IS_Re_ UKRI COVID-19 R&I - Research Priorities for Gender Impacts of COVID-19.msg
235	UKRI Agile R&I Call	ER_RE_ UKRI COVID-19 R&I - Research Priorities for Gender Impacts of COVID-19.msg
236	UKRI Agile R&I Call	DC_Re UKRI COVID-19 RI - Research Priorities for Gender Impacts of COVID-19.msg
237	UKRI Agile R&I Call	BLRE_ UKRI COVID-19 R&I - Research Priorities for Gender Impacts of COVID-19.msg
238	UKRI Agile R&I Call	AJ_RE_ UKRI COVID-19 R&I - Research Priorities for Gender Impacts of COVID-19.msg
239	UKRI Agile R&I Call	02062020_UKRI_R&Iprojects.xlsx
240	UKRI Agile R&I Call	02062020_UKRI_COVID19_Portfolioanalysis.docx
241	UKRI Agile R&I Call	02062020_R&I_Taskforcehighligts.docx

#	Programme/scheme/group	Source
242	UKRI Agile R&I Call	200520_R&Itaskforce_membership.docx
243	UKRI Agile R&I Call	020620_R&Itaskforce_readout.docx
244	UKRI Agile R&I Call	Wellcome Trust HSS COVID-19 Projects.4 May 2020.docx
245	UKRI Agile R&I Call	Council (20) 07 - Covid-19 Activity.docx
246	UKRI Agile R&I Call	04052020_Researchquestions.docx
247	UKRI Agile R&I Call	04052020_COVID-19Researchprojectlist.xlsx
248	UKRI Agile R&I Call	050520_R&Itaskforce_minuets.docx
249	UKRI Agile R&I Call	050520_R&Itaskforce_agenda.docx
250	UKRI Agile R&I Call	091220_R&Itaskforce_UKRI Open Call Applications.pptx
251	UKRI Agile R&I Call	091220_R&ITaskforce_UKRI COVID-19 portfolio analysis-Open Call-DHSC.pptx
252	UKRI Agile R&I Call	091220_R&ITaskforce_UKRI COVID-19 portfolio analysis-Open Call-DHSC.pdf
253	UKRI Agile R&I Call	091220_R&ITaskforce_MovingToBaU-Keeping urgency stream.docx
254	UKRI Agile R&I Call	091220_R&Itaskforce_agenda.docx
255	UKRI Agile R&I Call	091220_R&ITaskforc091220_R&Itaskforce_COVID monitoring update.docx
256	UKRI Agile R&I Call	Copy of 2020-15-06 SAGE Priority Consortium Tracker_v0.4-_16 September 2020.xlsx
257	UKRI Agile R&I Call	AHRC investment management summary.msg
258	UKRI Agile R&I Call	191020_COVID19_Researchpriorities .docx
259	UKRI Agile R&I Call	150920_UKRI COVID-19 portfolio analysis-Open Call-DHSC.pdf
260	UKRI Agile R&I Call	141020_UKRICOVID19_Taskforce_TOR_Update.docx
261	UKRI Agile R&I Call	141020_UKRI_COVID19_Portfolioanalysis.docx
262	UKRI Agile R&I Call	141020_RItaskforce_minutes-final.docx
263	UKRI Agile R&I Call	141020_R&Itaskforce_agenda.docx
264	UKRI Agile R&I Call	141020_Potentialhighlights.docx
265	UKRI Agile R&I Call	2020-10-08_UKRI CEO Submission_UKRI_COVID-19_Researchandinnvoationcall.docx
266	UKRI Agile R&I Call	2020-10-07_UKRI CEO briefing_COVID19_Researchandinnovation.docx
267	UKRI Agile R&I Call	150920_R&Itaskforce_minutes_final.docx
268	UKRI Agile R&I Call	150920_UKRI COVID-19 portfolio analysis-Open Call-DHSC.pptx
269	UKRI Agile R&I Call	150920_UKRI_COVID19_Portfolioanalysis.docx
270	UKRI Agile R&I Call	NERC Portfolio analysis.docx
271	UKRI Agile R&I Call	Portfolioanalysis_Data.xlsx
272	UKRI Agile R&I Call	Copy of AHRC CEO Briefing Portfolio Analysis 08.10.20.xlsx
273	UKRI Agile R&I Call	CEO brief 08.09.20 (003).docx
274	UKRI Agile R&I Call	ahrc_ ukri ceo brief on covid19.msg
275	UKRI Agile R&I Call	NERC COVID Air Quality highlights.docx
276	UKRI Agile R&I Call	FW_ CEO Briefing and Portfolio analysis .msg
277	UKRI Agile R&I Call	Copy of 01 Portfolioanalysis_template NERC Sept 2020.xlsx
278	UKRI Agile R&I Call	01 Portfolioanalysis_template NERC Sept 2020.xlsx
279	UKRI Agile R&I Call	STFC.docx
280	UKRI Agile R&I Call	AnnexB_15062020_UKRI_COVID19_Portfolioanalysis.docx

#	Programme/scheme/group	Source
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282	UKRI Agile R&I Call	160620_SAGELargepriorityconsortia.xlsx
283	UKRI Agile R&I Call	160620_R&Itaskforce_agenda.docx
284	UKRI Agile R&I Call	150620_UKRI_R&Iprojects.xlsx
285	UKRI Agile R&I Call	150620_UKRI_InternationalresponsetoCOVID-19.docx
286	UKRI Agile R&I Call	150620_SAGEpriorityresearchquestions_V2.docx
287	UKRI Agile R&I Call	090620 COVID-19 ExCo_draft_taskforce 16 June.docx
288	UKRI Agile R&I Call	UKRI COVID-19 research and innovation taskforce - Agenda .msg
289	UKRI Agile R&I Call	200121COVID19 EDI Data .xlsx
290	UKRI Agile R&I Call	170221_UKRI_MonitoringandEvaluationSurvey.docx
291	UKRI Agile R&I Call	170221_RItaskforce_minutes_final.docx
292	UKRI Agile R&I Call	170221_R&Itaskforce_agenda.docx
293	UKRI Agile R&I Call	171120_UKRI_COVID19_Portfolioanalysis.docx
294	UKRI Agile R&I Call	171120_RItaskforce_minutes-final.docx
295	UKRI Agile R&I Call	171120_R&Itaskforce_agenda.docx
296	UKRI Agile R&I Call	061120_UKRI_COVID19_ResearchPriorities.pdf
297	UKRI Agile R&I Call	UKRI COVID-19 research and innovation taskforce.msg
298	UKRI Agile R&I Call	SAGE sub-group research priorities .msg
299	UKRI Agile R&I Call	190820_R&Iprojectlist.xlsx
300	UKRI Agile R&I Call	180820_RItaskforce_minutes_FINAL.docx
301	UKRI Agile R&I Call	180820_R&Itaskforce_agenda.docx
302	UKRI Agile R&I Call	Portfolioanalysis_Data.xlsx
303	UKRI Agile R&I Call	COVID monitoring survey 080121.docx
304	UKRI Agile R&I Call	Copy of UKRI COVID EDI Data External.xlsx
305	UKRI Agile R&I Call	200121COVID19 EDI Data .xlsx
306	UKRI Agile R&I Call	200121_UKRI_MonitoringMockReportv1.pptx
307	UKRI Agile R&I Call	200121_Taskforcechairsbrief.docx
308	UKRI Agile R&I Call	200121_RItaskforce_minutes_final ER.docx
309	UKRI Agile R&I Call	200121_R&Itaskforce_agenda.docx
310	UKRI Agile R&I Call	200121_NCS Governance_v0.1.docx
311	UKRI Agile R&I Call	091220_R&ITaskforc091220_R&Itaskforce_COVID monitoring update.docx
312	UKRI Agile R&I Call	COVID_19 Data Monitoring source - Version for Taskforce 21 April - Distributed.xlsx
313	UKRI Agile R&I Call	210420_RItaskforce_Readout.docx
314	UKRI Agile R&I Call	210420_R&Itaskforce_agenda_FINAL.docx
315	UKRI Agile R&I Call	NCS Narrative.docx
316	UKRI Agile R&I Call	EMG Priority Research Questions Draft_SAGE -TWEG additions July.docx
317	UKRI Agile R&I Call	COVID-19 Priority Research Questions SPI-M.docx
318	UKRI Agile R&I Call	COVID-19 Priority Research Questions - COG-UK (Vaccines Q Only).docx
319	UKRI Agile R&I Call	AIP List 22.09.20.xlsx

#	Programme/scheme/group	Source
320	UKRI Agile R&I Call	150920_UKRI_COVID19_Portfolioanalysis.docx
321	UKRI Agile R&I Call	150920_UKRI COVID-19 portfolio analysis-Open Call-DHSC.pdf
322	UKRI Agile R&I Call	150920_R&Itaskforce_minutes_final.docx
323	UKRI Agile R&I Call	2020-15-06 SAGE Priority Consortium Tracker_v0.4__9 September 2020.xlsx
324	UKRI Agile R&I Call	R&I Taskforce 250620-CD.docx
325	UKRI Agile R&I Call	Barran(CentralTrackerNoCVRI&I 620)_FundingRecommendation18Jun2020.pdf
326	UKRI Agile R&I Call	280720_R&Itaskforce_agenda.docx
327	UKRI Agile R&I Call	250620_UKRI_R&Iprojects.xlsx
328	UKRI Agile R&I Call	250620_R&Itaskforce_agenda.docx
329	UKRI Agile R&I Call	250620_priorityareas.docx
330	UKRI Agile R&I Call	090620 COVID-19_Next Steps.docx
331	UKRI Agile R&I Call	270421_UKRICOVID19_Taskforce_TOR.docx
332	UKRI Agile R&I Call	270421_UKRICOVID19_PortfolioTaxonomy.docx
333	UKRI Agile R&I Call	270421_UKRICOVID19_Monitoringandevalutionsurvey.docx
334	UKRI Agile R&I Call	270421_R&Itaskforce_agenda.docx
335	UKRI Agile R&I Call	270421_CV19opencall_MonitoringandEvaluationreport.pptx
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337	UKRI Agile R&I Call	27072020_R&IProjectlist.xlsx
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340	UKRI Agile R&I Call	2020-15-06 SAGE Priority Consortium Tracker_v1.0.xlsx
341	UKRI Agile R&I Call	Researchquestions - not current version.docx
342	UKRI Agile R&I Call	Researchquestions - not current version_JD.docx
343	UKRI Agile R&I Call	Researchquestions - NOT CURRENT VERSION .docx
344	UKRI Agile R&I Call	271020_UKRI_COVID19_ResearchPriorities.pdf
345	UKRI Agile R&I Call	271020_UKRI_COVID19_ResearchPriorities.docx
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349	UKRI Agile R&I Call	061120_UKRI_COVID19_ResearchPriorities.docx
350	UKRI Agile R&I Call	Holmes et al. Lancet Psychiatry MQ-AMS mental health science research priorities.pdf
351	UKRI Agile R&I Call	COVID-19 AMS Domains Leadership Letter - SD 1 April 2020.docx
352	UKRI Agile R&I Call	AMS-BSI_Expert summary_ the state of the art in COVID-19 immunology, and current knowledge gaps.pdf
353	UKRI Agile R&I Call	CV19WG Minutes 301120.docx
354	UKRI Agile R&I Call	CV19WG Minutes 290620.docx
355	UKRI Agile R&I Call	CV19WG Minutes 270720.docx
356	UKRI Agile R&I Call	CV19WG Minutes 270420.docx
357	UKRI Agile R&I Call	CV19WG Minutes 250121.docx
358	UKRI Agile R&I Call	CV19WG Minutes 220620.docx

#	Programme/scheme/group	Source
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361	UKRI Agile R&I Call	CV19WG Minutes 190421.docx
362	UKRI Agile R&I Call	CV19WG Minutes 180520.docx
363	UKRI Agile R&I Call	CV19WG Minutes 150620.docx
364	UKRI Agile R&I Call	CV19WG Minutes 150420.docx
365	UKRI Agile R&I Call	CV19WG Minutes 141220.docx
366	UKRI Agile R&I Call	CV19WG Minutes 130720.docx
367	UKRI Agile R&I Call	CV19WG Minutes 110520.docx
368	UKRI Agile R&I Call	CV19WG Minutes 110121.docx
369	UKRI Agile R&I Call	CV19WG Minutes 080221.docx
370	UKRI Agile R&I Call	CV19WG Minutes 060420.docx
371	UKRI Agile R&I Call	CV19WG Minutes 040520.docx
372	UKRI Agile R&I Call	CV19WG Minutes 010620.docx
373	UKRI Agile R&I Call	CV19WG Meeting 240820.docx
374	UKRI Agile R&I Call	CV19WG Meeting 210920.docx
375	UKRI Agile R&I Call	CV19WG Meeting 191020.docx
376	UKRI Agile R&I Call	CV19WG Meeting 100820.docx
377	UKRI Agile R&I Call	CV19WG Meeting 161120.docx
378	UKRI Agile R&I Call	CV19WG Meeting 070920.docx
379	UKRI Agile R&I Call	CV19WG Meeting 051020.docx
380	UKRI Agile R&I Call	CV19WG Meeting 021120.docx
381	UKRI Agile R&I Call	UKRI COVID19 Governance Structure.pptx
382	UKRI Agile R&I Call	Additonal TC's for grant award letters v6_Covid-19 rapid response calls.docx
383	UKRI Agile R&I Call	Working Group Terms of Reference .docx
384	UKRI Agile R&I Call	UKRI_COVID19_R&I_Taskforce_ToR.pdf
385	UKRI Agile R&I Call	CV19 Coordination Group ToR.docx
386	UKRI Agile R&I Call	UKRI COVID19 Communications Campaign and Activities.docx
387	UKRI Agile R&I Call	UKRI Agile Call Selection of Case Studies for CV19 RandI response.docx
388	UKRI Agile R&I Call	UKRI COVID-19 Councils contacts.xlsx
389	UKRI Agile R&I Call	Current COVID19 Governance Membership.xlsx
390	UKRI Agile R&I Call	110221 UKRI Agile Call COVID Award Holders list.xlsx
391	UKRI Agile R&I Call	Innovate UK Project List with contact details.xlsx
392	UKRI Agile R&I Call	UKRI RC Funding C19 Projects Updated.xlsx
393	UKRI Agile R&I Call	ExCo Paper for Technopolis.docx
394	UKRI Agile R&I Call	ExCo Annex 3 - Case Studies from the CV19 RandI response.docx
395	UKRI Agile R&I Call	Lessons learned Coordination Group Input.docx
396	UKRI Agile R&I Call	Lessons Learned Brief.docx
397	UKRI Agile R&I Call	UKRI COVID19 Monitoring Survey FAQs.docx

#	Programme/scheme/group	Source
398	UKRI Agile R&I Call	MandE COVID Process Flowchart.pptx
399	UKRI Agile R&I Call	M&E Email to award holders.docx
400	UKRI Agile R&I Call	Data from COVID-19 Open Call Monitoring Survey.xlsx
401	UKRI Agile R&I Call	C19 Open call survey V7 Live 20210312.docx
402	UKRI Agile R&I Call	Analysis report C19 open call.pptx
403	UKRI Agile R&I Call	UKRI Agile Call Award Holders Web List.xlsx
404	UKRI Agile R&I Call	UKRI ExCo confirmation - STFC.msg
405	UKRI Agile R&I Call	UKRI ExCo confirmation - RE.msg
406	UKRI Agile R&I Call	UKRI ExCo confirmation - ESRC.msg
407	UKRI Agile R&I Call	UKRI ExCo confirmation - BBSRC.msg
408	UKRI Agile R&I Call	RE_ UKRI COVID-19 Business Case approval timeline.msg
409	UKRI Agile R&I Call	BEIS PIC Approval Confirmation.msg
410	UKRI Agile R&I Call	C-19 response logic lodels v9
411	UKRI Agile R&I Call	BEIS Confirmation of HMT conditions.msg
412	UKRI Agile R&I Call	Round 4 Questions.pdf
413	UKRI Agile R&I Call	Round 3 questions.pdf
414	UKRI Agile R&I Call	Round 2 questions.pdf
415	UKRI Agile R&I Call	Round 1 Questions.pdf
416	UKRI Agile R&I Call	Guidance document and survey questions v10R3 (002).docx
417	UKRI Agile R&I Call	Agile call survey responses Round 1_4 to share.xlsx
418	UKRI Agile R&I Call	Agile call survey responses Round 1_3.xlsx
419	UKRI Agile R&I Call	Agile call survey responses BB 220512.xlsx
420	UKRI Agile R&I Call	Agile call survey responses BB 220425 OLD.xlsx
421	UKRI Agile R&I Call	Agile Call Portfolio taxonomy.xlsx
422	UKRI Agile R&I Call	Round 1 Quantiative Analysis report C19 open call.pptx
423	UKRI Agile R&I Call	CV19opencall_MonitoringandEvaluationqualitativereport.pptx
424	UKRI Agile R&I Call	UKRI COVID-19 Portfolio Monitoring Report Round 2.pptx
425	UKRI Agile R&I Call	Round 2 Draft report C19 open call V2.pptx
426	UKRI Agile R&I Call	Round 3 draft report C19 open call Quant and Qual FINAL.pptx
427	Whole Genome Sequence Alliance	200314_COG-UK_final.docx
428	Whole Genome Sequence Alliance	Email from SMW re COG-UK support.msg
429	Whole Genome Sequence Alliance	Re OFFICIAL RE Genomics consortium.msg
430	Whole Genome Sequence Alliance	COG UK Consortium Members.xlsx
431	GCRF and Newton Fund	UKRI GCRF_NF Agile Call Web page - V1.3 edits.pdf
432	GCRF and Newton Fund	REVIEWER GUIDANCE - UKRI GCRF and Newton Fund COVID-19 Agile Call.pdf
433	GCRF and Newton Fund	Panel Guidelines for Assessing Gender Equality (1).pdf
434	GCRF and Newton Fund	PANEL GUIDANCE - UKRI GCRF and Newton Fund COVID-19 Agile Call - V2.0 (1).pdf
435	GCRF and Newton Fund	GCRF_NF UKCDR COVID19 Research Project Tracker Submission.xlsx
436	GCRF and Newton Fund	GCRF Newton Fund Agile call - Panel Attendees.pdf

#	Programme/scheme/group	Source
437	GCRF and Newton Fund	GCRF Newton Fund - COVID-19 call Proposal Form V2 – Update 29 June (10).docx
438	GCRF and Newton Fund	DRAFT GCRF_NF Agile call - Internal process.pdf
439	GCRF and Newton Fund	ASSESSMENT CRITERIA - UKRI GCRF and Newton Fund COVID-19 Agile Call.pdf
440	GCRF and Newton Fund	Agile Call EIA V1.pdf
441	GCRF and Newton Fund	Copy of GCRF_NF Agile - Contact Details
442	GCRF and Newton Fund	ENG COVID-19_Africa RGF_Framework and Application Guidelines_1.pdf
443	GCRF and Newton Fund	ENG COVID 19 Africa Rapid Grant Fund FAQs.pdf
444	GCRF and Newton Fund	AfricaFund_AdditionalBackground.docx
445	Vaccine Manufacturing Innovation Centre	105193 VMIC - GFA Variation No 1 (executed 111220).pdf
446	Vaccine Manufacturing Innovation Centre	210526 VMIC UKRI-IUK Variation Agreement 2 _final.pdf
447	Vaccine Manufacturing Innovation Centre	FW 10th Dec Investment Panel Papers.msg
448	Vaccine Manufacturing Innovation Centre	Good news from the BEIS Investment Panel.msg
449	Vaccine Manufacturing Innovation Centre	VMIC - Acceleration & Pandemic response PAF1565 v3 (030620).xlsx
450	Vaccine Manufacturing Innovation Centre	VMIC - Additional Funding PAF1790 (050521).xlsx
451	Vaccine Manufacturing Innovation Centre	VMIC - BEIS-UKRI MOU (Signed - 280120).pdf
452	Vaccine Manufacturing Innovation Centre	VMIC Contacts.xlsx
453	Vaccine Manufacturing Innovation Centre	ISCF Medicines Manufacturing Challenge Interim Evaluation v6 ICUO.pdf
454	Vaccine Manufacturing Innovation Centre	18-026207-01 ISCF MM Baseline and Process Report FINAL CLIENT USE.pdf
455	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 33 MO Report (Sep-21).docx
456	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 32 MO Report (Aug-21).docx
457	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 31 MO Report (Jul-21).docx
458	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 30 MO Report (Jun-21).docx
459	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 29 MO Report (May-21).docx
460	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 28 MO Report (Apr-21).docx
461	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 27 MO Report (Mar-21).docx
462	Vaccine Manufacturing Innovation Centre	105193 VMIC - Period 26 MO Report (Feb-21).docx
463	ED&I Data	105193 VMIC - Period 25 MO Report (Jan-21).docx
464	ED&I Data	Output Table Applications - EDI Summary COVID Call v2 (002).xlsx
465	Case study background	2021-01-05 NCS Business Case_v1.1.docx
466	Case study background	72822.pdf
467	Case study background	72845.pdf
468	Case study background	74797.pdf
469	Case study background	77807.pdf
470	Case study background	81872.pdf
471	Case study background	84877.pdf
472	Case study background	85395.pdf
473	Case study background	Aebischer CfS.pdf
474	Case study background	Aebischer proposa.pdf
475	Case study background	Appt Health.pptx

#	Programme/scheme/group	Source
476	Case study background	BiologIC Technologies.pptx
477	Case study background	Bonneaud_UExeter USFQ_Barcoding Galapagos.pdf
478	Case study background	CfS ES-V007033-1.pdf
479	Case study background	CV220-169 Baillie K Dr.pdf
480	Case study background	EP-V026488-1_Proposal Form.pdf
481	Case study background	GCRFNF143 - UKRI-COVID MEL Progress Report.docx
482	Case study background	Hatch cfs.pdf
483	Case study background	Hatch proposal form.pdf
484	Case study background	Martin CfS.pdf
485	Case study background	Martin proposal.pdf
486	Case study background	NEV0048831 - Application form.pdf
487	Case study background	NEW00481X1 - Application form.pdf
488	Case study background	ProAxsis.pptx
489	Case study background	Proposal ES-V007033-1.pdf
490	Case study background	ProAxsis.pptx
491	Case study background	Impactful projects by council (2) - 16 Dec.docx
492	Case study background	BiologIC Technologies.pptx
493	Case study background	Appt Health.pptx
494	Case study background	2022_Jan_ COVID 19 ESG Case Studies_.docx
495	Innovate UK response	UKRI Open progress report.xlsx
496	Innovate UK response	UKRI impact report_IUK_May2020.docx
497	Innovate UK response	IUK-21121-COVID-19-funding-evaluation-for-COP26.pdf
498	Innovate UK response	Covid-19_evidence_cover_note.pdf
499	Innovate UK response	Covid-19_evidence_cover_note.pdf
500	Innovate UK response	6.Position Paper - Fast Start Future ISO3.pdf
501	Innovate UK response	4.Fast Start Report_Innovation_Caucus(IUK internal only) v2.pdf
502	Innovate UK response	3.IUK_Covid_Outcome tracking report_OCT21.pdf
503	Innovate UK response	2.Position Paper - Fast Start Survival ISO 2.pdf
504	Innovate UK response	1.Covid_and_Innovation.pdf
505	Innovate UK response	1.1An innovation programme for a post-covid era_V3.pdf
506	National Core Studies	UKRI NCS Mid-Term Review Report 2022_03_22.pdf
507	National Core Studies	NCS Study Area Mid-Term Review Guidance_updated.pdf
508	National Core Studies	2021-01-05 NCS Business Case_v1.1.docx
509	National Core Studies	10-03 - Annex 1 NCS Monthly Reports - Sept 21.docx
510	National Core Studies	09-03-Appendix 1 - NCS Full Progress Reports.pdf
511	National Core Studies	08-03-Appendix 1 - NCS Full Progress Reports.pdf
512	National Core Studies	07-03 - Appendix 1 - NCS Full Progress Reports.docx

Source: UKRI Information provided to Technopolis.

Appendix N Supplementary data and other annex materials

N.1. Note on the UKRI M&E data analysis

In February 2021, a COVID-19 M&E survey was developed (from an initial survey set up by MRC/NIHR) to collect results data from all grant holders under the UKRI Agile COVID-19 portfolio. The purpose of the survey was to support UKRI communications with budget holders in UK Government on the impact of the funding. It was designed to complement reporting to Research Fish and was mandatory for grant holders (as per the terms in their grant agreement).

The survey was issued every three months and has completed four rounds at the time of writing, the last round gathered responses until the end of March 2022, around a year after Round 1. The same set of projects complete the survey (i.e. multiple rounds) until their grant is complete.

This secondary dataset was used to enhance the evaluation survey data while reducing burden on Agile Call awardees. In practice, this meant that Agile Call awardees were not asked six questions around outcomes and impact, which all other awardees were asked.[139] Data from the UKRI Agile call M&E survey was instead used to provide analysis against those questions. As such, this appendix does not present the full results of UKRI's survey, just those aspects that help answer our evaluation questions and fill gaps in the evaluation survey.

N.2. Risk levels of funded awards

The process review of UKRI's COVID-19 response noted that UKRI had generally erred on the side of caution in its funding processes, and that there may have been limited risk appetite. Here in the impact evaluation, we have probed into this aspect a little further. While the findings do not substantially affect our evaluation findings, we do note our further work here to complete the investigation that began in the process review.

Risk refers to the likelihood of awards achieving their stated objectives. The key question here is whether the awards generally present 'safe bets' or whether there is a prominent share of 'high risk, high reward' investments. The prevalence of the latter has implications for the extent to which we might expect a sizeable share of awards not to yield the hoped-for outcomes. At the same time, it would heighten the expectation for significant and unexpected impact in at least some awards. The process review highlighted that there were few signs of risk-taking in UKRI's selection processes.

To get a sense of the level of risk – and the extent to which funded awards are 'high risk, high reward' – we asked our survey respondents (n=320) to rate on a scale from one to ten the likelihood of their award achieving its planned outcomes, at start of award.

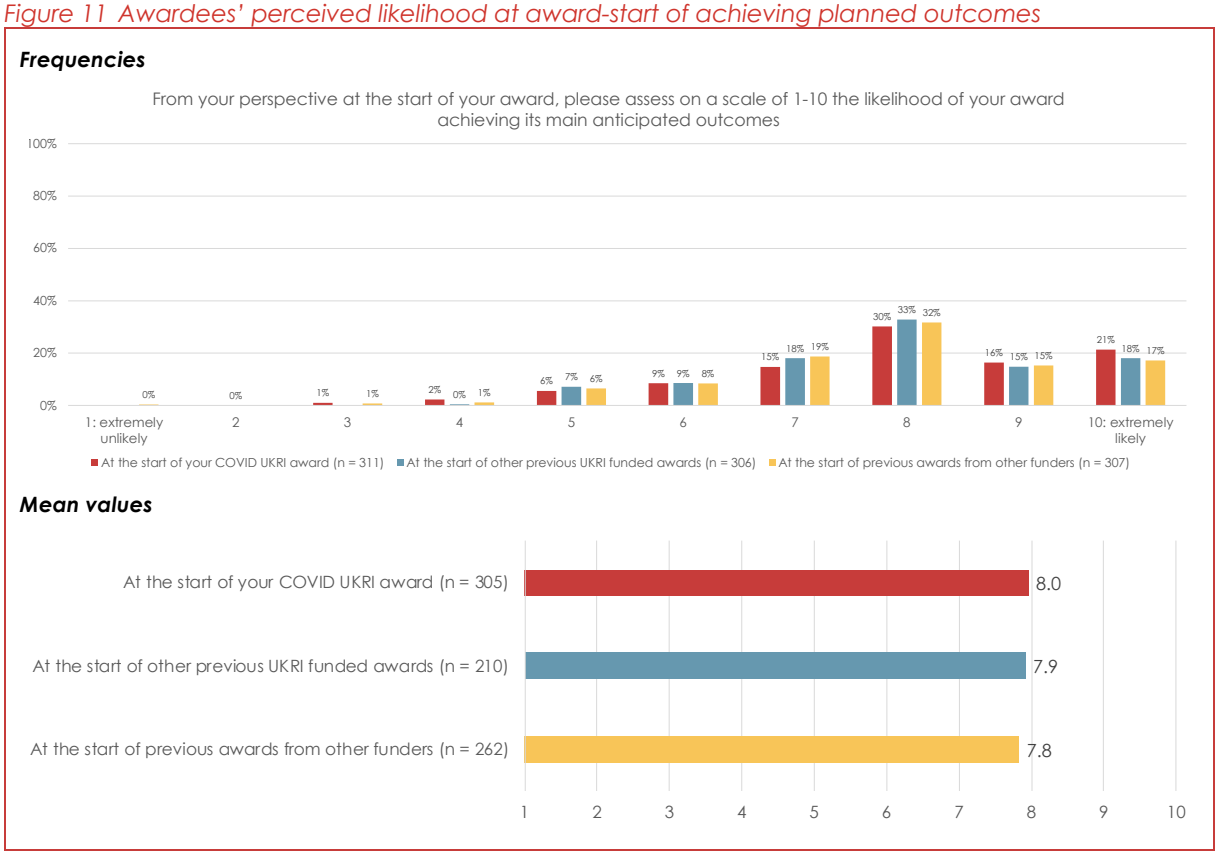
In itself, this scale is not very informative, so we asked respondents to also assess perceived risk level of any previous UKRI awards they may have held, as well as awards from other R&I funders, all using the same scale.

Our results indicate that the risk profile of UKRI's COVID-19 response awards is very similar to that of both previous UKRI awards and pre-COVID-19 awards from other funders, with the majority of responses consistently clustering around the 8/10 mark. There is in fact a slightly

[139] Data sources and/or solutions to understanding COVID-19 and its public health impact; data and/or knowledge that contribute towards managing and/or understanding the impact and challenges of measures to contain and/or respond to COVID-19; citations in any policy documents pertaining to the pandemic; technologies, materials, and/or design and manufacturing processes that contribute towards addressing the challenges presented by COVID-19; increased efficiency and/or efficacy of clinical solutions; further anticipated impacts.

higher perceived propensity for likelihood of achieving outcomes from UKRI COVID-19 awards to be rated 9/10 or 10/10. In short, there is negligible evident difference in the risk-profile between UKRI's COVID-19 portfolio and business-as-usual R&I funding, and no indication of stronger 'high risk, high reward' approaches.

Figure 11 Awardees' perceived likelihood at award-start of achieving planned outcomes



Source: Technopolis survey of UKRI COVID-19 Awardees. NB: The figures presented above exclude the 'Don't know / not applicable' option to aid comparability across output types, hence the lower and variable response numbers for each survey item.

We conducted further analysis on these data by funding council and investment type. This identified very little variation from the overall findings. The only notable differences are the Innovate UK Agile Call awards, whose awardees report far higher risk levels for their pre-COVID-19 awards both from UKRI and other funders, and Agile GCRF/Newton awards, who specifically report higher risk-levels for their pre-COVID-19 awards from funders other than UKRI.

Table 19 Average assessment of the likelihood of awards achieving their main anticipated outcomes, where '1' means 'extremely unlikely' and '10' means 'extremely likely' by funder

Funder	At the start of your COVID-19 award	At the start of previous UKRI funding schemes	At the start of other previous awards from other funders
AHRC (n = 44)	7.7	8.4	8.1
BBSRC (n = 24)	7.4	7.8	7.7
EPSRC (n = 29)	7.7	7.2	7.4
EPSRC/GCRF (n = 20)	8.2	9.1	8.6

Funder	At the start of your COVID-19 award	At the start of previous UKRI funding schemes	At the start of other previous awards from other funders
ESRC (n = 104)	8.3	8.2	8.1
Innovate UK (n = 17)	7.5	6.2	5.7
MRC (n = 20)	7.3	6.9	7
NERC (n = 10)	8	8	7.8
UKRI/DHSC (n = 49)	8.1	8.1	7.9

Source: Technopolis survey of UKRI COVID-19 Awardees. NB: The figure presented above excludes the 'Don't know / not applicable' option to aid visual comparability across output types, hence the lower and variable response numbers for each survey item.

Table 20 Average assessment of the likelihood of awards achieving their main anticipated outcomes, where '1' means 'extremely unlikely' and '10' means 'extremely likely' by competition

Competition	At the start of your COVID-19 award	At the start of previous UKRI funding schemes	At the start of other previous awards from other funders
COVID-19 Agile Call for R&I (n = 213)	8	7.9	7.9
COVID-19 Rapid Response Calls (n = 32)	8	8.2	8.1
COVID-19 Urgency Grants (n = 8)	7.5	7.5	8
GCRF/NF Agile awards (n = 20)	8.2	9.1	8.6
Global Effort on COVID-19 (n = 8)	8.5	7.5	8.3
NCS (n = 6)	8.3	7	6.5
Other (n = 9)	7.5	7.3	7.4
UKRI Ideas to Address COVID-19 (n = 17)	7.5	6.2	5.7

Source: Technopolis survey of UKRI COVID-19 Awardees. NB: The figure presented above excludes the 'Don't know / not applicable' option to aid visual comparability across output types, hence the lower and variable response numbers for each survey item.

N.3. Association between impact, impact speed and UKRI support to awardees

The analysis below looks into the possible relationship, at the general, overall portfolio level, between UKRI's supporting and convening efforts and the speed and prevalence of impact. We divide survey respondents into two groups: those who report no or minimal support ('minimal meaning only guidance/advice at application stage), and those who do report some additional form of support by UKRI staff either at application stage or during the award lifetime. The figures below indicate that being in the first or second of these groups has no overall effect on the speed at which first outputs, outcomes or impacts were achieved.

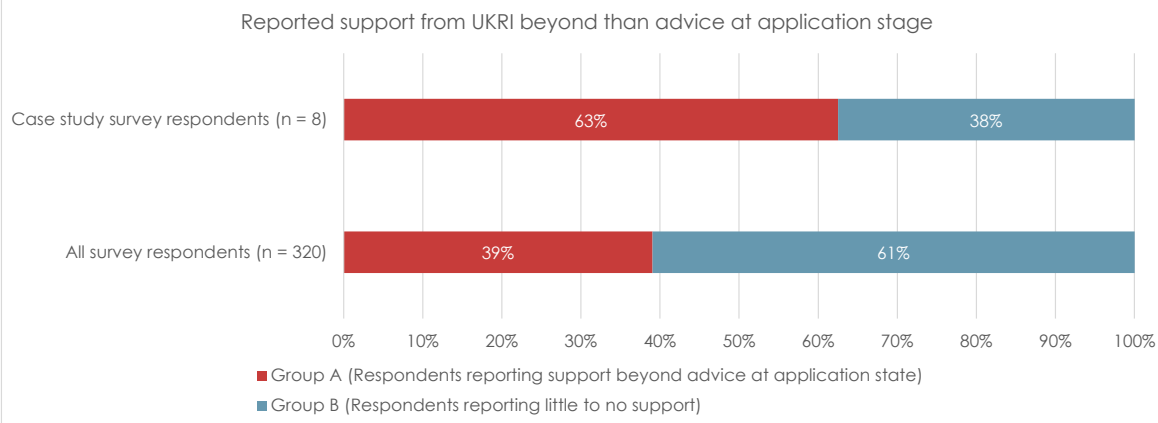
Further, eight survey respondents are awardees featured in our case studies (long or short). They are more likely than the general survey response population to report some level of support. However, this number of responses is too low to make any statistically significant claims.

Table 21 UKRI support and speed of outcomes

In relation to when you started your UKRI COVID-19 award, when did you achieve the following?	First publication		First research tool, method, database or model produced		First product, process or solution created		First public communication of results / data shared		First public engagement activity		First advice given to policymakers	
Group type*	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Within the first three months	13%	10%	22%	25%	10%	12%	19%	17%	35%	21%	13%	17%
Within the first 4-6 months	16%	13%	17%	25%	6%	8%	35%	24%	27%	21%	22%	11%
Within the first 7-9 months	14%	10%	12%	9%	11%	11%	19%	16%	14%	15%	18%	9%
Within the first 10-12 months	14%	16%	9%	10%	4%	6%	10%	13%	5%	8%	11%	12%
After more than 12 months	13%	13%	9%	5%	3%	5%	4%	5%	6%	8%	12%	7%
Not yet achieved, but expected in future	27%	35%	7%	7%	9%	11%	10%	22%	7%	16%	13%	19%
Don't know/not applicable	3%	3%	25%	19%	57%	46%	5%	3%	5%	11%	13%	26%

Source: Technopolis survey of UKRI COVID-19 Awardees. NB: Group A consisted of survey respondents who reported receiving support beyond advice at the application stage; Group B consisted of those who reported no support or advice at the application stage only.

Figure 12 Prevalence of UKRI support in our case studies vs all awardees

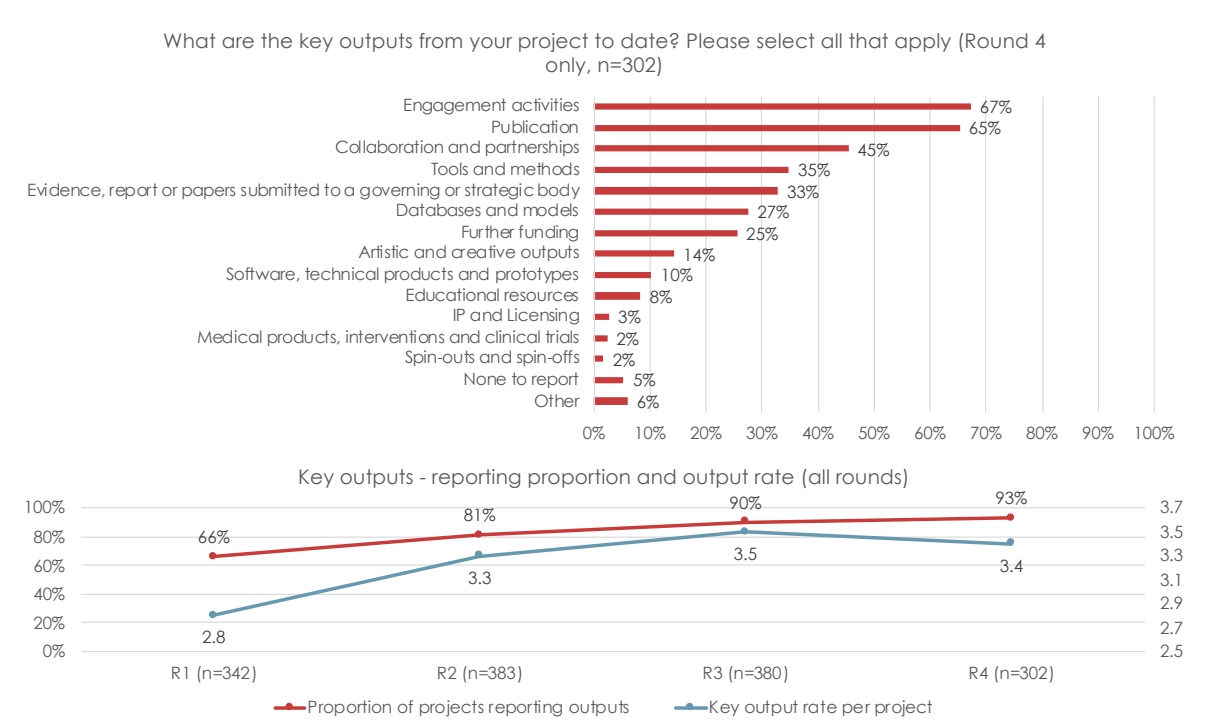


N.4. Engagement and communication activities in the Agile Call

The most commonly reported outputs in the monitoring and evaluation survey of Agile Call awardees were engagement activities, closely followed by publications. This is a significant insight in forming an understanding of how the UKRI COVID-19 awards portfolio achieved such a breadth and depth of outcomes and impacts. In response to COVID-19, there is a sense from these data that award holders' priorities were different from normal circumstances. This reflects many other parts of our findings that supporting wider society in dealing with COVID-19 was a clear central priority among large portions of awardees.

We further note on the Agile Call M&E survey data that there were positive trends over time in the proportion of awards reporting on outputs (up 27% from Round 1 and higher than the UKRI average of 88%[140]) and the number of outputs reported per award (up an average of 0.6 from Round 1). These results indicate that the awards were not only productive, but were consistently so from the beginning. However, there may be some issues in these data around duplication.

Figure 13 Key outputs – Agile call awardees

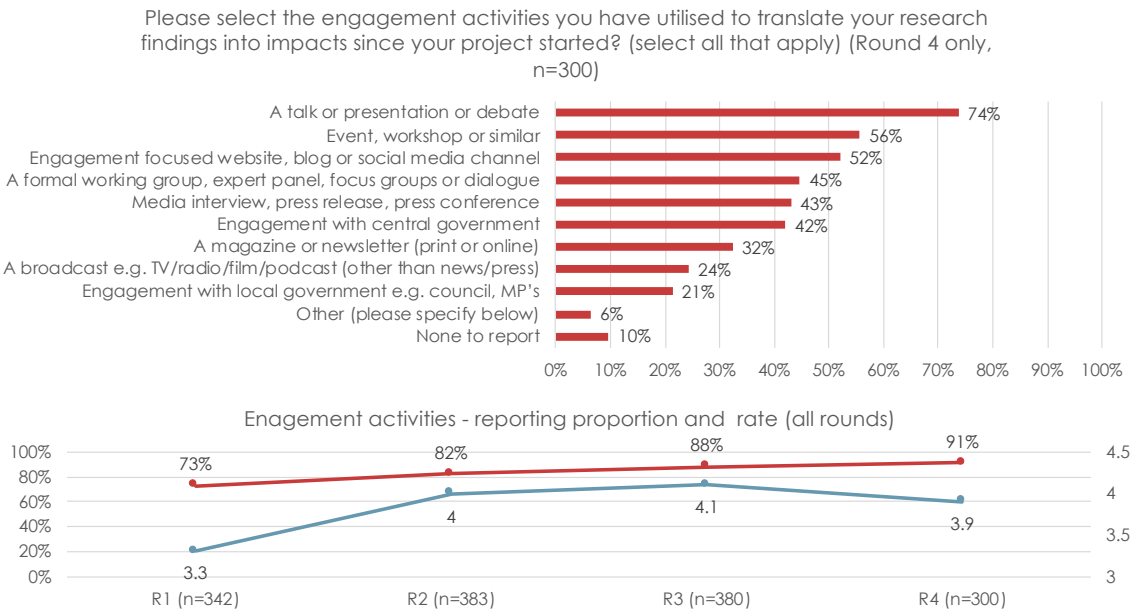


Source: UKRI M&E Survey Rounds 1-4, Agile Call awardees only.

Awardee's engagement activities tended to take the form of presentations, events and online content (Figure 14). The proportion of projects reporting engagements and the average rate of engagements remained high over survey rounds. Though these figures relate only to Agile Call awardees, they reflect this evaluation's survey results and short case studies, where awardees were continuing to communicate and apply their findings in society.

[140] Data source: https://public.tableau.com/app/profile/uk.research.and.innovation.ukri./viz/ResearchfishOutputs2021/Overview

Figure 14 Engagement activities – Agile call awardees



Source: UKRI M&E Survey Rounds 1-4, Agile Call awardees only.

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