

January 2023

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

Final report



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Executive Summary

This report presents the findings of the impact evaluation of UKRI's research and innovation (R&I) funding response to COVID-19. It provides an assessment of the impacts achieved and also considers enablers and barriers to impact as well as UKRI's own role in enabling impact. This study complements the process review of UKRI's R&I funding response to COVID-19, conducted by Technopolis from June to October 2021 and available on UKRI's website.¹

The study follows a mixed-methods approach. It combines documentation review and analysis of monitoring data, a survey and interviews with lead investigators, interviews with research and innovation experts, bibliometric analysis (including of uptake), case studies, an international review of six funders, a value for money assessment and contribution analysis.

The scale of UKRI investments and its focus on multiple critical themes has underpinned wide-ranging and substantive impacts. The thematic case studies developed for this report highlight the substantial impact of UKRI investments, often on highly prominent developments and policy decisions. This includes supporting the development of the Oxford/AstraZeneca vaccine (in partnership with the National Institute for Health and Care Research, NIHR), informing decisions around the introduction and relaxation of national and regional lockdowns, and the Coronavirus Job Retention Scheme ('furlough'). We note below some highlights from those cases. Further examples of impact across a wide range of social, economic and policy areas are presented in the main body of this report.

	<p>Figures published by the NHS for the RECOVERY trial, co-funded by UKRI and NIHR, confirmed that dexamethasone had saved the lives of around 22,000 patients in the UK and an estimated one million lives globally.</p> <p>More than 2.5 billion out of 10 billion doses of the COVID-19 vaccines administered globally (as of January 2022) have been the Oxford/AstraZeneca vaccine, which was in part supported by UKRI.</p>
	<p>UKRI-funded researchers advised on the benefits of a gradual lifting of restrictions after the UK's third national lockdown, in contrast to the option of a sudden removal of all restrictions. This is estimated to have saved up to 100,000 lives and prevented 300,000 hospital admissions.</p> <p>UKRI-funded research also informed a four-week delay in Step 4 of the 'Roadmap to Recovery', which is estimated to have reduced peak hospital admissions by 30%.</p>
	<p>Insights from UKRI-funded awards on transmission on public transport contributed to 1,200 London buses being fitted with a new ventilation system, decreasing the risk of exhaled air reaching the driver's cabin by 97%.</p>
	<p>UKRI-funded investments provided data to support the introduction, design and understanding of the Coronavirus Job Retention Scheme (CJRS, 'furlough'), which supported 11.7m jobs and 1.3m employers.</p>

UKRI's COVID-19 response led to a high proportion of relevant outputs and outcomes, produced in a timely manner (see Section [3.2](#)). We find, via survey, that **around 90% of UKRI-funded awards report producing at least one type of output geared towards supporting the response to COVID-19 or its consequences**. This includes advice on the relative effectiveness of policy options, development of mitigating technologies, the creation of reference data sources, and

¹ <https://www.ukri.org/news/independent-process-review-of-ukris-response-to-COVID-19/>

contributions to clinical efficiency. The majority of awards report that dissemination to, and/or adoption by research users has taken place.

In many awards, engagement activities with research users also took precedence over usual elements of scientific dissemination such as academic publications. However, academic impact has likewise been substantial: publications stemming from UKRI's COVID-19 response have significantly higher citation scores than other UK-based research on COVID-19, and in comparison with international funders. Publications stemming from UKRI COVID-19 investments are also cited in policy documents and in the public domain much more frequently in comparison with publications funded by UKRI pre-pandemic (2017 to July 2019). Time-to-citation in policy documents was also substantially shorter than is ordinarily the case.

Delivering impact at speed was a key aim of UKRI's COVID-19 response, with anticipated award lengths of 12-18 months (depending on investment type). Award holders progressed work at a faster pace than in pre-pandemic 'business as usual'. Almost 40% of surveyed awardees who planned or anticipated to develop products, processes or solutions had done so within six months of award start. Furthermore, 70% of surveyed awardees reported that the speed at which they achieved their outcomes was either significantly (44%) or slightly faster (26%) than had been the case in their previous R&I awards.

The nature of the UK R&I landscape played a substantial role in enabling a robust and timely response by public science and the realisation of wide-ranging and substantive social and economic impacts (Section 3.5), with significant contribution from UKRI. Almost all the individual awards looked at through the five case studies have benefitted from past investments by UKRI. Prior investments were directed to centres and consortia that have benefited from decades of strategic investment – by UKRI and others in the public, private and third sectors – in infrastructure, capacity, and international cooperation. The prior existence of various networks and world-class centres of excellence made a substantial contribution to the speed and quality of the work carried out which contributed to the uptake of early results by policymakers. The Oxford / Astra Zeneca vaccine is a good example: long-running strategic investments by UKRI, including in partnership with DHSC, provided the foundation for the development of one of the few effective vaccines that were rolled out globally (albeit UKRI played a more limited role in this development effort during the pandemic itself).

Furthermore, survey and interview data show that prior existing connections among researchers and users were a key common factor in enabling swift project starts and rapid progression towards meaningful outcomes. Interviewees noted that these past relationships enabled stronger collaborations, easier dissemination of findings, and successful implementation in a short period of time.

In addition to its funding (and the design of the response itself), UKRI also played a role in convening the community by catalysing partnerships, supporting strategic debate and other non-programmatic activity, and facilitating connections with SAGE and with policymakers more generally.

UKRI's COVID-19 response facilitated access to funding at speed, across multiple research areas (see Section 3.1). UKRI's objective (or 'mission') in relation to COVID-19 was (1) to fund research relevant to the stated, emerging and potential needs of government and other actors (e.g. public services, private enterprise) dealing with all aspects of COVID-19 and its wider implications; and (2) to produce impact or useable/actionable knowledge within the lifetime of short-to-medium term awards. To achieve this aim, UKRI sought to mobilise the UK research and innovation community, fund research across the disciplinary spectrum, and ensure fast translation of findings into policy and practice through strong networks/ strategic partnerships and ongoing dialogue/ collaboration with policymakers.

UKRI's COVID-19 response started in early 2020 and consisted of a variety of investments (as shown below). In total, UKRI's COVID-19 response funded 1,194 awards for a value of £501m (this includes 376 pre-existing UKRI awards worth more than £147m that were repurposed for the COVID-19 response). Thematically, awards addressed most aspects of the pandemic, from support for vaccines development through to studies to model the effects of policy measures and to understand the social consequences of lockdowns.

<p>Open calls: Launched to attract new ideas and teams to the challenge of COVID-19 using rapid streamlined processes (including UKRI Agile R&I Calls and UKRI/NIHR Rapid Response Initiative)</p>	<p>International calls: International efforts leveraging R&I partner efforts to address pandemic challenges. GCRF/Newton and FIC predated the pandemic</p>
<p>Platform and consortia studies: To support the national response at the very start of the pandemic (including COG-UK, RECOVERY, COVID-19 Therapeutics Advisory Panel (UK-CTAP), COVID-19 Immunology Consortium (CIC), Virus Watch, EAVE II, GenOMICC Consortium, GIDA and many others)</p>	<p>Operational and policy studies: The three adopted studies aligned with existing strategic objectives and COVID-19 investments made by UKRI (National Core Studies (NCS))</p>
<p>Dedicated calls: Research councils continue to accept COVID-19 related proposals through business-as-usual routes since the closure of the COVID-19 specific calls (including COVID-19 urgency grants (UKRI) and Long COVID Call)</p>	<p>Repurposed funding: UKRI 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.</p>

The major barriers to success were challenges caused by COVID-19 itself; in addition, administrative issues created some barriers to the achievement of outcomes and impacts (see Section 3.6). The first challenge related to delays in UKRI processes, specifically to delays in the pre-award process, leading to delayed award start (which was also identified and discussed in the process review of UKRI's COVID-19 response). Around 25% of surveyed awardees pointed to delays both between grant submission and award notification, and between award notification and the start of the award as major challenges to achieve intended results. UKRI processes were still running much faster than normal. However, given the time-critical nature of the research and short project durations, UKRI could consider mechanisms to minimise delays in a future response of similar nature. This may call for the need to design an on-system emergency response programme – with appropriate staffing arrangements – to cope with high levels of urgency over an extended period.

Administrative issues from other parts of the research system (e.g. restrictions on access to laboratories and test facilities within research-performing institutions, access to critical data including pricing of licences, bureaucratic approvals processes, restrictions on access, delayed releases) were named by survey respondents as moderately common and moderately severe barriers, typically leading to some delays to project start or during the early phases of projects. This suggests that further investments to support access to administrative data, with processes in place to facilitate access to sensitive information in special circumstances, could help to reduce this barrier in future crises.

Researchers suggested the benefits realised had been less than they might have been because of the short duration of awards. However, while the short timeframes have no doubt created challenges for researchers, we note that the nature of the COVID-19 pandemic meant that speed was of the essence, and short awards were an essential component to ensure a rapid response.

Lastly, interviewed science and innovation experts (including Chief Scientific Advisers) mentioned that they had to create or expand dedicated teams of internal specialists, in a short

period, to source the latest research findings or translate research data into information that was suitable to inform policy decisions. This highlights the need to keep on improving 'absorptive capacity' within government departments so they can make effective use of the insights emerging from the research community at a faster pace.

Assessing Value for Money for the UKRI COVID-19 response is a complex task, but a top-down approximation shows that the response represented value for money to taxpayers (see Section 3.7). It is an insurmountable challenge to calculate the impact of a portfolio of 800+ awards (excluding repurposed ones) and monetise it. Our evidence shows an impressive array of results supported by the ~£350m investment (excl. repurposed grants), several of which are of global significance. To give just one example, it is estimated that the use of dexamethasone to treat patients hospitalised with COVID-19 had saved around 22,000 lives in the UK and one million lives globally by March 2021. The clinical trial of dexamethasone was conducted by the RECOVERY trial, which was funded by UKRI and NIHR with a joint investment of £2.1 million. That equates to an investment of ~£2.1 to save each of those lives globally, with diminishing costs over time (as benefits have and will continue to accrue), although of course this estimate does not include historical investments.

Alongside life-saving research, UKRI-funded studies informed the speed and timing of various national and regional lockdowns, benefiting the country by saving lives that might otherwise have been lost and minimising harm to the economy through an earlier relaxation of restrictions. The earlier re-opening of schools was particularly important given the lost years of learning could negatively affect hundreds of thousands of students over the next 50-70 years. The impact of the faster reopening of the economy and schools is estimated to exceed £1.7 trillion (after accounting for the counterfactual), and if we claim just 1% of the economic benefits from those decisions link back to insights provided by UKRI research, this suggests the monetary impact could exceed £17bn. Even with an attribution of 0.1%, the resulting economic benefits of this cluster of UKRI funded projects could be around 5 times the total UKRI COVID-19 response investment.

This approach is not without its limitations; however, it reveals the substantial impact timely research can have on evidence-based policy decisions, notwithstanding the fact the negative effects of the lockdowns (also informed by research supported by UKRI) are yet to be determined.

Recommendations

Based on the evidence collected in this study, our headline recommendation is that the **UK government must support UKRI in its longstanding commitment to invest at scale in public research and innovation** as a means by which to ensure a healthy and diverse UK R&I system with the strength, breadth and connectivity to respond rapidly and effectively to any future global crises, whether that be the sudden shock of a new pandemic, a more broad-based and intractable crisis such as antimicrobial resistance or other crises (e.g. financial or environmental).

The barriers to impact identified above (and evidence collected in the process review of UKRI's COVID-19 response) also point to the need **to upgrade UKRI research information systems to allow an emergency response** programme to be launched on-system in days rather than weeks as is the case currently.

UKRI may also consider creating a permanent emergency response programme, with the capacity to launch several calls for proposals annually to deploy UK research – at speed and scale – to support national and international responses to other shocks or emergencies, such as the current geopolitical crisis centred on Ukraine. This would serve to provide additional



intelligence and ensure a greater readiness of both research funders and researchers, should the whole system need to pivot towards another major global emergency. UKRI may also consider funding network-mapping to improve system-level thinking, as well as research on how to facilitate knowledge mobilisation at speed, and training for researchers to further improve their ability to communicate complex research to policymakers (especially when they face the need to digest large volumes of evidence in a relatively short period of time).

Finally, we also recommend **UKRI continue its efforts to facilitate the sharing of clinical and other administrative data for future emergency-research**, and for UKRI to consider enhancing its efforts to connect stakeholders across academia, business, government and other users in strategically important areas.

1 Introduction

This report presents the findings of 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 by Digital Science) and was commissioned by UKRI. The study ran from January 2022 to August 2022. This main report is supported by an extensive technical annex document submitted alongside it, which contains the evidence materials on which this report is based.

This study complements the process review of UKRI's R&I funding response to COVID-19, conducted by Technopolis from June to October 2021 and available on UKRI's website.² Where relevant, we refer to findings from the process review.

1.1 Evaluation questions and objectives

This study has covered five main evaluation questions:

- What was the impact of R&I supported by UKRI and its main partners to respond to the COVID-19 pandemic? (see Sections [3.1](#)- [3.4](#))
- How successful was UKRI's R&I response to COVID-19, and was it value for money? (see Section [3.7](#) and Conclusions and Recommendations, Section [4.1](#))
- What were the key historical and real time drivers, barriers and enablers to impact of UKRI's R&I response to COVID-19? (see Sections [3.5](#) and [3.6](#))
- What are the key lessons for UKRI and, where applicable, the UK R&I system? (see Conclusions and Recommendations, Section [4.2](#))
- 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? (see Conclusions and Recommendations, Section [4.2](#))

1.2 Methodology: approach, caveats, and limitations

In this study, we followed a mixed-methods approach. Many considerations influenced the method design. However, it is informed above all by the fact that this evaluation needed to capture a broad range of impact types across many domains. This task required a range of quantitative and qualitative research components, so that we could draw overall conclusions about the breadth and scale of impact, while also detailing a range of different individual impacts in as much depth as possible.

Table 1 below provides an overview of data collection tasks and methods, while further information is provided in the technical annex document (as indicated in the table where relevant). Table 2 shows the extent to which each data collection and method component contributed to addressing each of the high-level evaluation questions.

² <https://www.ukri.org/news/independent-process-review-of-ukris-response-to-COVID-19/>

Table 1 Overview of data collection and methods

Data collection / Method	Description
Documentation review and analysis of monitoring data	<ul style="list-style-type: none"> • A review of the documents and data pertaining to UKRI's COVID-19 response, supplied by UKRI to the study team • Analysis of the monitoring and evaluation (M&E) surveys conducted by UKRI (including those in collaboration with NIHR) • Analysis of Gateway to Research and Researchfish data
Survey of lead investigators	<ul style="list-style-type: none"> • An online survey of Principal Investigators of awards funded as part of the UKRI COVID-19 response investments (N=692). It yielded 320 responses, equalling a response rate of 46.2% • The population included is smaller than the overall portfolio (818 grants, excluding repurposed grants) since it was agreed with UKRI not to survey those funded under the Africa Newton call (N=80 grants). Additionally, we surveyed 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 • The responses have a very good alignment with the distribution of the portfolio surveyed, both in terms of funding instrument/calls and lead Council • To avoid duplication of efforts, questions on 'outcome and impact' types were not collected from awardees from the Agile Call since they had already been captured via the UKRI's M&E survey. All other questions were put to all awardees • <i>Further information is provided in Appendix K</i>
Interviews	<ul style="list-style-type: none"> • Interviews with lead investigators of 27 awards funded as part of the UKRI COVID-19 response investments. They include at least 2-3 awards per lead Council, and for awards funded centrally by UKRI, and UKRI/NIHR • Interviews with 15 research and innovation experts. These include several current and former Chief Scientific Advisers to various UK government departments, members of the UKRI COVID-19 taskforce and representatives of various other organisations that made use of research-based evidence during the pandemic • <i>Further information is provided in Appendix L</i>
Bibliometric analysis (including of uptake)	<ul style="list-style-type: none"> • Bibliometric analysis (conducted by Digital Science using Dimensions) including benchmarking against comparable metrics for the UK and international comparators • The analysis also includes a citation analysis to showcase uptake of research outputs by the academic community, policy makers and wider society • To identify COVID-19 papers across a broad range of UKRI funded disciplines, the analysis adopted a keyword search strategy that maximises the chance of finding COVID-19 research papers. This approach does introduce some noise, 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>Further information is provided in Appendix I</i>
International review	<ul style="list-style-type: none"> • A review of six other international R&I funders' responses to COVID-19: the German Research Foundation (DFG), The Japan Science and Technology Agency (JST), The French National Research Agency (ANR), The National Research Council Canada (NRC), The Dutch Research Council (NWO), and the National Science Foundation (NSF, USA)
Case studies	<ul style="list-style-type: none"> • For the case studies, we focus on a dual approach. We developed: • Five in-depth case studies to explore in detail impact pathways, UKRI's role, and barriers and enabling factors. Each case study focuses on a theme of the COVID-19 response ('Responsive', 'Predictive', 'Transmission', 'Economic recovery' and 'Commercialising Healthcare Innovation'), and each takes 2-6 UKRI investments as its starting point and focus • 15 short case study fiches, each showcasing the impacts of individual UKRI awards made in response to COVID-19. This larger number of short cases allows a showcasing of the diversity of UKRI investments and the breadth of benefit types that have resulted from UKRI's strategy

Data collection / Method	Description
	<ul style="list-style-type: none"> Further information is provided in Appendix B-G
Value for Money assessment	<ul style="list-style-type: none"> A top-down approach to assessing the value for money of the responses, in monetary terms
Qualitative contribution analysis	<ul style="list-style-type: none"> A qualitative assessment of UKRI's COVID-19 contribution to the impacts emerging from the awards, taking into account prior investments and contribution from other funders and the research community

Table 2 Overview of method components and evaluation questions

	Documentation review and Analysis of monitoring data	Survey of lead investigators	Interviews	Bibliometric analysis (including uptake)	International review	Case studies	Value for Money assessment	Qualitative contribution analysis
What was the impact of the R&I supported by UKRI and its main partners to respond to the COVID-19 pandemic?	●●●	●●●	●●●	●●●	--	●●●	--	●●
How successful was UKRI's R&I response to COVID-19, and was it value for money?	●●	●●	●●●	●●	--	●●●	●●●	●●
What were the key historical and real time drivers, barriers and enablers to impact of UKRI's R&I response to COVID-19?	--	●●●	●●●	--	--	●●●	--	●
What are the key lessons for UKRI and, where applicable, the UK R&I system?	--	●●●	●●●	--	●		--	--
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?	--	●●	●●●	--	--	●●●	--	--

●●● "high extent", ●● "medium extent", ● "to some extent", -- "not applicable"

2 UKRI's COVID-19 response at a glance

2.1 Purpose and scope

UKRI's COVID-19 response sought to fund research **on COVID-19 and its wider implications**, i.e. both on the immediate medical pandemic response needs, as well as on the various knock-on effects of the pandemic, including socio-economic dimensions.

It also sought to fund research at speed **to help inform decisions made by government and other actors (e.g. public services, private enterprise) dealing with all aspects of COVID-19** and its wider implications. As such, funding was directed towards research that could produce **usable/actionable knowledge, data or products in the short term** (and within the lifetime of awards).

To achieve these goals, UKRI sought to **mobilise the UK research and innovation community** as rapidly as possible, i.e. to support the major known groups and institutes capable of delivering the immediate research and innovation needs of a pandemic response such as diagnostics, clinical trials and therapeutics, but also to enable individuals, groups and institutes across the entire research and innovation base to identify themselves and their ability to contribute research to the crisis at hand.

UKRI followed **a strong bottom-up ethos** (alongside some top-down components), in that the onus was to be on the research and innovation community to suggest and specify how best to respond to the needs and questions, how this could be done in the shortest possible timeframes, to independently form consortia, to draw on existing networks and opportunities to formulate robust impact pathways, and indeed to highlight potentially important questions and emerging issues not yet identified by central government.

Furthermore, funding was provided **across the disciplinary spectrum**, from medical disciplines to engineering and social sciences and the arts and humanities, as well as to multidisciplinary work, as relevant.

Finally, UKRI also sought to **communicate with central government** and other key actors to be able to fund research and innovation in response to their specified needs and questions.

2.2 The portfolio under scope

Starting in early 2020, UKRI's COVID-19 response consisted of a variety of investments. It included several large calls, notably the cross-council UKRI COVID-19 Agile Call, as well as the UKRI/NIHR Rapid Response launched at the very start of the pandemic. It also includes several large platform and consortia studies.

In total, UKRI's COVID-19 response funded 1,194 awards. This includes 818 new individual awards totalling £354m of UKRI funding. Around 70% of those new individual awards were made under the UKRI Agile R&I Calls.

Additionally, the response includes 376 pre-existing UKRI awards worth more than £147m that were repurposed for the COVID-19 response. These 'repurposed' awards are grants that were already in progress when the pandemic started but underwent a rapid scope change to pivot towards the pressing issues presented by COVID-19 and its consequences. The table below provides an overview of these investments. We describe them in more detail in Appendix A.

Beyond these awards, historical investments delivered by UKRI and its constituent parts, including centres of excellence, professional networks and research infrastructures, were also critical to various parts of the response, as we further discuss in sub-section 3.5.

Table 3 Investment sizes and award numbers

Programme	Total value	No. of awards
Open calls: Launched to attract new ideas and teams to the challenge of COVID-19 using rapid streamlined processes		
UKRI Agile R&I Calls (incl. Innovate UK)	£174.1m	568
UKRI/NIHR Rapid Response Initiative	Call 1&2: £25.5m (UKRI: £12.6m) Rolling call: £46.3m (UKRI: £23.4m)	80
International calls: International efforts leveraging R&I partner efforts to develop solutions to the pandemic. GCRF/Newton and FIC predated the pandemic		
GCRF/Newton Fund agile response call to address COVID-19	£10.7m (all UKRI)	40
Global Effort on COVID-19 (GECO) Health Research (UKRI/DHSC)	£12.0m (UKRI: £5.8m)	21
COVID-19 Africa Rapid Grant Fund	£3.8m (total initial funding including UKRI/ Newton Fund contribution)	80
Fund for International Collaboration (FIC) Strategic Opportunities Stream	MRC/ESRC with Department of Biotechnology (DBT) in India: £5m UKRI and the Japan Society for the Promotion Science (JSPS): £5m <u>Total: £10m</u>	14
Platform and consortia studies: To support the national response at the very start of the pandemic		
GenOMICC Consortium	£20m (UKRI: £3m)	1
COG-UK	£20.8m, funded in partnership with NIHR and Wellcome (UKRI: £6m)	1
RECOVERY	RECOVERY (Phase I): 2.1m (supported through the UKRI/NIHR rapid response initiative call 1) RECOVERY+: £18m (UKRI: £9m) <u>Total: £21m (UKRI: £10.5m)</u>	1
COVID-19 Therapeutics Advisory Panel (UK-CTAP)	£1m (all UKRI)	1
ACCORD	Information currently not available	1
Operational and policy studies: The three adopted studies aligned with existing strategic objectives and COVID-19 investments made by UKRI		
National Core Studies (NCS)	£37m (all UKRI)	3
Dedicated calls: Research councils continue to accept COVID-19 related proposals through business-as-usual routes since the closure of the COVID-19 specific calls.		
COVID-19 urgency grants (UKRI)	£1.9m (all UKRI)	17
Long COVID Call	£9.25m (UKRI), £9.25m (NIHR) <u>Total: £18.5m</u>	4
Repurposed funding	£147m* (all UKRI) [pre-existing investment]	376

Source: Based on UKRI awards data as at 07/02/2022, shared with us by UKRI. These figures include updates from those used in the process evaluation, see Kolarz et al (2021) Process evaluation of UKRI's R&I response. *Our updated awards data does not include financial value of most repurposed awards. The figure here is taken directly from the process evaluation and only accounts for 305 of the 376 awards.

3 Main findings

3.1 UKRI's COVID-19 response facilitated access to funding at speed, across multiple research areas

Originating in part from central government, UKRI's objective (or 'mission') in relation to COVID-19 was to fund research relevant to the stated, emerging and potential needs of government and other actors (e.g. public services, private enterprise) dealing with all aspects of COVID-19 and its wider implications, and to produce impact or useable/actionable knowledge within the lifetime of short-to-medium term awards.

To achieve this aim, UKRI sought to mobilise the UK research and innovation community, fund across the disciplinary spectrum, and ensure fast translation of findings into policy and practice through strong networks/ strategic partnerships and ongoing dialogue/ collaboration with policymakers.

The timeline of implementation was documented in our process review³ and is presented here again for completeness. In that study we show that UKRI's funding response to the COVID-19 crisis involved the following 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 the UK COVID-19 Therapeutics Advisory Panel, UK-CTAP, though the latter did not begin until summer of 2020)
 - Clinical studies (e.g. UKRI and NIHR funded clinical trials and GMP manufacture to aid the development of the Oxford/AstraZeneca vaccine; 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)
 - Surveillance and susceptibility genetics (e.g. the COVID-19 Genomics UK, COG-UK consortium and the Genomics England COVID-19 study on the Genetics of Mortality in Critical Care, GEL- GenOMICC)
 - Many other areas such as modelling (MRC GIDA), COVID-19 reagent supply (DST, Dundee), population health surveillance (EAVE II) and health data management (HDR UK)
- 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, listed above), and then a rolling call from March 2020 to July 2020. The projects were to be less than 18 months in length and provide data for or outputs to address the public impact of COVID-19
- 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

³ Kolarz et al (2021) Process evaluation of UKRI's R&I response. Technopolis on behalf of UKRI.

process managed by the nine UKRI Councils with oversight from a research and innovation Taskforce

- Calls for 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)
- UKRI also set up an accelerated process for changing the scope and objectives of existing UKRI-funded research projects (i.e. funded before the COVID-19 pandemic). This did not constitute any additional investment but allowed the usually lengthy process of mid-award scope-change to take place over just a few days or weeks. This enabled existing relevant funded work to become more directly suited to support the challenges presented by the pandemic
- HM Government commissioned six National Core Studies (NCS) to address priority operational and policy research questions. Three of these were adopted by UKRI, which funded and oversees them, as they aligned with existing strategic objectives and COVID-19 investments
- Since closure of the Agile Call (December 2020), the Research Councils continued to accept COVID-19 related proposals through business-as-usual routes, as well as through COVID-19 specific calls, notably a call on Long COVID and the fast-track COVID-19 Urgency Grants for time sensitive and exceptional COVID-19 proposals, including short projects with a timeline of just three months

Thematically, awards addressed many aspects of the pandemic, from vaccines to social consequences of lockdown. We looked at the distribution of grants across research areas based on information contained in Gateway to Research (GtR). Different classifications are used across Councils in GtR; Table 4 presents the distribution across Research Activity (used for grants that have MRC as the lead funder in GtR and including UKRI/NIHR awards) and across Research Subjects (used in GtR for all other Councils). Innovate UK grants are not tagged against research activity or subject. The use of both classifications results in an imperfect mix of research areas for this analysis but it also provides a good window into the variety of the UKRI's COVID-19 response portfolio.

Table 4 shows that around 25% of grants from MRC-led calls (including UKRI/NIHR awards) were focused on Biological and endogenous factors (which covers the identification and characterisation of endogenous factors known or suspected to be involved in the cause, risk or development of disease, conditions, or ill health). Around 16-17% of grants from calls led by other Councils focused on subjects such as Psychology, Sociology, Economics and Social Policy.

Table 4 Top 10 Research areas

Classification used in grants with MRC marked as lead in GtR (including UKRI/NIHR awards)			Classification used in grants with all other Councils marked as leads in GtR (excl. Innovate UK)		
Research Activity (based on HRCS)	Number of grants	% (of all grants: 181)	Research Subject	Number of grants	% (of all grants: 271)
Biological and endogenous factors	46	25.4%	Psychology	48	17.7%
Surveillance and distribution	24	13.2%	Sociology	46	16.9%
Psychological, social and economic factors	22	12.1%	Economics	44	16.2%

Classification used in grants with MRC marked as lead in GtR (including UKRI/NIHR awards)			Classification used in grants with all other Councils marked as leads in GtR (excl. Innovate UK)		
Vaccines	18	9.9%	Social Policy	41	14.0%
Factors relating to physical environment	17	9.4%	Medical & health interface	38	14.0%
Research design and methodologies (aetiology)	15	8.3%	Management & Business Studies	37	13.6%
Discovery and preclinical testing of markers and technologies	15	8.3%	RCUK Programmes*	37	13.6%
Management and decision making	15	8.3%	Education	20	7.3%
Resources and infrastructure (aetiology)	14	7.7%	Human Geography	19	7.0%
Organisation and delivery of services	14	7.7%	Law & legal studies	13	4.7%

Source: Technopolis based on Gateway to Research. The analysis is based on 452 grants that have information on Research Activity or Research Subject (incl. the percentage assigned to each area as reported in GtR). There are 183 grants missing this classification. Note that one grant can be classified in one or more research activity or area. *This classification is used for GCRF/NF Agile awards

Different disciplines, research areas and activities tend to have (and need) different budgets and resources, hence this distribution looks different when taking into account the value of the grants (see Table 5). Both tables reemphasise the point that UKRI's COVID-19 portfolio covered a wide range of topics.

Table 5 Top 10 Research areas (based on value of grants)

Classification used in grants with MRC as lead in GtR (including UKRI/NIHR awards)			Classification used in grants with all other Councils as leads in GtR (excl. Innovate UK)		
Research Activity (based on HRCS)	Number of grants	% (of total value of grants)	Research Subject	Number of grants	% (of total value of grants)
Biological and endogenous factors	46	25.4%	Civil engineering & Built environment	3	1.1%
Resources and infrastructure (aetiology)	14	7.7%	Material sciences	2	0.7%
Surveillance and distribution	24	13.2%	Process engineering	3	1.1%
Resources and infrastructure (health services)	7	3.9%	Mechanical engineering	1	0.4%
Resources and infrastructure (evaluation of treatments)	6	3.3%	Catalysis & surfaces	2	0.7%
Factors relating to physical environment	17	9.3%	Tools, technologies & methods	13	4.8%
Vaccines	18	9.9%	Medical & health interface	38	14.0%
Pharmaceuticals	10	5.5%	Mathematical sciences	3	1.11%
Discovery and preclinical testing of markers and technologies	15	8.3%	Chemical measurement	1	0.4%
Psychological social and economic factors	22	12.1%	Biomolecules & biochemistry	3	1.1%

Source: Technopolis based on Gateway to Research. The analysis is based on 452 grants that have information on Research Activity or Research Subject (incl. the percentage assigned to each area as reported in GtR). There are 183 grants missing this classification. Note that one grant can be classified in one or more research activity or area.

3.2 The response led to a high proportion of use-oriented outcomes, produced in a timely manner

Naturally, a key output emerging from the grants funded by the UKRI's COVID-19 response are publications. However, our evidence shows that awards prioritised stakeholder engagement/outreach and developed outputs and outcomes faster than during business-as-usual, which was an expectation set up in the design of UKRI's COVID-19 response.

3.2.1 *Outputs and outcomes geared towards supporting the COVID-19 response (beyond scientific publications)*

Around 90% of UKRI-funded awards produced at least one type of output geared towards supporting the response to COVID-19 or its consequences. We arrive at this estimate by looking at responses collected both via UKRI's M&E survey on the Agile Call awardees (see Figure 1) and via the Technopolis survey of awardees (non-Agile Call) (see Figure 2). Note that the Technopolis survey did not collect information on outputs and outcomes for Agile Call awardees to avoid duplication of efforts and to maximise the use of existing monitoring data.⁴ The Technopolis survey also asked respondents to clarify whether the outputs had been disseminated, and 41% reported that the outputs had been produced and disseminated.

Across these two sources of information, we find that the main outputs emerging from the awards were data, knowledge and understanding contributing towards managing/understanding COVID-19 and its consequences, in line with the main objectives of UKRI's COVID-19 response.

These results are reflected in responses provided via open question (i.e. unprompted). We asked all our survey respondents (including the Agile Call awardees) to specify briefly what they consider to be the single most important impact of their UKRI-funded work. Respondents were free to provide examples of outputs and outcomes. 244 of the 309 free-text responses are linked to criteria and elements from the Theory of Change for UKRI's COVID-19 response (see Appendix A). Furthermore, awardees tended far more often to highlight outputs and outcomes related to tackling the pandemic as most important rather than, for example, contributions to research fields, indicating that the aim of UKRI's COVID-19 response had been well understood by awardees. The most important outputs and outcomes noted via free-text answers were:

- Guidance provided to policy decision makers, government departments, key decision makers, local government, advisory groups, citation in speeches or reports and presentations at parliamentary hearings (25%)
- Contributions to management and treatment of COVID-19 as well as increased understanding of the virus (14%)
- Contributions to research, academic disciplines, or research processes in general (12%)
- Increased collaboration with outside partners (7%)
- Contribution to public or industry knowledge (4%)

Finally, 17% noted that they could not state an output or outcome, as either their research was still in progress, in the process of finalisation, the results were not yet in the public domain or

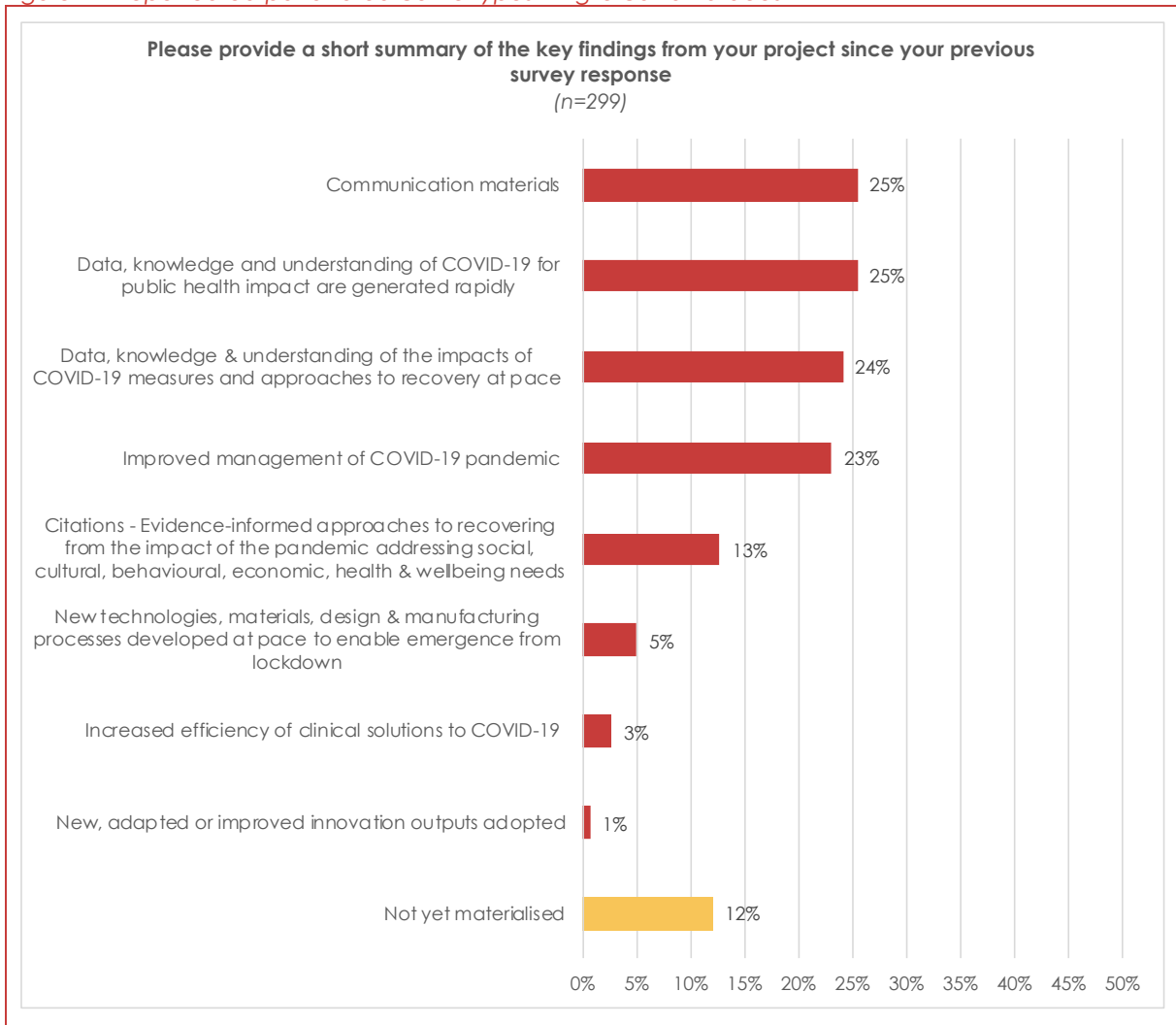
⁴ More specifically, around 87% of respondents to 'Agile Call' survey reported outcomes or impact in at least one of the categories surveyed for by UKRI (and listed in Figure 1). Similarly, 90% of respondents to the 'non-Agile Call' survey reported that they had achieved at least one of the outputs / outcomes types for which we surveyed (and listed in the first graph of Figure 2).

results had not yet materialised. The remaining 63 answers are diverse and could not readily be grouped into categories.

These output and outcome categories are very general: they help us understand how widespread relevant research results are across UKRI's COVID-19 response. More concrete examples are presented below (Sections 3.3 and 3.4) via case studies, which also provide evidence of uptake and impact.

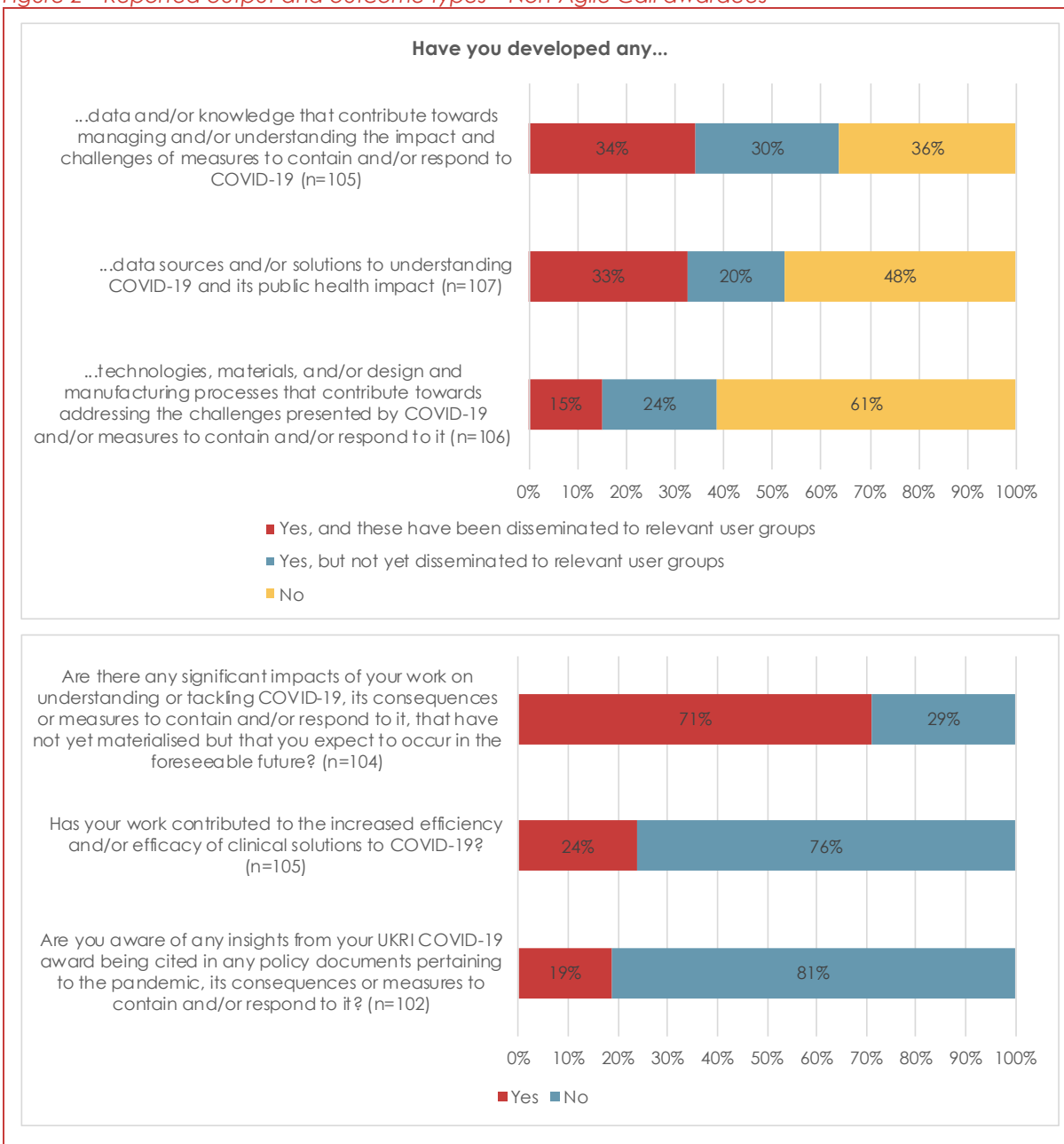
It is not possible to draw international comparisons to benchmark these results. The six international funders we reviewed have not yet completed comprehensive impact evaluations of their COVID-19 response funding measures. However, according to monitoring data and impact highlights reported by the funders, two main outcome and impact types prevail: contribution to scientific disciplines in the form of new knowledge, and general guidance to policymakers and policy influence (in line with the outcomes and impact types found in the case of UKRI).

Figure 1 Reported output and outcome types – Agile call awardees



Source: UKRI's M&E survey. Results correspond to the Round 4 of the survey, which included 300 awards. The question as for recent information ('since last report'), however, a manual check of responses to prior rounds revealed that researchers tend to provide similar responses towards the later rounds.

Figure 2 Reported output and outcome types – Non-Agile Call awardees



Source: Technopolis survey of UKRI COVID-19 Awardees (data above are for non-Agile Call awardees only)

3.2.2 Scientific production

Our bibliometric analysis shows that UKRI's COVID-19 response led to a substantial number of publications, many of them emerging at the outset of the pandemic, indicating rapid production of knowledge. The analysis also showcases the further contribution of UKRI (beyond the targeted response) as well as the proactiveness of the UK research community.

Linking information from Gateway to Research and Dimensions, we have identified a total of 1,867 COVID-19 publications (See Figure 3, “all UKRI COVID-19 response publications”).⁵ Note that in our approach, we have defined “COVID-19” publications in such a way that we can draw comparisons with similar publications emerging from activity funded by other organisations, nationally and internationally.⁶

We also find that there was a substantial number of publications emerging from grants funded by UKRI outside the portfolio identified as being part of the COVID-19 response (8,105 publications in total). This suggests that beyond UKRI’s targeted response, various other streams of UKRI-funded activity pivoted towards COVID-19 research.

Some of those publications correspond to activity funded via the repurposed awards (364 of which could not be matched in GtR due to changes in award reference codes). However, the volume of publications emerging from that group (again, 8,105 in total, excluding those linked to UKRI’s COVID-19 response) indicates that in practice the pivoting happened even beyond those repurposed awards. This indicates the further contribution of UKRI (beyond the targeted response) as well as the proactiveness of the UK research community.⁷ Overall, we found 9,972 publications that name UKRI as a funder (see Figure 3, ‘all UKRI funded COVID-19 publications’).⁸

Our analysis also reveals the role played by multiple funders. We find that 1,486 of the publications emerging from the UKRI COVID-19 response (80%) were co-funded by other UK funding organisations. The National Institute for Health Research (999 publications), Wellcome (910 publications), and the Department of Health and Social Care (which also funds NIHR) (399 publications) stand out as primary co-funders in terms of volume of publications. 61% of all publications that name the Health and Safety Executive as a funder also emerged from funding under UKRI’s COVID-19 response, though this is based on a low volume of publications (31 of 51). Similar results are found for The Nuffield Foundation (60 of 117), and Elrha (43 of 83).

In terms of non-UK funders, we find that 16% of publications also named a US funder and 16% named a funder based in Belgium (the latter mostly driven by the European Commission).

Finally, the analysis also shows that researchers in the UK were very active in producing ‘COVID-19 publications’, also mobilising other (non-UKRI) sources of funding (See Figure 3, “all UK-funded COVID-19 publications”). We find a total of 7,481 COVID-19 publications that named a

⁵ This includes articles, books, chapters of books, monographs, pre-prints, and proceedings.

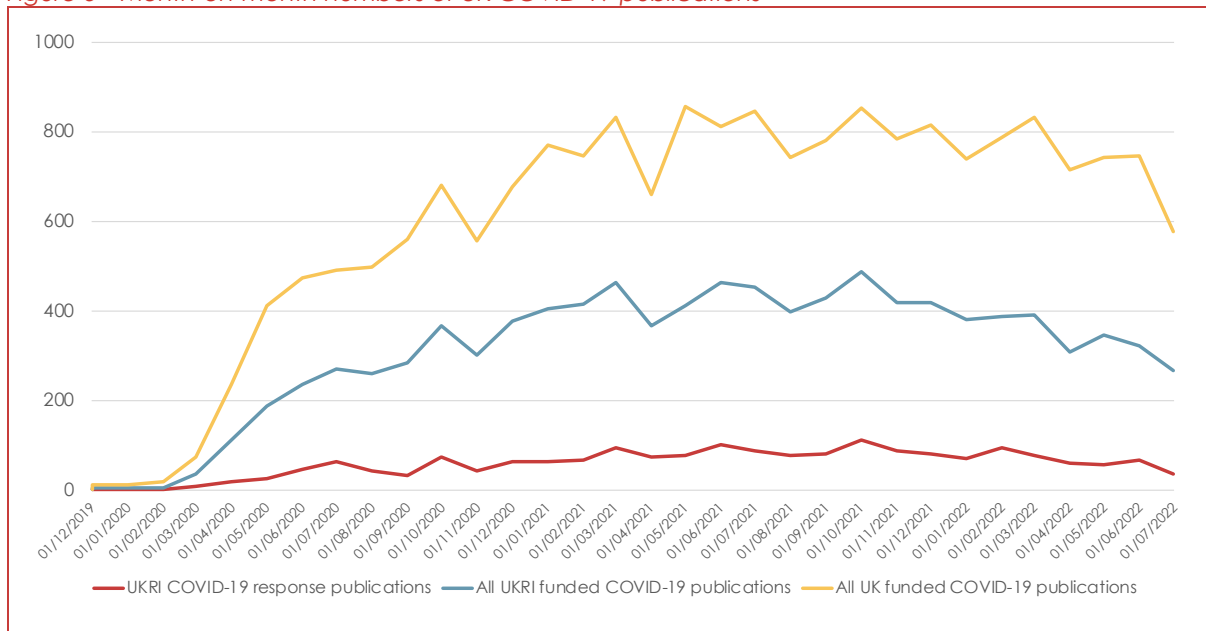
⁶ To identify COVID-19 we used a set of keywords with different ways to name the virus/disease (see Appendix I). During the analysis, a number of papers were identified associated with UKRI COVID-19 response awards that contained no language associated with COVID-19. These papers appear in the sample for a number of reasons. Firstly, a percentage of the UKRI COVID-19 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. As it is not possible to distinguish at an analysis level the reason a paper has been acknowledged, all acknowledged papers have been kept in the analysis.

⁷ In this analysis, we have opted for a wider approach, searching for related ‘COVID-19’ terms in the full text (rather than just the title and abstract). This may have led to some publications being included when they mention the key words in a tangential way (i.e. the fact that the fieldwork was conducted during the lockdowns). However, we have taken the view that a more restricted approach (e.g. only looking for those keywords on the abstract or title) could have led to a substantial amount of relevant publications being excluded. Any data driven approach may lead to some false positive and negatives, but a standard approach is needed to draw national and international comparisons. The key words used in the analysis are presented in Appendix I.

⁸ We note that UKRI-funded publications may be underestimated if not all researchers acknowledge the funder in their publications, although this is expected practice. Note that it is not possible to measure the number of papers without funders as there is a large amount of research - particularly hospital/clinical, that is not directly funded.

UK organisation as a funder but do not name UKRI. This means that overall UKRI contributed to 61% of the total COVID-19 publications emerging from funding provided in the UK, during the period of analysis (9,972 of 19,320 publications).

Figure 3 Month-on-month numbers of UK COVID-19 publications








All UK COVID-19 funded publications correspond to COVID-19 publications emerging from grants funded by any UK funder. All UKRI COVID-19 funded publications correspond to COVID-19 publications emerging from grants funded by UKRI (including those funded by the UKRI's COVID-19 response). Source: Digital Science (based on information from Gateway to Research and Dimensions).

From an international perspective, the UK stands out as focusing 10% of its research output on COVID-19 during the period of analysis (19,313 of 185,267 publications), showing a substantial 'pivot' and contribution towards the understanding of the disease and its consequences in comparison with international comparators. Below we show figures for the Top 10 countries by number of COVID-19 publications. Note that publications have been associated with a country based on the country of their associated funding organisation.

Table 6 Publications – international comparison (November 2019 – July 2022)















Country	All COVID-19 publications	All publications	COVID-19 publications as a % of total research output
United States	58,930	779,180	8%
China	34,271	1,166,088	3%
United Kingdom	19,313	185,267	10%
Belgium (incl. EC funding)	16,735	286,958	6%
Canada	7,837	110,143	7%







Country	All COVID-19 publications	All publications	COVID-19 publications as a % of total research output
Germany	7,021	 152,972	5%
Brazil	6,286	 117,782	5%
Spain	5,967	 91,257	7%
Japan	5,604	 169,434	3%
Australia	5,291	 78,951	7%

For this analysis, the Dimensions publication type has been restricted to type 'article'. Note that Belgium features prominently as the home of the European Union funding schemes. Publications totals are limited to those publications that have been associated with a funder in Dimensions. Source: Digital Science (based on information from Gateway to Research and Dimensions).

The bibliometric analysis also shows that the research output covers a variety of research activity areas. The top 3 areas (both of research funded via UKRI's COVID-19 response and UKRI more broadly) include biological and endogenous factors, factors relating to the physical environment, and pharmaceuticals (see Table 7). Many publications also relate to psychological, social and economic factors or primary prevention interventions to modify behaviours and promote well-being, but in smaller numbers.

Table 7 COVID-19 publications by HRCS Research Activity Codes







Research activity	All UKRI COVID-19 response publications	All UKRI COVID-19 publications	All UK-funded COVID-19 publications	UKRI COVID-19 response publications as a % of total UK-funded COVID-19 publications
Biological and endogenous factors	228	 1,201	 2,030	11%
Surveillance and distribution	226	 603	 929	24%
Vaccines	184	 443	 770	24%
Factors relating to the physical environment	158	 712	 1,078	15%
Pharmaceuticals	142	 617	 1,316	11%
Organisation and delivery of services	122	 456	 1,352	9%
Individual care needs	73	 371	 1,198	6%

Research activity	All UKRI COVID-19 response publications	All UKRI COVID-19 publications	All UK-funded COVID-19 publications	UKRI COVID-19 response publications as a % of total UK-funded COVID-19 publications
Evaluation of markers and technologies	60	 309	 643	9%
Discovery and pre-clinical testing of markers and technologies	59	 341	 617	10%
Normal biological development and functioning	23	 317	 512	4%

Given the long tail of research activities with small numbers of publications, the graph above only presents information for the areas where there were 100 publications or more for 'All UKRI COVID-19 publications'. Source: Digital Science (based on information from Gateway to Research and Dimensions).

Our analysis also reveals a high uptake of research funded by the UKRI COVID-19 response among the academic community, signalling its importance, relevance and/or quality. Publications produced by awards funded through the UKRI COVID-19 response received on average 69 citations per paper. This is 38 more citations than COVID-19 publications from other UKRI awards, and 44 more than the UK average for COVID-19 publications (see Table 8).

Table 8 Citations of COVID-19 publications in other publications (November 2019- July 2022)

Cohort	Publications	Total citations	Citations per paper
Within UKRI COVID-19 response	 1,866	 128,427	69
All UKRI COVID-19	 9,965	 307,730	31
All UK-funded COVID-19	 19,309	 485,664	25

Source: Digital Science (based on information from Gateway to Research and Dimensions). Figures differ slightly from the numbers cited above as this table only includes publications with citations.

Furthermore, international comparisons (at country level) show that the uptake of publications produced by awards funded through the UKRI COVID-19 response is higher in comparison with publications funded by other countries (see Table 9).

Overall, publications with UK funders appear among the most cited in the world. Note that the figures on publications and citations per publication are slightly different from the figures above since here the analysis is based on grants linked from the listed countries, while the figure above relates to the address of the author(s).

Table 9 Citations of COVID-19 publications in other publications – international comparison

Country	Publications	Citations per paper
United States	60,103	22
China	34,454	22
United Kingdom	21,116	29
Belgium	17,087	21
Canada	7,928	15
Germany	7,065	21
Brazil	6,325	11
Spain	5,816	14
Japan	5,627	15
Australia	5,376	18

Source: Digital Science (based on information from Gateway to Research and Dimensions). Figures differ slightly from the numbers cited above as this table only includes publications with citations. Time window is November 2019-July 2022 as above.

3.2.3 Speed of results

One of the main objectives of UKRI's COVID-19 response was to support projects that had the potential to deliver academic and non-academic outcomes at speed. This is arguably the main facet that sets apart COVID-19 response-funding from other 'types' of funding, and a critical theme throughout not only UKRI's response but that of other funders across the globe.

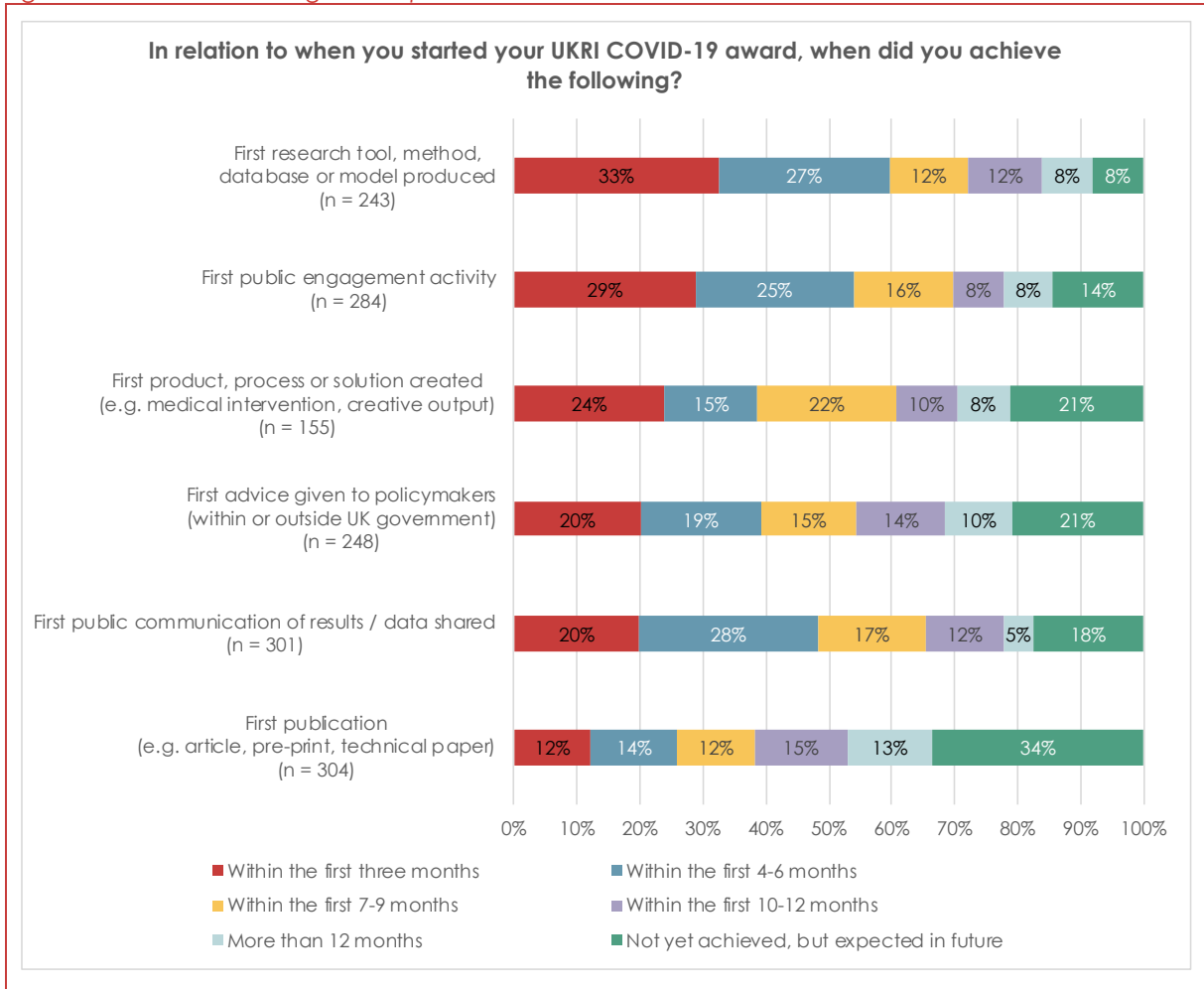
Speed in funding processes and expectations of awards to produce results soon was a strong feature of most international funders' responses. However, some funders, most notably Germany's DFG and Japan's JST (specifically its CREST programme), committed to their role of funding primarily basic research and supported projects with long time horizons and strong scientific impact focus. These funders have not collected evidence yet on how this strategy translated in terms of delivering health or other impacts.

We explored the issue of speed of production of outcomes within the UKRI-funded awards in response to COVID-19 via survey and found **significant evidence that awards prioritised user-oriented outputs, and that large shares of awards achieved their objectives faster than would normally be the case.**

We asked all respondents to select how quickly they were able to produce a range of outputs. Survey responses (n=311) show that awards were highly productive within the first few months of their lifetime (see Figure 4). 26% of respondents had produced a publication within the first

six months.⁹ Within the same time frame, respondents had produced a research tool, method, database or model (60%), and/or a product, process, or solution (39%). Furthermore, between 39% and 54% of respondents had disseminated results, including via a public engagement activity (54%), a public communication of results (48%), or advice given to policy makers (39%). These figures indicate that, beyond conducting the R&I work itself, awardees prioritised tasks around communication of findings to research users, and that outputs and activities aimed at practically addressing COVID-19 tended strongly to take precedence over academic publishing (see Appendix K for further details).

Figure 4 Time of achieving first outputs and outcomes



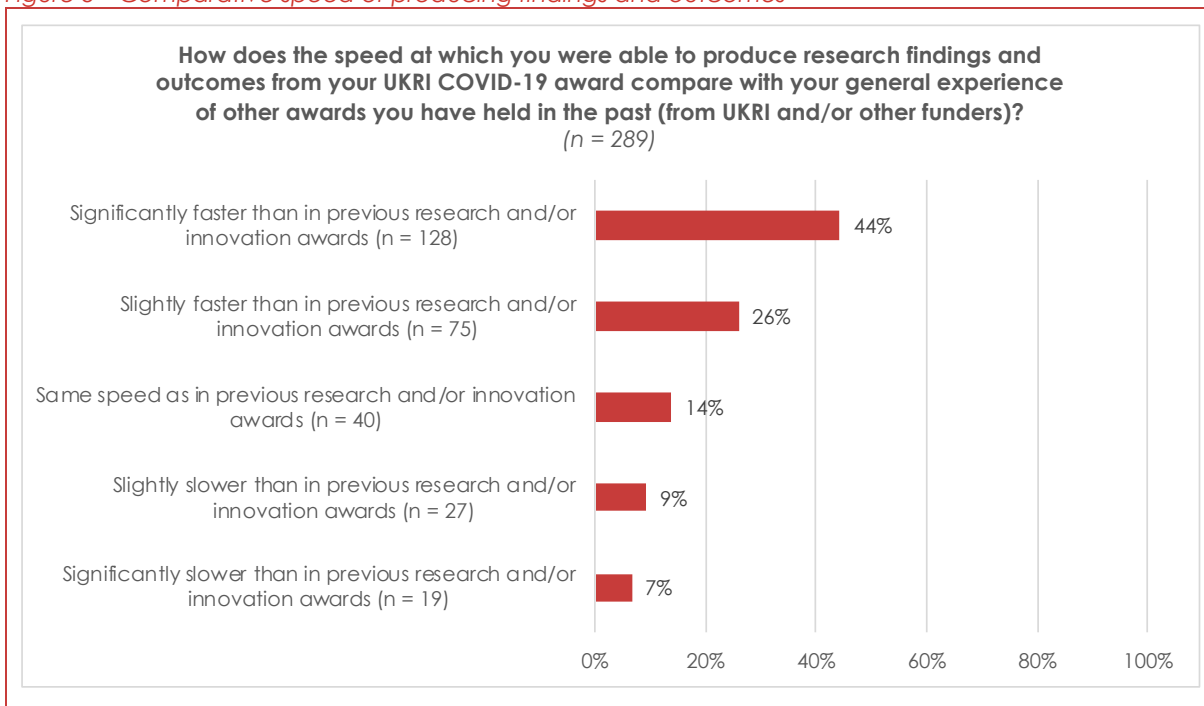
Source: Technopolis survey of UKRI COVID-19 Awardees. NB: The figures presented above exclude the 'Don't know / not applicable' option to aid visual comparability across output types, hence the lower and variable response numbers for each survey item.

⁹ Note that almost all respondents planned or anticipated to produce published academic outputs, but these generally mostly appear to have occurred in the latter stages of the awards, with only around a quarter reporting such outputs within 6 months of award start, and around a third reporting such outputs not to have occurred yet. The process of academic publication takes time and is in part beyond awardees' control.

To contextualise these overall reported speeds of productivity, we asked awardees how the speed at which they were able to produce results in UKRI COVID-19 response awards compared to their experience with previous awards (UKRI and non-UKRI). Note that there is no comparable dataset to benchmark speed of results with the UKRI portfolio. Consequently, we have relied on researchers' self-assessment of speed. In response, 70% of awardees reported that they did so either significantly (44%) or slightly faster (26%) than in previous R&I awards (see Figure 5).

Further analysis of survey responses shows that those funded under the UKRI/NIHR Rapid Response, as well as by Innovate UK and AHRC, most frequently report faster-than-usual achievement of research findings and outcomes.

Figure 5 Comparative speed of producing findings and outcomes



Source: Technopolis survey of UKRI COVID-19 Awardees. NB: The figure presented above excludes the 'Don't know / not applicable' option to (for instance from respondents who did not have prior R&I awards and therefore could not compare)

UKRI supported the achievement of these results by design. UKRI requested applications and funded awards that were expected to produce results in a relatively short period of time (up to 18 months for the Agile Call, 12-18 months for the UKRI/NIHR Rapid Response initiative, and 3-6 months for COVID-19 Urgency Grants). Projects were also expected to start reporting on results after 3 months from project start.

In our international review, many funders noted the importance of the 'signalling' function of funding awards with relatively short durations. They argued that the tight time-parameters of their awards combined with the evident urgency of the crisis at hand may have been critical in ensuring that awards progressed quickly.

While there were hindrances to speed (which we explore in Section 3.6 below), there is ample evidence of the positive effects and the importance of speedy award progression. Many of our case studies highlight this. For example, in our 'Predictive' case study (see Section 3.3 and

Appendix C) outputs were not only quickly generated but rapidly made available to government advisory groups, public health bodies, other researchers or in the public domain.

The rapid nature of this generation and availability of data and insights was also possible due to (i) the ability of 'pivoting' established centre staff, (ii) repurposing of existing platforms and building on prior research, and (iii) the existence of researcher links to government advisory groups and public health bodies, alongside the commitment and efforts of each of the research groups and the community more generally.

All these factors were essential to ensure the funded awards could inform a targeted vaccination strategy and provide input on lockdowns and the lifting of restrictions.

Moreover, our interviews with science and innovation experts (which included, among others, several UK government departments' Chief Scientific Advisers) highlight the importance of UKRI funding to achieve impacts at speed. When asked to imagine a counterfactual ('What would have happened if the UKRI-funded research had not been available?'), six experts (40% of interviewees) focused on speed and noted this would have led to delays at various stages of the research process and in the return to 'normal life'.

3.2.4 *Uptake beyond the academic community*

Our evidence also suggests that there was a high uptake of research outputs beyond the academic community. This was supported in the design of the response, with grant holders being required to share their research data and findings as rapidly and widely as possible, including with public health and research communities and the World Health Organisation. This was to be done in accordance with the statement on sharing research relevant to COVID-19.¹⁰ As shown above, between 39% and 54% of respondents had disseminated their results within the first six months of the lifetime of the award.

Our bibliometric analysis also shows that there was rapid and frequent citation of publications emerging from awards funded by UKRI's COVID-19 response in policy documents and the public domain in comparison with a pre-COVID-19 baseline.

Table 10 shows that the percentage of UKRI COVID-19 response publications cited in policy documents is considerably higher compared with UKRI-funded publications in prior years (published in the period 2017-July 2019). This further emphasises the relevance of the research emerging from the response (but also the need and demand for research insights in this area from policy makers during this period of time). Similar results are found when looking at Wikipedia mentions, which serves as a proxy for dissemination of knowledge for citizens more generally.¹¹

¹⁰ <https://wellcome.org/press-release/sharing-research-data-and-findings-relevant-novel-coronavirus-ncov-outbreak>

¹¹ 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 a 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.

Table 10 Policy documents and Wikipedia mentions in comparison with baseline

	% of UKRI COVID-19 response publications cited	Number of UKRI COVID-19 response Publications with policy mentions	Average days to citation	% UKRI publications cited (baseline)	Number of UKRI Publications with policy mentions (baseline)	Average days to citation (baseline)
Policy documents mentions	12.85%	327	77	0.22%	1,512	228

	% of UKRI COVID-19 response publications cited	Number of UKRI COVID-19 response Publications with Wikipedia mentions	Average days to citation	% UKRI publications cited (baseline)	Number of UKRI Publications with Wikipedia mentions (baseline)	Average days to citation (baseline)
Wikipedia mentions	6.76%	172	73	0.34%	2,618	201

The baseline corresponds to the period 2017-Jul 2019. Where available, date inserted into Dimensions was used as the date of publications as this is frequently earlier than the official date of publication. Where the publication date was earlier than the date inserted, the publication date was used instead where known. Publications with a date of 01-Jan-2017 were removed from the analysis, as 01-Jan is also used when the day and month is unknown, and publications were first inserted into Dimensions in Aug 2017. Source: Digital Science (using Gateway to Research and Dimensions).

3.3 The scale of UKRI investments and its focus on multiple, critical themes has underpinned wide-ranging and substantive impacts

Our five main in-depth case studies each focused on a prominent theme around addressing COVID-19: vaccines and treatments ('Responsive'), disease modelling ('Predictive'), understanding and preventing transmission ('Transmission'), protecting jobs and the economy ('Economic recovery'), and commercialising healthcare innovations ('Commercialisation').

Each of these thematic case studies highlights the substantial impact of UKRI-investments, often on highly prominent developments and policy decisions, including supporting the early development of the Oxford/AstraZeneca vaccine in partnership with NIHR, and informing decisions around the introduction and relaxation of national and regional lockdowns, and the Coronavirus Job Retention Scheme ('furlough').

Below we present a summary of each case followed by a series of boxes that summarise the main (quantifiable) outcomes and impacts,¹² as well as a description of UKRI's contribution to the awards and achievement of impact (taking into account the contribution from prior investments and other funders).

The 'Responsive' case study (see Appendix B for full details) covers two investments by UKRI, both made in partnership with NIHR, focused on developing treatments and candidate vaccines against COVID-19 to reduce the number of infections and deaths. These are the RECOVERY trial and the Oxford/AstraZeneca vaccine programme.


¹² Sources of all indicators highlighted below are provided in the full case study write-ups in the Annex report to this study.

The RECOVERY Trial was jointly funded between UKRI and the National Institute for Health Research (NIHR) for a total of £2.1 million in March 2020 (with an additional £19m provided later in 2020). The RECOVERY Trial was part of a global initiative (RECOVERY-international) which also included Wellcome, the Bill & Melinda Gates Foundation, and the Foreign, Commonwealth & Development Office. Further infrastructure support was provided by Health Data Research UK, the Medical Research Council's Population Health Research Unit, the NIHR Oxford Biomedical Research Centre and NIHR Clinical Trials Unit Support Funding as funders.

The RECOVERY trial has provided clinical treatment guidelines for hospitalised COVID-19 patients, which have been used and updated in multiple countries. Results demonstrated the benefits of dexamethasone and tocilizumab as well as a lack of effect of lopinavir/ritonavir, hydroxychloroquine, azithromycin, convalescent plasma, and colchicine. Guidance has been updated by the World Health Organisation, the UK NHS, the US National Institutes of Health, the European Medicines Agency, and many others, as a result of the RECOVERY trial.

The Oxford/AstraZeneca vaccine received £2.2m in March 2020 via the UKRI-NIHR Rapid Response call funding, which was jointly funded (50:50) by UKRI through the Medical Research Council (MRC), and the National Institute for Health Research (NIHR). The vaccine development built upon over 20 years of in-depth research, supported by UKRI and others, including DHSC. 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).

The Oxford/AstraZeneca vaccine was successfully tested and produced at speed. The vaccine was made accessible and affordable globally, not only due to the price but, uniquely, due to its temperature-tolerant design combined with high efficacy. The Oxford/AstraZeneca vaccine had the highest global reach of all vaccines, with a total of 178 countries having used it. As of January 2022, more than 2.5 billion out of 10 billion doses of the COVID-19 vaccine administered globally had been the Oxford/AstraZeneca vaccine.

 Case study 1: Responsive	
<p>Key Impact indicators</p> <ul style="list-style-type: none"> Figures published by the NHS for the RECOVERY trial in March 2021 confirmed that dexamethasone had saved the lives of around 22,000 patients in the UK and an estimated one million lives globally¹³ Baricitinib, an anti-inflammatory used to treat arthritis, showed a reduction of 13% of deaths compared to patients receiving the usual standard of care¹⁴ As of January 2022, more than 2.5 billion out of 10 billion doses of all brands of COVID-19 vaccines administered globally have been the Oxford/AstraZeneca vaccine¹⁵ 	<p>UKRI Level of contribution/notes</p> <p>UKRI, with NIHR, had a convening role in supporting the launch of the RECOVERY trial, moving it from China as initially proposed to the UK, and in facilitating data sharing, best practice, and results comparison.¹⁸ The support of UKRI and NIHR, including its extensive infrastructure investments, prior to and during the RECOVERY trial has proven to be instrumental in facilitating recruitment at</p>

¹³ NHS England » COVID treatment developed in the NHS saves a million lives. Accessed May 4, 2022. <https://www.england.nhs.uk/2021/03/covid-treatment-developed-in-the-nhs-saves-a-million-lives/>

¹⁴ Baricitinib reduces deaths in patients hospitalised with COVID-19 – UKRI. Accessed April 29, 2022. <https://www.ukri.org/news/baricitinib-reduces-deaths-in-patients-hospitalised-with-covid-19/>

¹⁵ AstraZeneca vaccine: Did nationalism spoil UK's "gift to the world"? - BBC News. Accessed May 3, 2022. <https://www.bbc.co.uk/news/health-60259302>

¹⁸ Gale E, Viney I, Samarasinghe B, et al. COVID-19 Response Interim Report Methods and Acknowledgements.; 2021.

<ul style="list-style-type: none"> • A first dose of the Oxford/AstraZeneca vaccine reduced the likelihood of hospitalisation by 94%¹⁶ • Two doses of the Oxford/AstraZeneca vaccine have been demonstrated to be very effective against hospitalisation (92% against Delta and 86% against Alpha variant)¹⁶ • 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 days after vaccination)¹⁷ 	<p>unprecedented speed. This has changed the landscape for clinical trials.</p> <p>The investments made by the UK government prior to the pandemic, including support from UKRI for vaccine developments over the past few decades, and the development by the UK Vaccines Network (DHSC, MRC and BBSRC) of vaccines against priority pathogens laid important groundwork for the response. In particular, in 2016 the UK Vaccines Network, with funding from DHSC and led by MRC, funded the development and testing by Professor Gilbert's team of a ChAdOx1 vectored MERS coronavirus spike vaccine in a Phase I trial. This was vital for the rapid development of the Oxford/AstraZeneca COVID-19 vaccine, as this earlier work had established the safety and effectiveness of the ChAdOx1 platform with a coronavirus spike antigen.</p>
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The **'Predictive' case study** (see Appendix C for full details) focused on seven awards¹⁹ in surveillance and disease modelling. Outputs from these awards included briefings to the Scientific Advisory Group for Emergencies (SAGE) and its subgroups and tools such as the COV-GLUE database of mutations and the CoV toolkit of plasmids proteins and antibodies.

Modelling and disease surveillance²⁰ research outputs influenced national decisions, including the decision to lockdown in March 2020, an age-prioritised vaccine rollout strategy, and the gradual timed removal of restrictions from the final lockdown. Specialised reagents for study of SARS-Cov-2, the CoV toolkit provided by the Division of Signal Transduction Therapy at Dundee University (funded by UKRI), have been distributed worldwide and have facilitated research into clinical pathologies, variants of concern and drug screening.

These achievements and the speed with which they were delivered were facilitated by world-leading expertise such as the MRC Centre for Virus Research, MRC Protein Phosphorylation Unit and research infrastructures such as the 'Cloud Infrastructure for Microbial Bioinformatics' (CLIMB). They were born of sustained and strategic prior investment by UKRI.

A key impact pathway for many of the awards in this case study was the uptake of both modelled and primary data into government decision making throughout the pandemic and the impact this had on health outcomes and other societal impacts. As such, policy makers and their decisions as well as the timing and quality of implementation of those decisions are key moderators of the impacts generated by these awards. Analysis undertaken into the relationships between the advice of SAGE and decision making suggests that (early in the

¹⁶ COVID-19 Vaccine AstraZeneca Real-World Evidence Summary. doi:10.1101/2021.05.14.21257218v1.full-text. https://www.astrazeneca.com/content/dam/az/covid-19/media/factsheets/COVID-19_Vaccine_AstraZeneca_Real-World_Evidence_Summary.pdf

¹⁷ Harris RJ, Hall JA, Zaidi A, Andrews NJ, Kevin Dunbar J, Dabrera G. Impact of vaccination on household transmission of SARS-COV-2 in England. :133-155.


¹⁹ COVID-19 Genomics UK Consortium (COG-UK), MRC Centre for Global Infectious Disease Analysis (GIDA), The MRC BioStatistics Unit (BSU), The MRC Centre for Virus Research (CVR), Joint UNiversities Pandemic and Epidemiological Research Center (JUNIPER), i-Sense (Agile Early Warning Sensing System for Infectious Disease and Antimicrobial Resistance) and EAVE II (Early Pandemic Evaluation and Enhanced Surveillance of COVID-19).

²⁰ Including from surveillance programmes such as MRC GIDA, COG-UK, MRC BSU, i-sense, JUNIPER and EAVEII

pandemic at least) policy decisions were largely in line with and connected to SAGE evidence and advice.

Awards in this case study were highly interlinked with each other, as well as with previous platforms and other ongoing projects, meaning that sustained prior investment by UKRI, particularly in centres and units, played a critical role in fast mobilisation of world leading expertise. Within centres and specific awards, much of the rapid identification of opportunities for repurposing previous work or redirection of staff time in centres came from the researchers themselves. Similarly, researchers supported impacts outside of the direct funding route via the use of their networks in facilitating key collaborations, using pre-existing links to key advisory groups and policy makers, industry, and private partners to promote uptake, sharing and 'in-kind' resourcing.

Impacts were also supported by the fast dissemination of data and sharing of early findings in an unprecedented way, both in getting data to policy makers, and informing data linkages that allowed different projects to interact and leverage each other.

 Case study 2: Predictive	
<p>Key Impact indicators</p> <ul style="list-style-type: none"> The decision to roll out an age targeted vaccine strategy is estimated to have halved the prospective COVID-19 deaths compared to random distribution strategy²¹ A gradual lifting of lockdown restrictions in early 2021 through three phases rather than a sudden lifting is estimated to have saved up to 100,000 lives and prevented 300,000 hospital admissions²² A four-week delay in step 4 of the roadmap to recovery (mid 2021) that determined the schedule of lifting restrictions in the UK is estimated to have reduced peak hospital admissions by 30%²³ 	<p>UKRI level of contribution/notes</p> <p>These are just a few specific examples at fixed points in the pandemic and not a cumulative impact. Each example uses the output of a model from UKRI-funded work that predicted what would happen in the event of (an) alternative decision(s).</p>
<ul style="list-style-type: none"> A seventy-fold increase in the genomic sequencing capacity among the four Public Health Bodies Tracking of viral transmission trajectories on a local and global scale 	<p>UKRI supported COG-UK, which provided knowledge transfer and training to the four public health agencies scaling up sequencing in the UK and then collaborated in a phased handover of a sustainable platform for genomic surveillance. Between pre-pandemic and April 2022, the Public Health Bodies, with the help of COG-UK transitioned from sequencing 50,000 genomes a year to up to 70,000 COVID-19 genomes a week.</p>

²¹ Moore S, Hill EM, Dyson L, Tildesley MJ, Keeling MJ. Modelling optimal vaccination strategy for SARS-CoV-2 in the UK. PLOS Computational Biology. 2021 May 6;17(5):e1008849

²² Whittles LK, Imai N, Knock ES, Perez-Guzman PN, Sonabend R, Ghani A, et al. "Unlocking" Roadmap Scenarios for England v2. :15.


²³ SPI-M-O: Summary of further modelling of easing restrictions – Roadmap Step 4 on 19 July 2021, 7 July 2021 [Internet]. GOV.UK. [cited 2022 May 16]. Available from: <https://www.gov.uk/government/publications/spi-m-o-summary-of-further-modelling-of-easing-restrictions-roadmap-step-4-on-19-july-2021-7-july-2021/spi-m-o-summary-of-further-modelling-of-easing-restrictions-roadmap-step-4-on-19-july-2021-7-july-2021>

The 'Transmission' case study (see Appendix D for full details) covers four UKRI-funded awards²⁴ 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 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 decision to buy CO₂ monitors for schools in England and provided guidance for the use of the monitors. UKRI-funded research and findings also contributed to decisions on reopening the events industry, allowing the industry to produce value and the employees to leave furlough. UKRI's coordinating role, combined with demand and support from other government departments and public bodies, facilitated the achievement of impact by supporting strong partnerships with research users.

The awards covered in the Transmission case study were significant in informing the decisions that led to the impact demonstrated above. Some decisions (e.g. modifications to buses, DfT decisions regulating the transport environment during the pandemic) and resulting impacts are almost fully attributable to the UKRI investments. In terms of research evidence, decision-makers relied almost solely on the evidence provided by the specific UKRI award holders (though other factors influencing decision-making may also have played a role).

Other decisions, especially the re-opening of the events industry, relied on a much broader evidence pool than the UKRI-funded research covered in this case study. In particular, 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 decision-makers. UKRI-funded awards contributed to the Events Research Programme efforts but were not the only source of evidence.

 Case study 3: Transmission	
<p>Key Impact indicators</p> <ul style="list-style-type: none"> • Safe Re-opening of the Events Industry with estimated value around £11.5bn per year²⁵ • Around 50,000 arts, entertainments and recreation sector furloughed employees returning to work²⁶ 	<p>Level of contribution/notes</p> <p>UKRI-funded awards were one of the several evidence sources for decisions that led to the impact.</p> <p>The data gathered through the Events Research Programme pilot events fed into advice on the safe re-opening of the events industry. The existence of the DCMS Events Research Programme and other groups contributing to the programme was a significant precondition to achieving the impact.</p>

²⁴ Risk of Transmission on London's transport vehicles (VIRAL), Transport Risk Assessment for COVID Knowledge (TRACK), COVID-19 Transmission Risk Assessment Case studies – education establishments (Co-Trace), Airborne Infection Reduction through Building Operation and Design for SARS-CoV-2 (AIRBODS).

²⁵ 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

²⁶ House of Commons Library (2021). Coronavirus Job Retention Scheme: statistics. Available: <https://researchbriefings.files.parliament.uk/documents/CBP-9152/CBP-9152.pdf>

<ul style="list-style-type: none"> UKRI funded research supported the Department for Transport and various transport operators' understanding of virus transmission on public transport and decisions regulating the environment²⁷ 1,200 London buses fitted with a new ventilation system decreasing the risk of exhaled air reaching the drivers' cabin by 97%; 55% of London bus drivers reported feeling improved safety²⁸ 	<p>Fully attributable to UKRI funded award (as documented in Appendix D and based on desk research and interviews).</p>
<ul style="list-style-type: none"> 353,000 CO₂ monitors delivered to all state-funded schools across England²⁹ 96% confirmed they were able to use the monitors to identify when ventilation in a room needed to increase³⁰ 	<p>These results are also highly attributable to UKRI funding. Findings on transmission, seasonal trends and calculations on adequate ventilation levels informed the decision to introduce CO₂ monitors and provided guidance on proper use (with the researchers involved working closely with DfE to inform those decisions). Other factors might have been relevant in the government decision.</p>

The **'Economic Recovery' case study** (see Appendix E for full details) shows that UKRI-funded research³¹ was relevant for evidence-informed introduction, design and understanding of the Coronavirus Job Retention Scheme (CJRS, '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. Previous 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.

The evidence produced by award holders is one of several data and information sources that supported policy making. Decision-makers and other users of research (e.g. Bank of England analysts) used several internal and external data sources and had informal consultations with multiple organisations or individuals providing relevant evidence. Several principal investigators consulted for this case study pointed out that this richness of multiple sources of evidence coming from researchers using different approaches (yet often arriving at similar conclusions) was important for policymakers and likely added credibility to decisions. Awards covered in

²⁷ Interview with the Department for Transport COVID-19 Science Cell representative and Chief Scientific Advisor.

²⁸ Malki-Epstein, 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


Institute of Health Equity (2021). Report of the second stage of a study of London bus driver mortality from COVID-19. Available: <https://www.instituteoftheequity.org/resources-reports/london-bus-drivers-review/london-bus-driver-review-phase-2-report.pdf>

²⁹ Department for Education (2022). CO₂ monitors evaluation survey and applications for DfE-funded air cleaning units. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1049310/CO2_monitors_evaluation_survey_and_applications_for_DfE-funded_air_cleaning_units.pdf

³⁰ Ibid.

³¹ Household panel study Understanding Society, Decision Maker Panel, Institute for Fiscal Studies award on modelling the effects of pandemic control measures and financial support on businesses, regions and households, National Institute of Economic and Social Research award on modelling the impact of COVID-19 on the UK economy, the University of Oxford award to analyse the impact of COVID-19 on economic inequality and employment progression and King' s College London award on gendering the UK's social policy response to the COVID-19 crisis.

this case study provided nuance, near real-time evidence and new knowledge crucial for policymakers (though full attribution is impossible).

 Case study 4: Economic recovery	
<p>Key Impact indicators</p> <ul style="list-style-type: none"> • CJRS supported 11.7m jobs and 1.3m employers³² • UKRI funded research informed monetary policy decisions such as interest rate cuts and increases in funding schemes and asset purchases by the Bank of England. The Bank of England used the Decision Maker Panel and Understanding Society survey data to inform the work of its Monetary Policy Committee and the Financial Policy Committee.³³ The Bank of England Monetary Policy Committee sets monetary policy to keep inflation low and stable. The Committee 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 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. Understanding Society and the Decision Maker Panel survey data fed into and justified the Monetary Policy Committee decisions on these tools.³⁴ It led to cheaper borrowing for households and businesses, encouraging companies to employ people and invest • Informing decisions on easing the first lockdown. The National Institute of Economic and Social Research developed sectoral modelling to show how shocks in one sector spill over to others and calculated the cost of stay-at-home measures which informed relaxing of some measures³⁵ 	<p>Level of contribution/notes</p> <p>Among other evidence, UKRI funded awards provided data to support the introduction, design and understanding of the CJRS. Researchers provided near real-time data on the economy, informed the change in the design of CJRS to make it flexible and provided the data on CJRS gendered effects.</p> <p>Among other evidence, UKRI-funded longitudinal society and business survey data provided evidence on market and society sentiments and helped to justify monetary policy decisions.</p> <p>Sectoral approach modelling formed part of the evidence base, which BEIS and Cabinet Office economists used to support decisions on reopening the economy after the first lockdown.</p>

The ‘Commercialising healthcare innovations’ case (see Appendix F for full details) covers five UKRI-funded awards³⁶ focused on improving healthcare delivery through the commercialisation of innovative products. UKRI funding has increased the UK’s medical capability to address COVID-19 and future pandemics by (i) enabling the development of

³² HM Revenue and Customs (2021). Coronavirus Job Retention Scheme statistics: 16 December 2021. Available: <https://www.gov.uk/government/statistics/coronavirus-job-retention-scheme-statistics-16-december-2021/coronavirus-job-retention-scheme-statistics-16-december-2021>

³³ Bank of England (2021). Monetary Policy Report, August 2021. Available: <https://www.bankofengland.co.uk/monetary-policy-report/2021/august-2021>

Bank of England (2021). Monetary Policy Report, November 2021. Available: <https://www.bankofengland.co.uk/monetary-policy-report/2021/november-2021>

Bank of England (2022). Monetary Policy Report, February 2022. Available: <https://www.bankofengland.co.uk/-/media/boe/files/monetary-policy-report/2022/february/monetary-policy-report-february-2022.pdf>

³⁴ Ibid.

³⁵ Interview with Dr Garry Young, National Institute of Economic and Social Research, Principal Investigator.

³⁶ 1. Multiplexed COVID-19 Flu-20 Antigen-Antibody Testing (COVIDFLU); 2. Miniaturised transport biosecurity system hardware that is 3D printed, next-generation, data-connected, machine learning with integrated biological configurability; 3. A new innovation in approaching vaccine programme administration and public engagement using accessible digital communication technology at-scale; 4. MedicCom – Overcoming the communication barriers caused by Personal Protective Equipment (PPE); 5. DIOS_CoVax – A vaccine designed to protect against COVID-19 and future Coronavirus epidemics, mitigating antibody enhanced disease.

diagnostic testing, and (ii) supporting the early clinical trial of the DIOS-CoVax vaccine which offers potential for broad protection against SARS-Cov2 variants and other Betacoronaviruses.


The funding will also enable the smooth management of healthcare services during future pandemics by supporting the development of Appt, an automated booking system for healthcare appointments and MedicCom, a device enabling clear communication whilst wearing PPE.

The innovative technologies described in this case study may have a wide range of applications in addressing other healthcare needs beyond COVID-19. However, as the commercialisation of innovative products is a lengthy process, the impacts of these awards will unfold over many years. Outputs recorded below therefore only provide an illustration of the 'direction of travel' (rather than an exhaustive account of the full impact).

Several awards were built on the back of prior UKRI funding which allowed them to progress quicker and deliver rapid results in response to the pandemic. As most of these innovations were supported from an early stage in their development, it is reasonable to believe that UKRI's contribution to the observed outputs is significant.

For instance, Appt-Health's booking system and BiologIC's bioprocessing unit were built using prior UKRI awards which helped to develop the technology that underpins more recent outputs created as part of their COVID-19 awards. Similarly, DIOSynVas's coronavirus vaccine technology was originally developed in a previous project administered by Innovate UK and funded by the Department of Health and Social Care (DHSC) as part of the UK Vaccine Network (UKVN). The additional COVID-19 funding that the company received from UKRI allowed them to swiftly apply the vaccine technology that they had been using in other areas into the coronavirus space. Since then, all three project leads have secured private sector funding to further develop their products, which is indirectly attributed to UKRI as the funding allowed them to demonstrate the projects' progress, develop the right skills and expertise, and increase their network and exposure.

One example of a project output that was initially supported by non-UKRI sources of funding is Attomarker's multiplexed COVID-19 antibody immunity test which received philanthropic donations raised through the University of Exeter. While UKRI's funding allowed the company to advance their technology and launch the test to market, full attribution is not possible as the test was already developed, tested, and MHRA-approved when the UKRI funding was awarded.

 Case study 5: Health Innovations	
Key Impact indicators <ul style="list-style-type: none"> • Appt's reach increased from 1 borough in London to 7 boroughs in England. Target is to reach 3,000 GP practices by the end of 2023³⁷ • Appt increases patient uptake of preventative healthcare by up to 40%³⁸ • Appt could save GP practices up to £1.22 per eligible patient³⁹ 	Level of contribution/notes UKRI funding supported the early development of Appt.

³⁷ Interview with Hector Smethurst, Founder/CEO of Appt-Health

³⁸ Appt-Health website, <https://www.appt-health.co.uk>


³⁹ Appt-Health website, <https://www.appt-health.co.uk>

<ul style="list-style-type: none"> Wearing PPE reduces speech comprehension by almost 40% in a simulated clinical environment. Tests of the MedicCom device have shown to improve speech clarity and comprehension whilst wearing PPE⁴⁰. 20 prototypes of the MedicCom communication device have been produced⁴¹ 	<p>UKRI funding supported the early development of the MedicCom device.</p>
<ul style="list-style-type: none"> Vaccinated several people with the DIOS-CoVax vaccine as part of the Phase I clinical trial. The results from the trial are expected in late 2022⁴² Developed a next-generation needle-free vaccine that aims to be more broadly protective against multiple viruses. (Note that between 3.5% and 10% of the UK adult population have some degree of needle phobia)⁴³ Developed a vaccine that doesn't require a 'cold-chain'. Around 3 billion people live in countries where temperature-controlled storage is insufficient for a vaccine that requires a 'cold-chain'⁴⁴ 	<p>The vaccine was originally identified in a project administered by UKRI and funded by the Department of Health and Social Care (DHSC)</p>

3.4 There are ample further examples of impact across a wide range of social, economic and policy areas


Beyond the selected awards in the five headline areas above, our research has found ample further examples of impact on a wide range of issues related to tackling COVID-19 and its consequences. They illustrate the breadth of areas where UKRI investments made a difference. We present below just a small selection of examples from our 15 case study fiches (see Appendix G).

Figure 6 Impacts of selected awards at a glance



Use of wastewater analysis to evaluate the incidence of coronavirus (SARS-CoV-2) in the UK population (UKRI COVID-19 Urgent Grant)

Impact: 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 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.



ISARIC - Coronavirus Clinical Characterisation Consortium (ISARIC-4C) (UKRI/NIHR COVID-19 Rapid Response Call 1)

Impact: 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. Researchers have been able to recruit over 300,000 patients, and have identified key risk factors of disease severity, revealed the impact of comorbidities and socio-economic effects in explaining susceptibility in some ethnic groups, supporting and deepening findings from various other awards made as part of the Rapid Response calls. 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

⁴⁰ 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>

⁴¹ Interview with representatives from Project Pitlane

⁴² Interview with Rebecca Kinsley, Chief Operating Officer at DIOSynVax

⁴³ Injection Phobia, <https://www.anxietyuk.org.uk/anxiety-type/injection-phobia/>

⁴⁴ Vaccine storage issue could leave 3B people without access, October 2020, <https://apnews.com/article/virus-outbreak-pandemics-immunizations-epidemics-united-nations-fc4c536d62c5ef25152884adb1c14168>

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.



Responding to the COVID-19 domestic abuse crisis: developing a rapid police evidence base (COVID-19 Agile Call)

Impact: This award collaborated with 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 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 research was also 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.



Barcoding Galápagos: Recording and mitigating COVID-19 impacts using key-workers in eco-tourism (GCRF Agile COVID-19 Rapid Response (UKRI/GCRF))

Impact: 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 conducted the sampling and testing, supporting the recovery of the local economy when it was needed most.



Ensuring Respect for Human Rights in Locked-Down Care Homes (COVID-19 Agile Call)

Impact: 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 a 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. The webinars served both as a training opportunity for frontline workers and as a data-gathering exercise to use in informing policy development. 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.



REACT Long COVID (REACT-LC) (NIHR/UKRI LONG COVID)

Impact: 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.

3.5 The nature of the UK R&I landscape played a substantial role in enabling impact

3.5.1 The UK R&I landscape

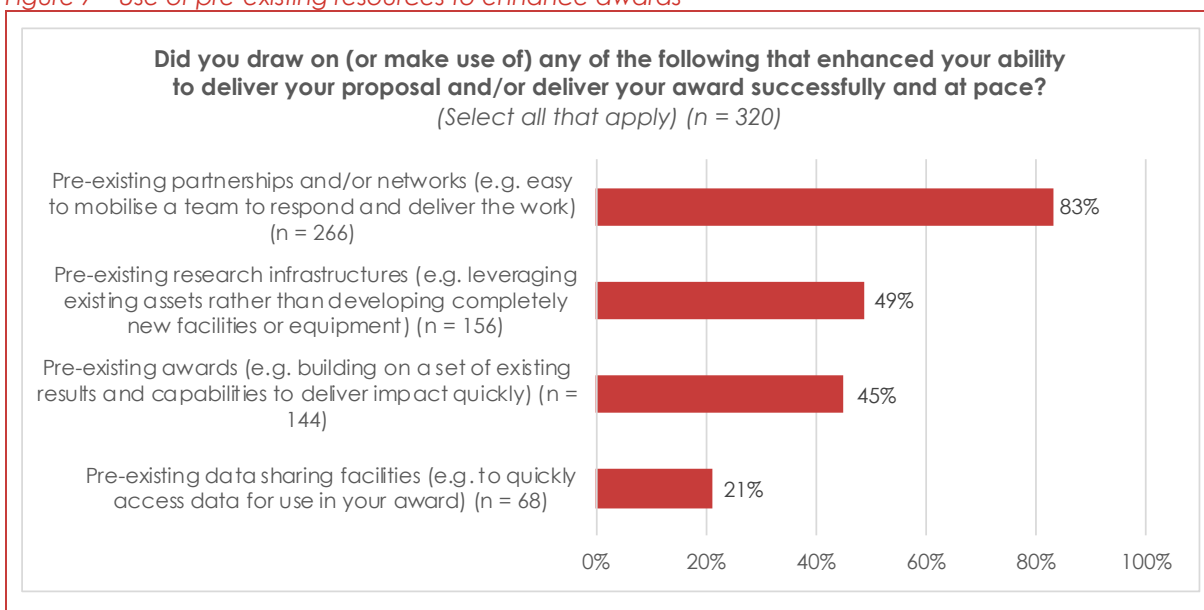
In terms of enabling factors, our headline conclusion is a systemic one. Our evaluation encountered an R&I landscape with (i) many world-leading institutions and centres in a range of fields able to pivot to tackling a crisis such as the pandemic and its consequences, (ii) sustained investment in many facilities and infrastructures critical to various parts of the pandemic response, and (iii) an active and highly motivated researcher base well-connected

internally as well as to potential research users. This is the result of sustained public investment in R&I, which has remained stable over many years preceding COVID-19.⁴⁵

Our evidence shows the nature of the UK's R&I system (its size, breadth, and quality) played a fundamental role in enabling impact, with strong contribution from UKRI to this state of affairs.

Furthermore, our evidence (collected via survey and interviews) also shows that prior existing connections among researchers and users were a key common factor in enabling swift project starts, and rapid progression towards meaningful outcomes. Just under half of interviewees stated that pre-existing relationships were the strongest enabling factor in their work achieving its intended impact.⁴⁶ Interviewees noted that these relationships enabled close and increased collaborations, easier dissemination of findings and their project to 'get going' more generally.

Figure 7 Use of pre-existing resources to enhance awards



Source: Technopolis survey of UKRI COVID-19 Awardees.

Almost all the individual awards looked at through our case studies have benefitted from past investments by UKRI. Many of them were directed to centres and consortia that have benefited from decades of strategic investment – by UKRI and others in the public, private and third sectors – in infrastructure, capacity, and international cooperation. For example, ISARIC 4C (Coronavirus Clinical Characterisation Consortium, Short Case 8 in Appendix G) was able to pivot so quickly to COVID-19 because ISARIC had more than nine years of experience as a consortium (funded by UKRI/NIHR) with severe acute respiratory infections and was preparing for such an outbreak. The University of Dundee COVID-19 toolkit provided relevant reagents to researchers for COVID-19 research. The Diamond Light Source's work in supporting and hosting over 60 COVID-19 related projects (Short Case 3 in Appendix G) was possible thanks to years of investments made by UKRI and Wellcome. This funding equipped Diamond with world

⁴⁵ According to the ONS, in constant prices (adjusted for inflation), civil net expenditure on R&D and knowledge transfer activities (excluding EU R&D budget contributions) increased by 25.1% over the long term, from £9.1 billion in 2008 to £11.4 billion in 2019.

⁴⁶ This factor was the most commonly reported across UKRI, with the exception of BBSRC and MRC, whose awardees reported research infrastructures more often.

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. The Oxford / Astra Zeneca vaccine is also a good example of where long-run strategic investments by UKRI provided the foundation for the development of one of the few effective vaccines that have been rolled out globally (albeit UKRI played a more limited role in this development effort during the pandemic itself).

The rapid engagement with the wider research community, practitioners and policymakers were the most common pathways to impact identified across our 15 short case studies. 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.

The dissemination of results was embedded in project plans. Information from the UKRI's Rapid Response survey shows that, by January 2022, 75% of awards had mechanisms in place to feed the research results into policy decisions. Furthermore, 58% had mechanisms in place to feed the research results into clinical decisions.

This was echoed in our interviews with R&I experts, most of whom mentioned that pre-pandemic investments and relationships resulted in the infrastructure which enabled the fast pivoting of experts and resources towards addressing COVID-19.

3.5.2 UKRI's role

UKRI's enabling and convening role can be separated into two components: (i) activities undertaken during the COVID-19 emergency, and (ii) activities undertaken in the years prior to it (as documented above).

Aside from playing its part in ensuring that a broad and healthy R&I landscape was in place at the onset of the COVID-19 crisis, UKRI also had substantial convening power once the pandemic occurred. This includes first and foremost its role in designing 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.

Additionally, we have explored the role of UKRI in terms of convening the community by facilitating partnerships, supporting non-programmatic activity, and facilitating connections with policymakers.

Convening the community by facilitating partnerships: UKRI awards were allocated to portfolio managers who were able to connect similar awards. Overall, 39% of respondents to the Technopolis survey report some form of support from UKRI beyond receiving guidance at the application stage (i.e. they selected at least one of the other forms of support listed in Figure 8 below). Specifically, around a quarter report that UKRI staff or representatives connected them to other researchers working on related topics, while around 20% reported UKRI staff or representatives connecting them to research users. This is arguably a high figure considering the size of the portfolio, and time and resources available. (As our process review pointed out,

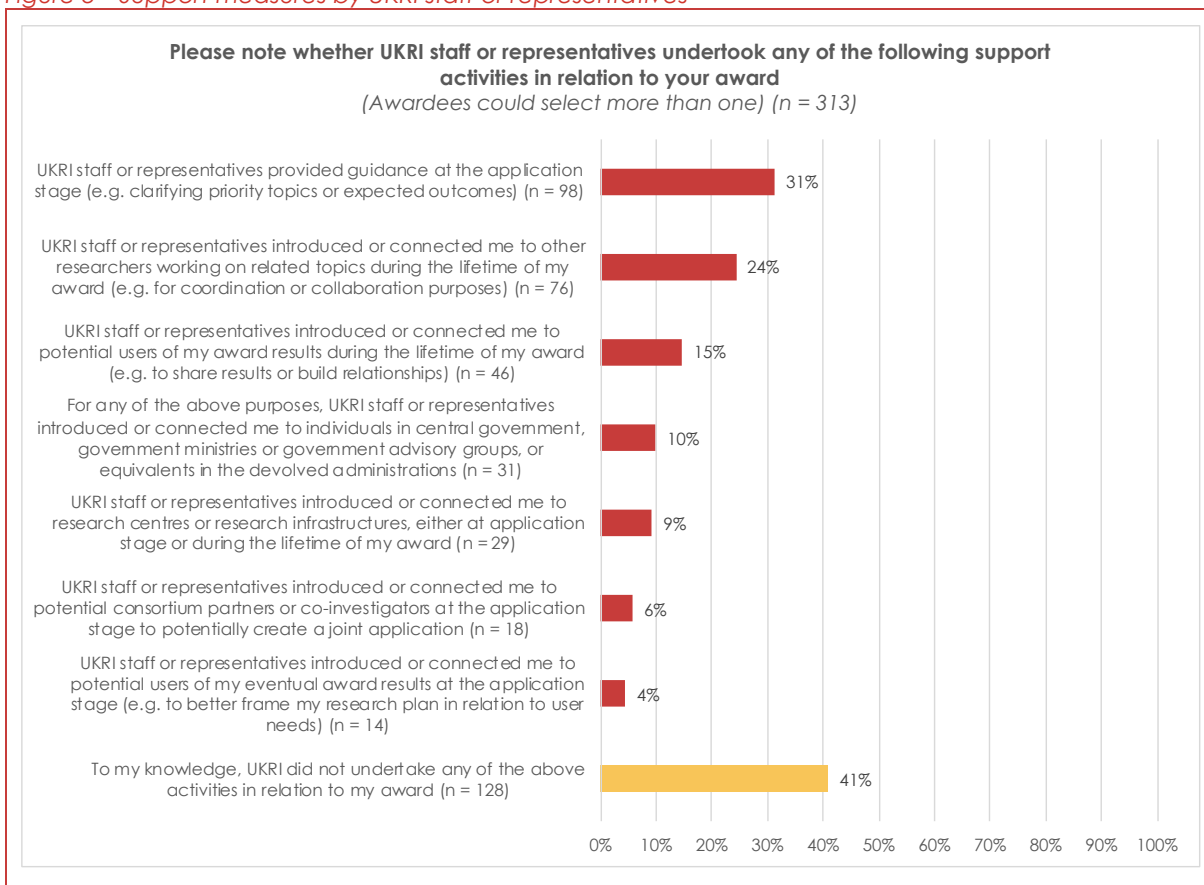
UKRI staff were working flat-out during the COVID-19 response, with many mentioning burnout and exhaustion. It is unlikely therefore that UKRI would have had the resources to provide more widespread support and convening than was already the case).

We also find evidence of this convening role via case studies, most notably in the large consortia and platform studies set up in the early stages of the pandemic (see for example our 'Responsive' and 'Predictive' case studies).

In contrast, most international funders we reviewed engaged in very little convening work across their funding portfolios, typically only focussing such efforts on a few select awards (typically the larger ones).

From this perspective, UKRI's convening efforts to support pathways to impact may not have covered the entire portfolio of awards but appears to have been more extensive than equivalent efforts by many other comparable funders abroad.

Figure 8 Support measures by UKRI staff or representatives



Source: Technopolis survey of UKRI COVID-19 Awardees. NB: We opted for 'staff or representatives' to ensure this would include, for example, members of the various COVID-19 governance committees and other acting in a UKRI-related capacity, but who awardees would not necessarily have considered as UKRI staff

Supporting non-programmatic activity: As part of its COVID-19 response, UKRI participated in a series of COVID-19 taskforces and working groups (this was covered in our process review). In this report we documented that the first part of the COVID-19 response was largely led by UKRI's regular governance structures, with MRC leading much of the funding work, and through interaction between SAGE and UKRI/MRC. For the Agile Call, a cross-UKRI Coordination Group

was set up as the central part of the COVID-19 response governance, aided by an advisory expert Taskforce and a Working Group focussing on the operational and administrative aspects of the response. UKRI COVID-19 governance arrangements worked well, especially in terms of facilitating cross-council work through the establishment of a central Coordination Group with substantial decision-making power. The overall leadership of the UKRI Chief Executive, and especially of the Coordination Group chair, was widely praised. Consultees for the process review often noted that cross-council collaboration worked exceptionally well compared with previous endeavours.⁴⁷

Connection to SAGE and policymakers more generally and knowledge mobilisation: As documented in the process review, a further important aspect of the governance was its ability to ensure communication between UKRI and central government (and with other actors involved in addressing the COVID-19 pandemic and associated issues). The interface with government occurred largely through Sir Mark Walport's position in SAGE, and later also through Prof. Charlotte Deane, once she was also included on SAGE part-way through 2020. Additionally, several other senior individuals at UKRI also had contacts and communication with various parts of central government, including SAGE, the CSA network and other ministries and agencies. Furthermore, ministerial scientific advisers, representatives of the devolved administrations, and GO-Science were represented on the COVID-19 Taskforce (as observers rather than members). There were therefore multiple lines of communication that could inform UKRI's Coordination Group on government research-needs.

There were also further efforts put in place to connect with policymakers. Some Councils, for example ESRC, were able to support direct engagement with policy makers through the establishment of an 'Actionable Insights' seminar series with government drawing on the emerging evidence to provide actionable insights to policymakers and the analyst professions across government. This series reached 15 ministerial departments, nine non-ministerial departments, 33 agencies and public bodies and devolved administrations with a total of 2,500 attendees over 13 webinars.

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 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 and lessons for UKRI in their efforts to synthesise information and make the findings of COVID-19 research publicly available. However, like UKRI, other international funders struggled with making time and resources available, among other responsibilities, to engage in as much convening work as might be desirable to maximise the impact of the research. Furthermore, some international funders largely perceive that it is primarily the researcher's responsibility to ensure the use of their findings.

In our consultation with R&I experts, we enquired about their expectations around UKRI's role in the research response: the most common expectations of UKRI were to coordinate a holistic response rapidly (8/14 interviewees, 57%), to mobilise funds or experts effectively (7/14, 50%)

⁴⁷ <https://www.ukri.org/news/independent-process-review-of-ukris-response-to-COVID-19/>

and to be able to make decisions and prioritise needs correctly (e.g. focus on needs-based research over blue-skies research) (7/14, 50%). Overall, interviewees expressed that their expectations were met. Six interviewees reported explicitly that their expectations were either met or exceeded (42%), while one consultee reported feeling disappointed (6%). The most common justification for satisfaction was the perceived speed at which decisions were made, funding was awarded, and large projects were off the ground (50%). Other positive comments concerned successful joint work with NIHR (33%).

It has not been possible to test whether more active 'convening' and knowledge mobilisation efforts would have led to higher impact (which would have required comparing results among those awards that benefited from the support and those that did not), but from a Theory of Change perspective, it is plausible that the actions listed above contributed to facilitating impact.

Looking towards the possibility of learning lessons, we asked Technopolis survey respondents in an open question format whether, with hindsight, there is anything that UKRI could have done differently to enhance their award and optimise its ability to address the challenges presented by COVID-19 and its consequences.

Of 238 respondents to this question, 49 (21%) mentioned general support or facilitative action. This included additional support with ethical approvals or technology exploitation, but also with making introductions, connecting to policymakers, facilities or relevant networks. A few reported wishing that UKRI organised networking or training events during the lifetime of awards. Given the evidence that UKRI were indeed active in facilitating those connections, this shows an appetite from the research community to see this happening in future similar responses. A balance of resources is needed and a focus on those awards that are more likely to deliver greater impact appears to be a reasonable strategy in this and other similar responses.

Other things to consider (even if coming from a small number of researchers) include:

- 39 awardees (16%) said UKRI could have allowed more flexibility in award timelines, noting that 12-18 months (UKRI/NIHR Rapid Response) 18 months (Agile Call) may not always have been sufficient, and some commented on ideally needing follow-on funding or an extension to award timelines. (However, it is also worth noting that in some cases, like in the Rapid Response Initiative, requests for further funding and extensions were assessed and provided as deemed valuable)
- 40 awardees (17%) commented on delays, especially between application submission and notification of the award, and between the notification and sending an official letter in which the total funding was confirmed. Some researchers commented on long response times to basic queries such as about deadline extensions
- 27 awardees: (11%) noted UKRI might increase clarity – some awardees reported a lack of clarity with, or full understanding of the review processes, application criteria or conditions for extension. Some respondents also indicated that they were not aware of what kind of convening support UKRI might have been able to offer

3.6 Beyond the challenges imposed by COVID-19 itself, administrative issues created some barriers to the achievement of outcomes and impacts

Our triangulation of evidence – emerging from our survey of awardees, UKRI's own M&E surveys, our interviews and case studies – reveals a series of barriers and challenges to awards' ability to achieve outcomes and impacts.

As expected, one of the main barriers emerged from the conditions imposed by COVID-19 itself (and the public response to it), including lockdowns and staff shortages. Around three quarters of our survey respondents identify national COVID-19 restrictions as a barrier to achieving outcomes and impacts. Further comments provided via survey and captured via the short case studies note that COVID-19 restrictions hindered some research staff in performing experiments, but also affected staff recruitment, retention and led to some isolation (see e.g. Short Case 15). UKRI's Agile Call survey also found that a high proportion of awardees encountered challenges around staffing (49%).

Aside from UKRI's efforts to support and stabilise the R&I system (these activities were separate from the R&I funding response and beyond the scope of this evaluation), these barriers are firmly beyond the control of UKRI and are unlikely to provide fruitful ground for recommendations or 'lessons learnt' in this evaluation.⁴⁸

Beyond these testing conditions, we have identified three main barriers that limited impact to some extent. The first challenge relates to delays in UKRI processes, specifically to **delays in the pre-award process, leading to a delayed award start** (which was also identified and discussed in the process review of UKRI's COVID-19 response). Around 25% of respondents to the Technopolis survey (78 out of 306, including Agile Call awardees) pointed to the time elapsed between both grant submission and award notification, and award notification and the start of the award, as major barriers to achieving outcomes and impact, and a further 34% noted that these were minor barriers. Consistent with this, half of the 27 award holders consulted via interview also stated that they faced issues with application and funding delays. Interviewees mentioned long delays between application and receiving funding.

The process review discussed the possibility of faster, simplified application review processes. However, it also highlighted the lack of resources and consequently high level of necessary effort from UKRI staff and reviewers (from the academic and user communities) to avoid delay as much as possible, and also noted that these delays were partly attributable to HM Treasury's reviewing of a business case to reallocate UKRI's existing budget to the COVID-19 response.⁴⁹

⁴⁸ Some international funders pointed to significant challenges the research community faced because of the pandemic. Some of them (DFG in Germany and NSF in the USA) will conduct evaluations to look into the effect of the pandemic and rapid research funding on the research workforce. The evaluations will analyse the participation of different groups in the portfolio of COVID-19 response research programmes and examine whether and how the pandemic response funding measures contributed to the negative effects and how the funders can alter those in the future.

⁴⁹ Note also that three funders (France's ANR, Canada's NRC, the Dutch NWO) of our international review were able to accelerate their response by bypassing 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). Given the urgency associated with the pandemic, consulted funders concluded that bypassing peer review was the right approach. The funders could rapidly select high-quality research that delivered impact. 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.

Researchers also suggested the benefits realised had been less than they might have been because of the **short duration of awards**. More than three quarters of Technopolis survey respondents (78%, 235 out of 301) identify the permitted duration of awards as a challenge to achieving intended impacts (with 43.2% reporting this as a major challenge). While the short timeframes have no doubt created challenges for researchers, the nature of the COVID-19 pandemic meant that speed was of the essence, and short awards were an essential component to ensure the R&I system would respond rapidly.

Additionally, Technopolis survey respondents also found that securing additional resources to enhance impact created additional challenges (77.5%). This challenge may have been less prevalent among awardees of the Agile Call. According to UKRI's M&E survey of Agile Call awardees, more than two thirds of respondents in survey rounds 3&4 reported having received further support of some kind from other funders (e.g. collaborations with other projects, access to infrastructure).⁵⁰ Overall, the severity of this challenge is unclear.

Administrative issues from other parts of the research system (e.g. restrictions on access to laboratories and test facilities within research-performing institutions, access to critical data including pricing of licences, bureaucratic approvals processes, restrictions on access, delayed releases) are a moderately common and moderately severe barrier, typically leading to minor delays to project start or during the early phases of projects. 60.3% of respondents to our survey stated that securing approvals for work (e.g. ethics approvals) posed a challenge. This was echoed by half of the 27 awards holders consulted via interview.

Furthermore, evidence collected via our short case studies reveals that data sharing/access was also a major challenge in some cases, though data sharing was identified as an enabler by some (e.g. open data sources for air quality in Short Case 1 in Appendix G).⁵¹ Issues around establishing data sharing agreements with partners (Short Cases 12 and 13) as well as IP implications for the dissemination of results (Short Case 15) also caused delays.

We also explored the extent to which there were **barriers preventing or limiting the uptake/implementation** of results. However, this is rarely cited as a barrier by researchers, likely owing in part to the evident prioritisation by the award holders of use-oriented outputs, outreach and communication activities, as well as to research users' increased demand for research outcomes evidenced throughout our case studies and interviews.

More specifically, 'Lack of stakeholder buy-in' is rarely noted as a challenge in UKRI's M&E survey of Agile Call awardees (7%). This goes in line with evidence collected via our interviews and case studies, where we only detected anecdotal evidence on the lack of engagement from potential research users, leading to award outcomes not being implemented in certain spheres. However, these are rare, while the other barriers and challenges we have noted so far are expressed far more frequently across our various forms of data collection.

This point was also echoed in our interviews with science and innovation experts. We asked the experts to comment on 'absorptive capacity' in their organisation and any other user-organisations they might be able to speak for. There is strong consensus that interest in research-based evidence heightened considerably during the pandemic, making barriers less likely here

⁵⁰ The question focused on funding from other sources beyond UKRI. This question was not asked in Rounds 1 and 2 of the survey.

⁵¹ We note that significant effort was made by UKRI and the research community to improve data sharing/access both over the recent past and during the early stages of COVID-19 research, including issues around clinical data sharing. Issues around data sharing and access are noted by a relatively small proportion of awardees so it is possible that the proportion would have been significantly larger if those efforts had not been made.

than in pre-pandemic times. However, of our 15 interviewees (including Chief Scientific Advisers), seven reported having to create or expand dedicated teams of internal specialists, within a short period of time, who would be able to source the latest research findings or translate research data into information that was suitable to inform policy decisions. Positively, six further interviewees reported an increase in capacity to access and use evidence in more general terms. This highlights the need to keep on improving 'absorptive capacity' within government departments so they can make effective use of the insights emerging from the research community at a faster pace.

3.7 Assessing value for money for the UKRI COVID-19 response is a complex task, but a top-down approximation shows that the response represented value for money

A key evaluation question in this study is the extent to which UKRI's R&I response to COVID-19 represented value for money. The impacts noted so far in this report show an impressive array of results supported by the ~£354m investment (excl. repurposed grants). Just as an example, it is estimated that the use of dexamethasone to treat COVID-19 had saved around 22,000 lives in the UK and one million lives globally by March 2021. The clinical trial of dexamethasone was conducted by the RECOVERY trial, which was primarily funded by UKRI and NIHR with a joint investment of £2.1 million by the time the effectiveness of dexamethasone. That equates to an investment of ~£2.10 to save each of those lives globally, with diminishing costs over time (as benefits have and will continue to accrue), although of course this estimate does not include historical investments.

However, any attempt to arrive to a global figure of (net) costs and benefits through a bottom-up approach faces strong limitations, which we explain below.

Methodological challenges of assessing costs and benefits of UKRI's COVID-19 response

Assessing benefits: First, it is not practically feasible within the parameters of this study to calculate the impact of a portfolio of 800+ awards (excluding repurposed ones) and monetising it.

Second, there is also a methodological challenge in terms of assigning a monetary figure (which is required in a cost-benefit analysis) even for a sub-set of those awards. There are various impacts that are difficult, if not impossible, to monetise in a credible way (including the value to policymakers of accessing insights and knowledge to make decisions in a time of uncertainty, or the direct impact of those decisions on final outcomes). Furthermore, in cases where it is arguably possible to attempt a monetary approximation, this would have required access to intermediate modelling by subject experts. For instance, the in-depth case study on "Transmission" shows that as a direct result of research funded by UKRI, 1,200 London buses were fitted with a new ventilation system, decreasing the risk of exhaled air reaching the driver's cabin by 97%. However, there is no further (rigorous) research that has been conducted by specialists to estimate the impact of that intervention on transmission, or working hours protected, or lives saved (which in turn could have allowed a monetary estimation, however partial, in the context of this study).

Assessing attribution and counterfactual: Given the national and international nature of the COVID-19 response, it is difficult to ascertain the degree of attribution to UKRI of achieving impacts (reported in this study). In many cases the investments came from various funders internationally (e.g. the RECOVERY trial) or results were built on years of public investment more generally, not just by UKRI (modelling capacity as presented in the "Predictive" case study, previous investments in ISARIC which provided the platform for recruitment that contributed to the success of the RECOVERY trial). The achievement of results also depended in many cases on other factors or organisations playing a role (e.g. vaccination roll-out). Finally, achieving those results were also due in no small part to the decisive response from the UK and the international community, who made their knowledge and focus available to contribute to the response.

Establishing a counterfactual scenario is also difficult. Our bibliometric analysis shows there has been a great deal of academic activity (publications) funded nationally and internationally, so one could

argue that some key developments would have happened anyway. Even in the case of dexamethasone, which was the first effective treatment available at the time (June 2020), one could argue that a similar trial (like the one supported by RECOVERY) would have happened as well (although perhaps not at the same speed).

Given the complexity of the intervention, and in line with the government evaluation guidelines,⁵² UKRI's attribution to achieved outcomes is better addressed qualitatively with a focus on its *contribution* (as presented in this report and in particular on Section 3.3, via case studies).

Assessing cost: Beyond the issue of investments, a cost-benefit analysis may need to include the negative costs that have emerged from the response to the pandemic. While the effects of lockdown on COVID-19 transmission were highly positive, there were immediate and lasting negative impacts on, for instance, the economy which shrank by a fifth during the period April 2020-June 2020, on mental health which worsened with particular concerns for young people, women and over the 70s,⁵³ on education with children being home schooled and existing attainment gaps exacerbated,⁵⁴ as well as on other health conditions including cancer due to lack of access to treatment.⁵⁵

Alongside life-saving research, UKRI-funded studies informed the speed and timing of various national and regional lockdowns, benefiting the country by saving lives that might otherwise have been lost and minimising harm to the economy through an earlier relaxation of restrictions. The earlier re-opening of schools was particularly important given the lost years of learning could negatively affect hundreds of thousands of students over the next 50-70 years.

Taking into account these contributions, and the challenges of a bottom-up approach (as explained above) we have used modelling on the (monetised) effect of these two impact routes to arrive at an estimate of value for money.⁵⁶ We identified and reviewed 11 papers and documents that have modelled some of these effects (see Appendix H):

- **Faster reopening of schools.** Here we focus on the learning losses that were avoided thanks to a faster reopening of schools:
 - In England, all levels of schooling closed on March 23, 2020. On June 1st, teaching resumed for Reception, Year 1, and Year 6. At the start of the new academic year in September, all levels of education resumed. All levels of education were closed on 5 January 2021, then reopened 8 March (Tatlow, et al., 2020)⁵⁷
 - We argue that schools re-opened faster due in part to available research on how best to equip schools to make them safe for students and teachers. In particular, the "COVID-19 Transmission Risk Assessment Case Studies – Education Establishments" which generated evidence to predict the likelihood of airborne transmission within schools with the aim of reducing the uncertainties associated with airborne transmission routes.

⁵² HM Treasury (2020). Magenta Book 2020. Supplementary Guide: Handling Complexity in Policy Evaluation

⁵³ O'Connor R, Wetherall K, Cleare S, McClelland H. Mental Health and Wellbeing during the COVID-19 pandemic: longitudinal analysis of adults in the UK COVID-19 Mental Health and Wellbeing Study. *Br J Psychiatry*. 2021;(218):326–33.

⁵⁴ Scott E. Lockdown 1.0 and the pandemic one year on: What do we know about the impacts? Mar 5 2021. Available from: <https://lordslibrary.parliament.uk/lockdown-1-0-and-the-pandemic-one-year-on-what-do-we-know-about-the-impacts/>

⁵⁵ Jenkins, P., K. Sikora, P. Dolan (2021). Life-Years and Lockdowns: Estimating the Effects on COVID-19 and Cancer Outcomes from the UK's Response to the Pandemic. *European Journal of Clinical Oncology*, Vol.3, Issue 1, 001-003

⁵⁶ We also considered a third route (sustaining R&D investment) but do not present it here as we could not identify an appropriate counterfactual for this route

⁵⁷ TATLOW, Helen, CAMERON-BLAKE, Emily, GREWAL, Sagar, HALE, Thomas, PHILLIPS, Toby and WOOD, Andrew. 035: *Variation in the response to COVID-19 across the four nations of the United Kingdom*. Oxford, 2020. BSG Working Paper Series.

Findings had significant implications for policy, guiding schoolwork during the upcoming school year. Other research, including research contributing to better prediction, testing and treatment of COVID-19, also played a role

- We assume a counterfactual scenario where schools were reopened later, with higher loss in GDP due to years of learning lost, based on research conducted by Hanushek & Woessmann (2020).⁵⁸ This assessment does not account for other benefits emerging from the faster reopening of schools, such as potential positive effects on children's and parents' mental health
- **Faster reopening of the economy.** We add this route given UKRI's COVID-19 response funding to grants that provided evidence that helped to model the spread of COVID-19 under different restrictions. This includes provisions and guidance for safely reopening various economic sectors, which in turn informed decisions on restrictions and the reopening of the economy, as well as research informing on the socioeconomic aspects of lockdown-easing. Research covered in our "Transmission" case study is a case in point, as this contributed to re-opening of the events industry.

We also made use of a 'natural experiment' whereby Northern Ireland, which shows historical parallel trends in GDP growth similar to the other 3 UK nations (based on research conducted by Tatlow et al. (2020)), imposed lighter restrictions in Q3 and Q4 of 2020, which provides a counterfactual scenario

Results and further methodological details are provided in the table below. To arrive at a monetary figure, we need to assess what proportion of the impact is attributable to UKRI. For the reasons explained above, it is difficult to arrive at a definitive quantitative factor. Consequently, we have used a conservative and a very conservative scenario, where we attribute only 1% or 0.1% respectively of the overall impact to UKRI's R&I response to COVID-19. This is a methodological device rather an attempt to estimate the attribution factor. One could argue that the attribution factor could actually be zero. However, the evidence presented in Section 3.3, via case studies, strongly suggests that UKRI did play an important a role by making high-quality research available at speed.

We find that the impact of the faster reopening of the economy and schools is estimated to exceed £1.7 trillion (after accounting for the counterfactual), and if we claim that just 1% of the economic benefits from those decisions link back to insights provided by UKRI research, the monetary impact would exceed £17bn. Even with an attribution of 0.1%, the resulting economic benefits of this cluster of UKRI funded projects could be £1.7bn, around 5 times the total UKRI COVID-19 response investment. This approach is not without its limitations; however, it reveals the substantial impact timely research can have on evidence-based policy decisions, notwithstanding the fact the negative effects of the lockdowns (also informed by research supported by UKRI) are yet to be determined.

⁵⁸ HANUSHEK, Eric A. and WOESSMANN, Ludger. The Economic Impacts of Learning Losses. *OECD Education Working Papers*. 2020. Vol. 225, no. September, p. 6–24.

Table 11 Cost-benefit analysis

Impact route	Total impact	Indicative UKRI impact, assuming 1% of total impact is attributable to UKRI	Indicative UKRI impact, assuming 0.1% of total impact is attributable to UKRI
<p>Impact on faster reopening of schools</p> <p>Based on estimations of GDP loss over the next 80 years due to years of learning lost (among grade 1-12 students), according to Hanushek & Woessmann (2020). We argue that research supported by UKRI (along with other factors and evidence) helped to inform the decision to open schools faster.</p> <p>Based on estimates provided by the authors, the present value of GDP lost due to 2/3 of a year of learning lost due to school closures is estimated to be USD 4.24 trillion, while the present value of GDP lost due to 1/3 of a year of learning lost is USD 2.15 trillion in UK.</p>	<p>£1.67 trillion (USD 2.09 trillion)</p> <p>GDP losses avoided from faster reopening of schools (so that 1/3 rather than 2/3 of a year of learning were lost)</p>	£16.7bn	£1.67bn
<p>Impact of earlier reopening of the economy</p> <p>We exploit a natural experiment, whereby Northern Ireland did not impose hard restrictions compared to the rest of UK (Tatlow et al, 2020), i.e. in Q3 and Q4 of 2020. While GDP in UK decreased around 6% and 7% in these two quarters, the GDP in Northern Ireland only decreased by 1% and 2% (NICEI Q4 2021, March 2022). We can attribute the 5% averted loss in GDP to the reopening of the economy in Northern Ireland during that time.</p> <p>We can apply the 5% of GDP per quarter to the GDP of the 4 UK countries to get the total benefit of faster reopening of the economy.</p>	<p>£52.6bn</p> <p>Difference in GDP growth in Q3 2020 between Northern Ireland and UK in Q3 and Q4 2020</p>	£525.7m	£52.57m
Total benefits	£1.73tn	17.28bn	1.73bn
	Total cost	£354m	£354m
	NPV	49 times	4.9 times

4 Conclusions and recommendations

4.1 Conclusion

UKRI-funded R&I awards were critical in the wider national and global effort to tackle the COVID-19 pandemic and its consequences. UKRI was largely successful in its original aim to fund research relevant to the pandemic and its consequences, and for that research to respond to the needs of government and other key actors and decision-makers.

We find that **UKRI's COVID-19 response facilitated access to funding at speed, across multiple research areas**. Thematically, awards addressed most aspects of the pandemic, from support for vaccines development through to studies to model the effects of policy measures and to understand the social consequences of lockdown.

The response led to a high proportion of outputs and outcomes, produced in a timely manner.

Naturally, one key output emerging from the awards funded by the UKRI's COVID-19 response are publications. However, our evidence shows that awards prioritised the development of outputs (data, knowledge, products) that could serve to inform the management of the pandemic and its consequences, and that these were developed (and communicated with relevant stakeholders) faster than during pre-pandemic business-as-usual.

In terms of scientific outputs (publications), researchers in the UK were very active in producing publications on COVID-19 and/or its consequences, also mobilising other (non-UKRI) sources of funding. We find that UKRI contributed to 58% of the total COVID-19 publications emerging from funding provided in the UK, during the period of analysis, and that these publications were picked up in policy documents faster than usual.

From an international perspective, the UK stands out as having 10% of its research output on COVID-19 during the period of analysis (19,313 of 185,267 total publications). This is a more substantial 'pivot' towards COVID-19 than can be observed in other countries with large and advanced R&I systems. These figures indicate a substantial contribution to the understanding of the disease and its consequences at the international level.

UKRI supported the speedy achievement of these results by design, by requesting applications and funding awards that were expected to produce results in a relatively short period of time and requesting projects to provide an update on progress after 3 months of project start. The 'signalling' function of funding awards with relatively short durations combined with the evident urgency of the crisis at hand was likely critical in ensuring that awards progressed quickly.

Our case studies reveal the depth of impact, as well as the role of UKRI. Each of our thematic case studies highlights the substantial impact of UKRI-investments, often on highly prominent developments and policy decisions, including supporting the development of the Oxford/AstraZeneca vaccine and informing decisions around the introduction and relaxation of national and regional lockdowns, and the Coronavirus Job Retention Scheme ('furlough').

The 'Responsive' and 'Predictive' case studies have showcased impressive contributions by UKRI-funded researchers to UK and global efforts to understand, treat and control the pandemic. The RECOVERY trial identified the first effective treatments for the most unwell patients; the modelling work carried out by the MRC Centre for Global Infectious Disease Analysis (GIDA) persuaded the UK government of the need for lockdowns and provided modelling techniques used around the world; new surveillance systems have improved early warning and tracking capabilities greatly.

The scale and autonomy of the centres behind these developments may have played a factor in the success. Governance and management systems enabled whole institutions to pivot from

the 'day job' to tackling the pandemic with university centres behaving in a manner more typical of national laboratories or government research establishments. This ability to pivot towards a national emergency echoes the behaviour of UKRI itself.

The 'Transmission' case study shows the benefit of close working relationships with the government departments, regulators and professional institutions responsible for making and implementing policy relating to the safe use of public spaces and buildings, with some notable successes in public transport and schools.

The 'Economic Recovery' case study shows the contribution of research to economic decisions. The University of Nottingham's Decision Maker Panel monthly survey stands out as having achieved very substantial influence within the Bank of England's monetary policy committee and its decisions on interest rates and Qualitative Easing. The NIESR economic model was clearly helpful in targeting sector-specific support measures.

Finally, the 'Healthcare Innovations' case study seems to suggest that this is one area where UKRI funding has delivered rather more modest achievements, perhaps reflecting the nature of technological innovation and the challenges of gaining market traction, taking on competitors and rendering existing solutions less cost-effective or obsolescent.

The nature of the UK R&I landscape played a substantial role in enabling a robust and timely response by public science and the realisation of wide-ranging and substantive social and economic impacts, with strong contribution from UKRI to this state of affairs.

We find ample evidence of substantial impact on a wide range of issues relating to the pandemic, from vaccine development, through informing the introduction and lifting of social restrictions, to understanding and mitigating the societal and economic consequences of those restrictions. Almost all the individual awards looked at through the five case studies have benefitted from past investments by UKRI. Many of them were directed to centres and consortia that have benefited from decades of strategic investment – by UKRI and others in the public, private and third sectors – in infrastructure, capacity, and international cooperation.

Prior existence of various networks and world-class centres of excellence made a substantial contribution to the speed and quality of the work carried out and also contributed to the early uptake of results by policymakers. The Oxford / Astra Zeneca vaccine is a good example of where long-standing strategic investments by UKRI and others provided the foundation for the development of one of the few effective vaccines that have been rolled out globally.

Furthermore, our evidence (collected via survey and interviews) also shows that prior existing connections among researchers and users were a key common factor in enabling swift project starts, and rapid progression towards meaningful outcomes.

In addition to its funding, UKRI also played a role in convening the community by catalysing new partnerships, supporting strategic debate and other non-programmatic activity, and facilitating connections with SAGE and policymakers more generally.

One of the main **barriers to success** were conditions imposed by COVID-19 itself, including lockdowns and staff shortages, which are of course beyond the control of UKRI. Aside from these testing conditions, we find four main barriers that limited impact to some extent.

The first challenge related to delays in UKRI processes, specifically to delays in the pre-award process, leading to delayed award start (which was also identified and discussed in the process review of UKRI's COVID-19 response). UKRI processes were still running much faster than normal, but given the time-critical nature of the research and the short project duration, these delays did limit success in some cases and may have constrained overall outcomes and impact. This

suggests a need to design an on-system emergency response programme – with appropriate staffing arrangements – to cope with high levels of urgency over an extended period.

Administrative issues from other parts of the research system (e.g. restrictions on access to laboratories and test facilities within research-performing institutions, access to critical data including pricing of licences, bureaucratic approvals processes, restrictions on access, delayed releases) are a moderately common and moderately severe barrier, typically leading to minor delays to project start or during the early phases of projects. This suggests that barriers in a future crisis could be reduced by further investments to support access to data, with processes in place to facilitate access to sensitive information in special circumstances.

Researchers suggested the benefits realised were less than they might have been because of the short duration of awards. But while the short timeframes no doubt created challenges for researchers, the nature of the COVID-19 pandemic meant that speed was of the essence, and short awards were an essential component to ensure the R&I system would respond rapidly.

Lastly, our interviews with science and innovation experts (including Chief Scientific Advisors) mentioned that they had to create or expand dedicated teams of internal specialists, within a short period of time, who would be able to source the latest research findings or translate research data into information that was suitable to inform policy decisions. This highlights the need to keep on improving 'absorptive capacity' within government departments so they can make effective use of the insights emerging from the research community at a faster pace.

4.2 Recommendations

Based on the evidence collected in this study, our headline recommendation is that the **UK government must support UKRI in its longstanding commitment to invest at scale in public research and innovation** as a means by which to ensure a healthy and diverse UK R&I system with the strength, breadth and connectivity to respond rapidly and effectively to any future global crisis, whether that be a new pandemic or any other type of societal emergency (including social or ecological crises, and potentially more broad-based and intractable crises such as antimicrobial resistance).

The barriers to impact identified above (and evidence collected in the process review of UKRI's COVID-19 response) also point to the need **to upgrade UKRI IT systems for application processing and research information to allow an emergency response** programme to be launched on-system in days rather than months as is the case currently.

UKRI may also consider creating a permanent emergency response programme that might launch several calls for proposals annually to deploy UK research – at speed and scale – to support national and international responses to other shocks or emergencies, such as the current geopolitical crisis centred on Ukraine. This would serve to provide additional intelligence and ensure a greater readiness of both research funders and researchers, should the whole system need to pivot towards another major global emergency.

UKRI may also consider funding network mapping to improve system-level thinking, as well as research on how to facilitate knowledge mobilisation at speed, and providing training to researchers to further improve their ability to communicate complex research to policymakers (especially when they face the need to digest large volumes of evidence in the relatively short period of time).

Finally, we also recommend that **UKRI continue its efforts to facilitate sharing of clinical and other administrative data for future emergency-research**, and for UKRI to review its support-mechanisms to optimise its operations for awardees, many of whom may need assistance in connecting and/or collaborating with potential users of their research, or vice versa.

Note on annexes to this report

There is a substantial amount of annex material to this report. In order to ensure this report is as compact and user-friendly as possible, and to enable readers more easily to move back and forth between main report and supporting materials, we supply the annex as a separate document.

The annex report contains three types of materials:

- Further explanation and detailing of UKRI's COVID-19 response, including description of the individual investments and a theory of change for the response as a whole
- Full write-ups of our five main case studies, the 15 short case studies and our international funders' review
- Methodological details of our various data collection tools, including survey response rate details, our interview tools and lists of interviewees, our bibliometric analysis and a detailed breakdown of our cost benefit analysis

The sections of the annex report document are as follows:

- **Appendix A:** UKRI's COVID-19 response: definitions and details
- **Appendix B:** Case study 1: Responsive
- **Appendix C:** Case study 2: Predictive
- **Appendix D:** Case study 3: Transmission
- **Appendix E:** Case study 4: Economic recovery
- **Appendix F:** Case study 5: Healthcare innovations
- **Appendix G:** Case study Fiches (x15)
- **Appendix H:** Value for money
- **Appendix I:** Bibliometric analysis - methods
- **Appendix J:** International funders' review
- **Appendix K:** Survey of award holders
- **Appendix L:** Interviews
- **Appendix M:** List of documents
- **Appendix N:** Supplementary data and other annex materials

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