2 Mobilising public research funding and infrastructures in times of crisis

The COVID-19 pandemic has triggered an unprecedented mobilisation of the scientific community. In record time, public research agencies and organisations, private foundations and charities, and the health industry at large have set up an array of newly funded research initiatives worth billions of dollars. Nevertheless, this exceptional response from the scientific system has also revealed many challenges. This chapter examines how the scientific community has been mobilised during the COVID-19 crisis, with a particular focus on funding and infrastructures. It explores how the lessons learned can be extrapolated to other crisis situations and the operations of science more broadly, drawing policy implications for science policy makers and administrators, such as the need for better preparedness, for flexible funding mechanisms, for new policies related to early publications of scientific results, and for strengthening the overall resilience of the research system.

Key findings

- **The research system has responded strongly and flexibly during the pandemic**. The research funding system as well as research infrastructures were able to quickly refocus towards crisis-relevant topics and streamline their procedures, although the capacity to allocate or reallocate resources quickly could be improved. Assessing the effectiveness of different mechanisms in producing useful research outputs could provide insights into what works for the future.
- **The COVID-19 crisis has spurred new practices in scientific communication as rapid sharing of data and scientific discoveries worldwide has become essential**. Many traditional constraints have been lifted or relaxed to accelerate the production, publication and dissemination of scientific results relevant to the pandemic. Pre-prints, i.e. academic papers that have not been peer reviewed, have become more common, allowing for faster diffusion of scientific findings, but also raising risks around quality assurance. This raises questions as to how peer review operates, its importance and its limitations. More than three-quarters of all COVID-19 publications are open access, compared to less than one-half in other biomedical fields. These developments could accelerate the transition to a more open science in the longer run.
- **There are considerable uncertainties regarding long-term funding for research once the immediate emergency has passed**, as significant resources have been reallocated towards research fields that are relevant to the crisis. Governments and research funding bodies should define and communicate quickly their capacities to support research in the coming years, as well as their strategic priorities, in order to foster cooperation and collaboration, avoid unnecessary duplication and identify “dark spaces” where research is needed but not being performed. This would allow research performing organisations to elaborate realistic long-term strategic plans, and enable a coordinated global approach.

Introduction

The COVID-19 pandemic has generated a series of exceptional challenges for the research system. Both governments and citizens are relying on science to come up with solutions to the crisis. Starting from limited information, research is expected to provide an understanding of the disease – its causes and transmission, its impacts on society, potential cures and preventive actions – in record time. The intense pressure has tested the research system to its limits, shedding light on its inherent response capacity and flexibility, but also revealing areas needing to be strengthened to increase its overall resilience and preparedness for existing and future crises.

This chapter examines how the scientific community has been mobilised during the COVID-19 crisis, with a particular focus on research funding and infrastructures. Research infrastructures have mobilised their resources and opened up their facilities to new projects targeting COVID-19. Research databases and scientific publishers have removed traditional barriers to access, so that COVID-19 related data and publications can be quickly shared across the whole scientific community. However, national and international co-ordination has sometimes been slow and hindered by structural hurdles. Research organisations and institutions have had to reorganise their operations, rapidly setting new priorities and considering how to balance new investments to address the pandemic with the need to maintain support for the science base as a whole. Traditional peer-review processes have been stretched, and maintaining the quality of scientific production under intense public scrutiny has emerged as a particular challenge.

The chapter explores how the lessons learned can be extrapolated to other crisis situations and the operations of science more broadly, drawing policy implications for science policy makers and administrators.

Resources unlocked for research on COVID-19

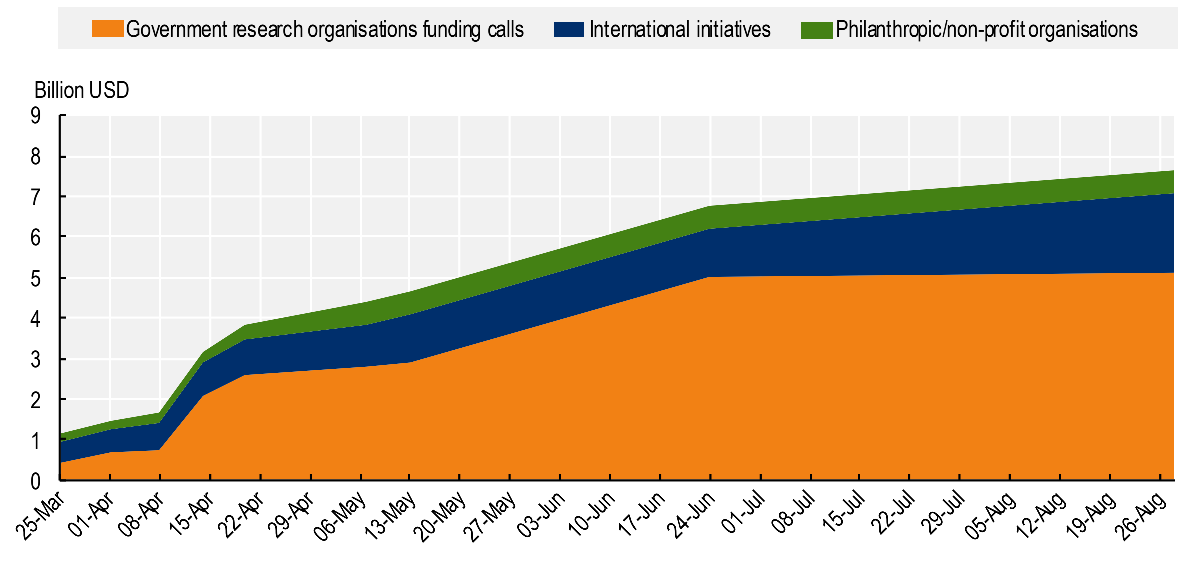
The COVID-19 pandemic has led to a worldwide mobilisation of research funders and research performing organisations. Research funders have set up numerous rapid-funding mechanisms to respond to COVID-19, and encouraged and supported researchers to redirect their efforts towards pandemic-related priorities. Philanthropic investment directed towards COVID-19 has also significantly increased, particularly to support international research efforts. While it is difficult to sum up the resources allocated by various funders to support research related to COVID-19, a preliminary analysis of the major research funding initiatives worldwide[1] (Figure 2.1) suggests that over USD 7 billion of new or redirected resources were unlocked in the first nine months of 2020.[2]

- Over USD 5 billion have been announced for public research funding schemes supported by national public research funding agencies and organisations. These include about USD 300 million for the Asia-Pacific region (excluding the People’s Republic of China, hereafter China), over USD 850 million for Europe, and over USD 3.5 billion for North America. These figures do not include internal resources that have been redirected towards COVID-19 within research performing organisations.
- About USD 2 billion (a mix of public and private money) have been pledged (mostly through the Coalition for Epidemic Preparedness Innovation [CEPI] and the Global Alliance for Vaccines and Immunization [GAVI]) for international research efforts focusing on the development of COVID-19 vaccines (see Chapter 5).
- At least USD 550 million have been allocated by philanthropic foundations to COVID-19 research in addition to their pledges to major international co-operative initiatives.

Resources pledged by industry are more difficult to ascertain, but over USD 1 billion have been allocated by private companies for public-private research initiatives. Internal research resources invested by industry in diagnostics, therapeutics and vaccines research are likely much larger.

Figure 2.1. Evolution of COVID-19 research funding programmes and pledges

March-August 2020



Note of caution: Overall investment is almost certainly underestimated: the expected level of funding is not yet fully known or validated for all funding schemes, and some funders do not publicly disclose the sums allocated. There may also be some duplication when funding commitments are redistributed among different funding programmes. These figures should therefore be treated cautiously, given the complexity of mapping funding declarations to actual investment and the absence of data from some countries. The sharp increase in funding seen in April is linked to the clarification by some major research funders of their resource allocation to major funding programmes.
Source: Data were gathered from public sources published by funders. Data on government research funding calls are available on the STIP COVID-19 Watch portal: https://stip.oecd.org/covid/.

StatLink https://doi.org/10.1787/888934223232

Countries have committed to funding research and the search for treatments at several high-level intergovernmental meetings devoted to fundraising.[3] However, these pledges were not allocated to specific funders and funding schemes, and the amounts pledged probably included those already committed by research funding agencies. More generally, reallocating funding from an existing budget during a crisis was often challenging for governments and institutions, as budgetary processes often involve complex and lengthy validation; this was sometimes circumvented by unlocking supplementary budgets, but "financial flexibility" was highly heterogeneous between countries.

Looking at the level of research projects, over 2 000 projects funded worldwide (excluding China) were registered by mid-September 2020 in a live database of funded research projects on COVID-19 maintained by the UK Collaborative on Development Research (UKCDR) and the Global Research Collaboration for Infectious Disease Preparedness (*GloPID-R*).[4] The database shows that public funding organisations had already awarded at least USD 770 million to research groups by that date. This overview of research projects, which is mapped against the priorities identified in the World Health Organization (WHO) Coordinated Global Research Roadmap (WHO, 2020[1]) illustrates the broad diversity of research being supported.

It is not easy to distinguish precisely, either at aggregate or project level, between entirely new funding and resources that have simply been reallocated. Moreover, the situation appears to be very much country-specific. In the United States, about 40% (i.e. USD 75 million) of the US National Science Foundation (NSF) resources allocated to COVID-19 as of end of October 2020 (USD 190 million) came from additional funds provided by the United States Congress. In France, the share of new resources provided by the Ministry of Research was probably even higher. By contrast, resources were mostly repurposed by the German and Norwegian research funding agencies, Deutsche Forschungsgemeinschaft (DFG) and Norges forskningsråd, respectively, at least in the first half of 2020. At DFG, available resources that had not yet been allocated to specific programmes were directed towards COVID-19 funding schemes.

Finally, while research funding on COVID-19 during the first half of 2020 was characterised by the launch of a large number of new emergency funding schemes, the situation has progressively transitioned towards integrating COVID-19-related research calls into mainstream funding mechanisms. Many research funders have now integrated calls for research proposals in various domains relevant to COVID-19 within their normal operations. Whether the integration of COVID-19 research into these mainstream funding streams is happening at the expense of funding for other disciplines – and if so, to what extent – is unclear. Researchers in the biomedical field have warned that funding and calls for proposals in their non-COVID-19-related domain may be severely cut back, both because of a potential reduction in overall funding (e.g. from medical charities, which have experienced significant drops in donations) and the new prioritisation of research related to COVID-19 (Kourie et al., 2020[2]). There are also concerns on the potential impacts of rapid response on equity, diversity and inclusion within the research funding system (Witteman, Haverfield and Tannenbaum, 2020[3]).

Research areas supported by new research funding initiatives

In response to the pandemic crisis, research funding and research performing organisations have launched a diverse range of funding projects and initiatives, covering a mix of topics and objectives (Figure 2.2). Funding schemes rarely focus on a single topic and it is difficult to assess the exact funding scale allocated to these various categories, but support for therapeutics and vaccines has been pre-eminent. The data provided by the UKCDR-GloPID-R tracker[5] show that funding agencies have issued calls and awarded significant funding in different categories, with a remarkable number of projects dedicated to studying societal responses to the COVID-19 crisis (Figure 2.3).[6]

Figure 2.2. Mix of topics targeted by funding organisations to address COVID-19 and its impacts

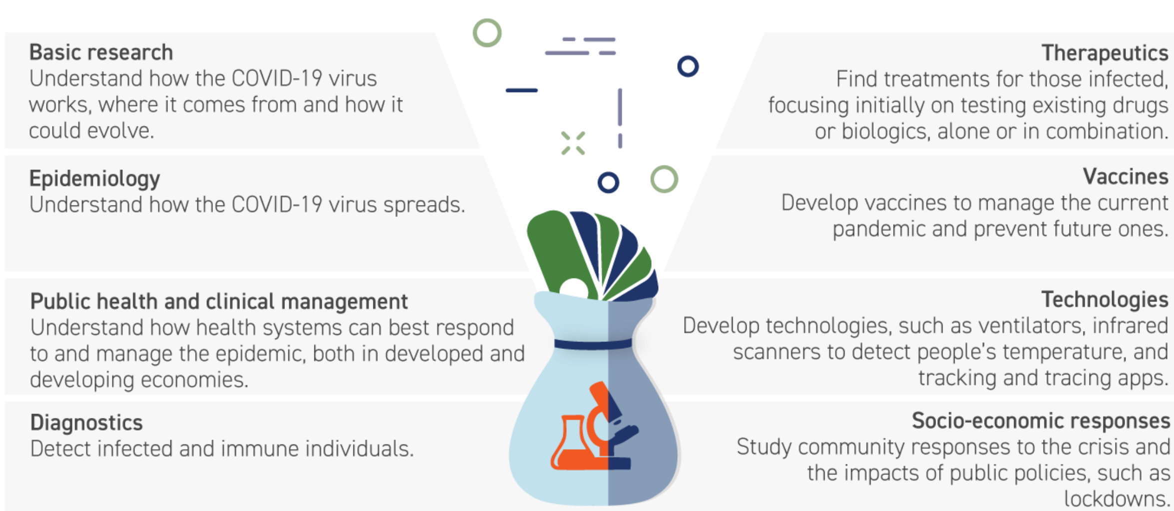
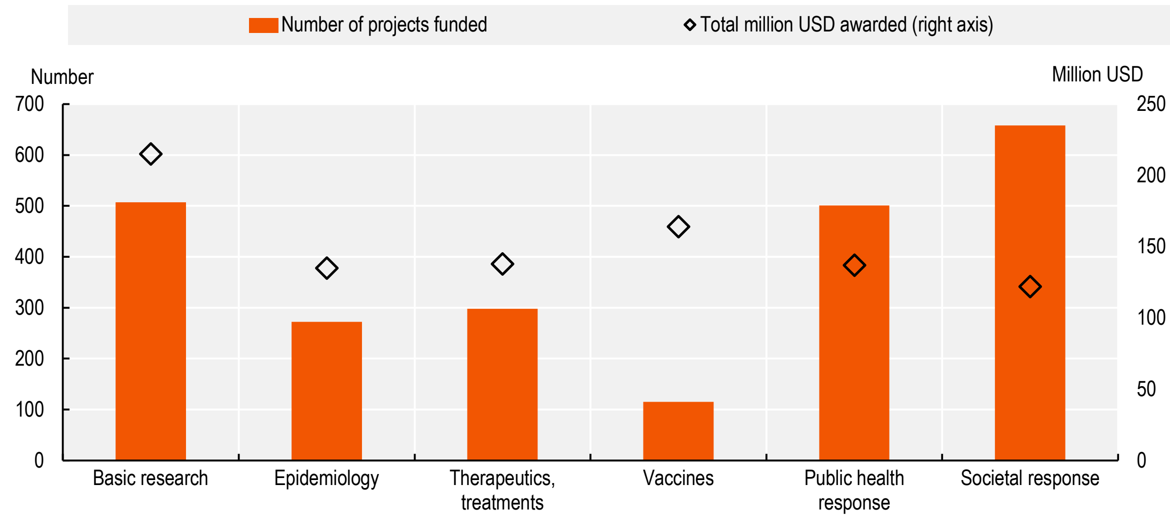


Figure 2.3. Research projects funded by public funding organisations in various research areas



Note: Large programmes on therapeutics and vaccines, such as CEPI, are not included. No disaggregated data were available on research projects on diagnostics and technologies. Some projects may be assigned to several priorities. The database currently has limited information on funding amounts for a significant number of projects. Hence, the total amount displayed significantly underestimates the actual total funding awarded.
Source: Data are derived from the UKCDR-GloPID-R tracker: https://www.glopid-r.org (accessed 15 September 2020).

Challenges in managing emergency research funding projects

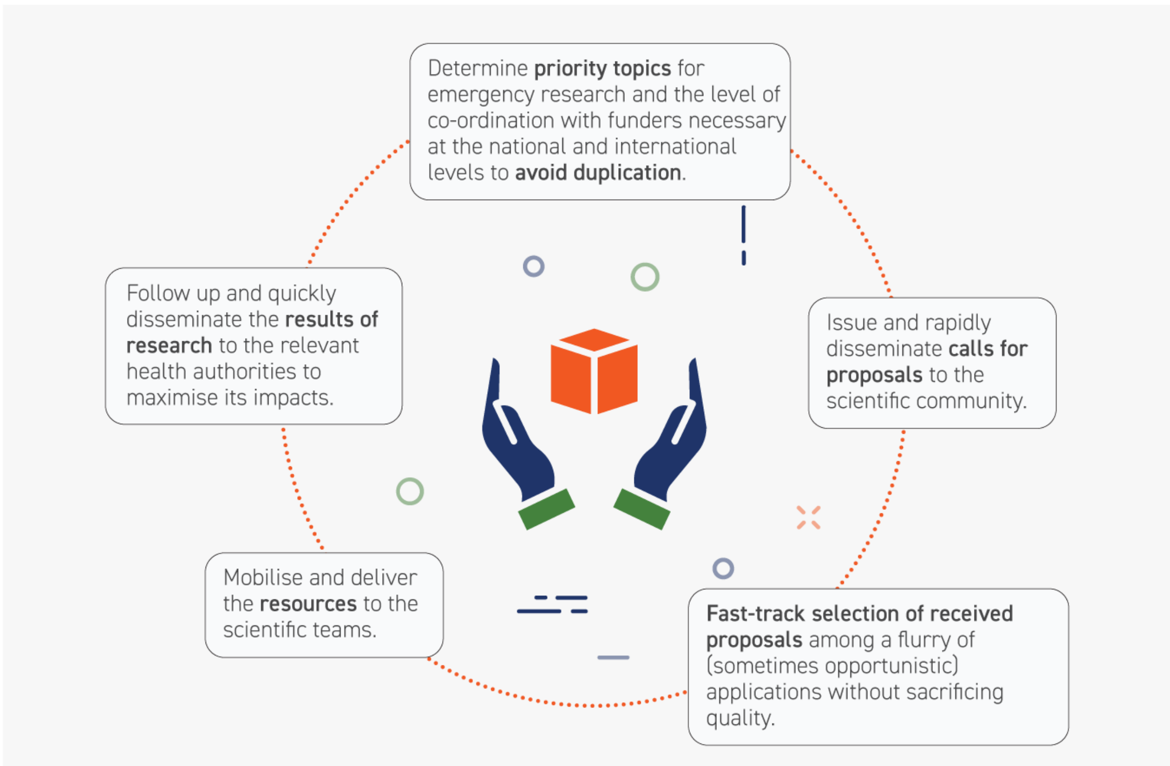
Research funders that are setting up emergency schemes for research funding face a series of specific challenges, notably around prioritisation of topics and dissemination of calls, resources and research results (Figure 2.4). Some of these are described below.

Priority-setting

Funding organisations have various ways of setting priorities. Particularly in biomedical areas, initial priorities were often defined on the basis of research gaps, as determined by the WHO, to ensure essential issues were addressed. Representatives from GloPID-R, WHO, health research funders and scientists met in February 2020 to assess the current state of COVID-19 knowledge, agreeing on key research priorities and ways to work together to accelerate and fund priority research (see Chapter 5). As an example, the Government of Canada designed its key research funding opportunities to align with the COVID-19 R&D Blueprint that came from the meeting between WHO and GloPID-R. These priorities were then often adapted to the national context, so as to take into account the relative strengths of national research performing organisations in particular domains and avoid duplication with projects (e.g. on vaccines) carried out by international consortia. In several countries, national priorities were determined by established or ad hoc advisory panels of experts set up by governments to provide a co-ordinated strategic approach. In the UK, for example, priorities were first identified by the Scientific Advisory Group for Emergencies (SAGE) in synergy with the various relevant national and international stakeholders. By contrast, priority-setting was much less prevalent in non-medical areas. For example, the NSF asked its broad research community to propose research related to the non-medical and non-clinical dimensions of COVID-19. This generated a huge and varied response, with thousands of inquiries and proposals, and over 1 000 awards granted by end of October 2020. Co-ordination was required within the NSF to avoid duplication, and extensive communication took place with other US agencies to avoid overlap and ensure projects were directed to the most appropriate agency. Similarly, in France, the Agence Nationale de la

Recherche (ANR) opened calls for proposals regarding the holistic impact (e.g. economic, societal and environmental) of the COVID-19 pandemic, extending research beyond the public-health priorities defined by the WHO.

Figure 2.4. Emergency research funding schemes face new management challenges



Fast-tracking research proposals

During the initial stages of the COVID-19 crisis, funders often assessed research proposals internally, using their own experts and project managers to fast-track awards. Research teams with a proven track record were often favoured.[7] To keep the number of applications manageable, some funders (e.g. the FWO Research Foundation in Belgium-Flanders) initially limited the number of funding slots per university and added a requirement for co-operation between research institutions within projects. In other cases, expert panels comprising both national and international researchers were established through accelerated procedures and operated virtually (for example, the Dutch Research Council funding agency reduced the proposal evaluation time to one month, compared to the average three to four months applicable in normal times). As described in a later paragraph, such accelerated procedures were also successfully implemented by research infrastructures, suggesting possible gains of efficiency in the management of research proposals in normal operational processes. However, fast-tracking very large numbers of research proposals in record time did stretch funding agencies' capacities to their limits: in the UK, for example, the number of proposals to review was twice as high as normal, and had to be done over a very short period, which led to an intense workload and fatigue of all agency personnel and reviewers involved.

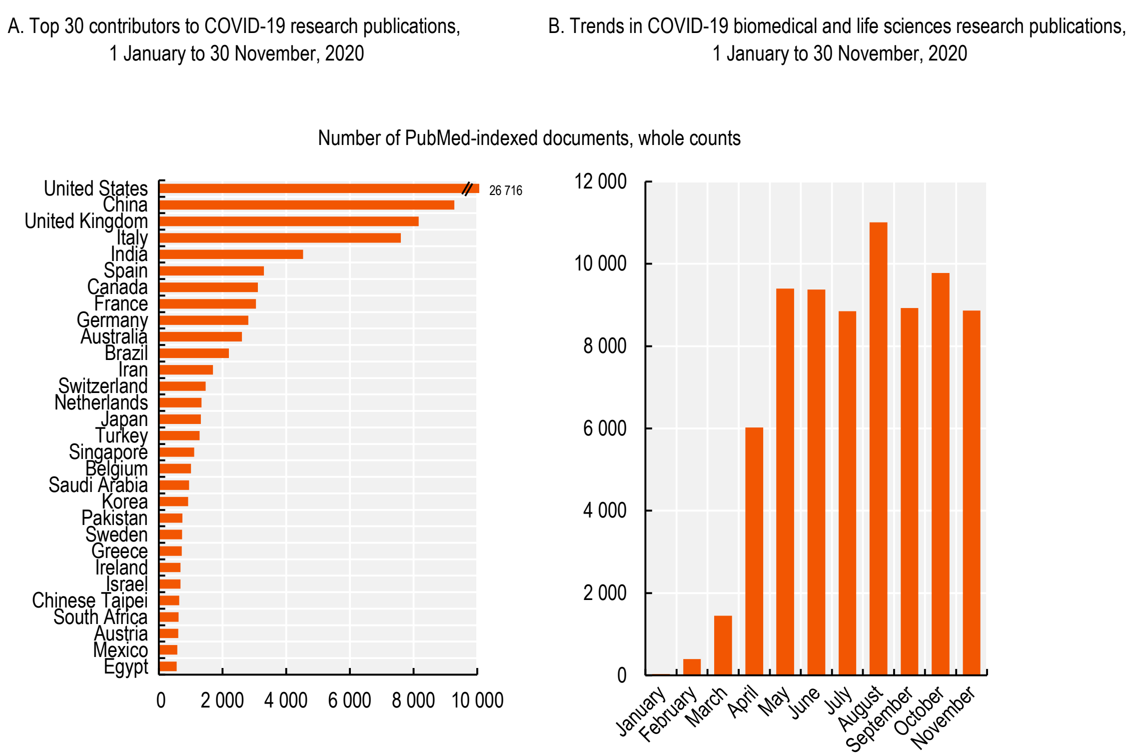
The main objective of these initial funding schemes was to deliver results that could inform solutions as soon as possible, favouring a "low-hanging fruit" approach and the funding of well-established research laboratories with a known track record. Nevertheless, some funders developed schemes that clearly prioritised the interest of the project over the reputation of the team, recognising that breakthrough research proposals could be developed by non-specialist research teams (as was the case for the Flash Covid-19 et RA-Covid-19 calls for proposals issued by France's ANR).

In most cases, funders have not set up dedicated procedures to facilitate uptake of research results. Although responsibilities are split in this matter, it is an area that probably merits greater attention. In the United States, the NSF supported the creation of the COVID Information Commons,[8] which connects projects' principal investigators, provides tools to search across NSF awards related to COVID-19, and links to other US and international research efforts. Similarly, the Canadian Institutes of Health Research (CIHR) also launched a call for a COVID-19 Knowledge Synthesis Network.[9] In France, a new centralised monitoring mechanism for research results is being set up by the national COVID-19 platform. While funding agencies have largely encouraged sharing of scientific data and results (see below), exploiting these results has been largely left to other stakeholders in the research ecosystem (i.e. researchers, institutions and private companies). There exist opportunities for funders to support and work more closely with these other actors.

Uncertainties on the long-term impacts of emergency research funding

Overall, although research funders reacted very quickly and effectively established strategies and funding schemes, many lessons can be learned from the COVID-19 crisis to improve the efficiency of these measures in future crises. While scientific production in terms of academic publications resulting from this large investment has been impressive (Figure 2.5), a number of important questions need to be addressed to inform future science policies on crisis preparedness and response.

Figure 2.5. Growth in COVID-19 related publications



Note: The period covers from 1 January to 30 November 2020 and includes 74 115 documents. Publications include the following type of peer-reviewed articles: books and documents, clinical trials, meta-analysis, randomised controlled trials, reviews and systematic reviews. Iran stands for Islamic Republic of Iran.

Source: OECD and OCTS-OEI calculations, based on US National Institutes of Health PubMed data, https://pubmed.ncbi.nlm.nih.gov/ (accessed 30 November 2020).

StatLink https://doi.org/10.1787/888934223251

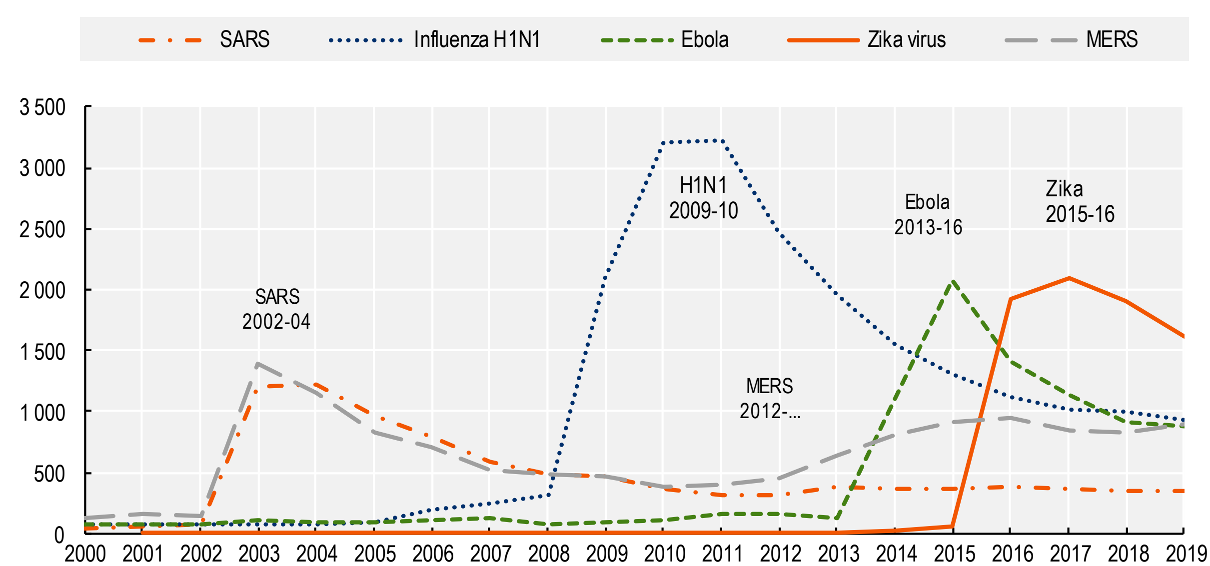
Quality and impact of the science produced

Although an abundance of research articles has already been published, it is still difficult to assess whether the scientific production was worth the public investment, and what impact it will have on informing solutions for the many problems stemming from the pandemic. It is equally important to determine whether certain types of funding mechanisms – many funders tried to innovate to respond to the emergency – have been more effective than others in producing useful research outputs (for example, did the "safe" investments based on track record and reputation yield better results than "riskier" investments?). Assessing the impacts of various funding approaches, using a range of relevant indicators, should provide useful insights on what works for the future.

Long-term impact on research domains

As previously mentioned, the COVID-19 crisis has displaced scientific funding and efforts towards specific areas of biomedical research. Even if definitive numbers are not yet available, significant resources have been reallocated towards research fields that are relevant to the crisis. Whether this will be a long-lasting shift remains unclear, but it will likely continue for some time as new waves of the pandemic take hold. How this will affect other research domains cannot be ascertained, but it does raise questions about the overall long-term research strategy both research funders and research performing organisations must put in place to ensure they have balanced research portfolios and the capacity to address new challenges, wherever they may come from. The shift in funding also has important implications for the research workforce, potentially forcing researchers to move to domains outside their real expertise. Recent examples such as the 2003 severe acute respiratory syndrome (SARS) epidemic, the 2014-16 Ebola outbreak or the 2016 Zika epidemic were associated with relatively short-term dedicated research and vaccine-development programmes that were not pursued once the urgency disappeared (Figure 2.6).

Figure 2.6. Tracking research on previous global health crises, 2000-19



Note: Publications include the following types of peer-reviewed articles: Books and Documents, Clinical Trials, Meta-Analysis, Randomized Controlled Trials, Reviews and Systematic Reviews.
Source: OECD calculations, based on US National Institutes of Health PubMed data, https://pubmed.ncbi.nlm.nih.gov/ (accessed 13 October 2020).

StatLink https://doi.org/10.1787/888934223270

This "panic and neglect cycle" had both economic and health consequences, as federal funding agencies reallocated funds that had been committed to vaccine development, leaving manufacturers with financial losses and setting back other vaccine-development programmes (Lurie et al., 2020[4]). COVID-19 is on a much larger scale and the shifts in research directions it has provoked are much more substantial. Hence, the longer-term impact on different research domains will require careful consideration.

Impact on the science-funding system

The future of research funding after the crisis is uncertain (Subbaraman, 2020[5]). On the one hand, the emerging economic crisis could trigger significant cuts in public research budgets, putting thousands of researchers out of work and reducing research capacities for many years to come. In Europe, for example, the EUR 750 billion (euros) economic recovery plan decided by the European Council will be implemented partly at the expense of the Horizon 2020 R&D budget: only EUR 80.9 billion of the reserved EUR 94.4 billion proposed in May by the European Commission remained in the final budget approved in July by the European Council, a significant EUR 13.5 billion cut (Wallace, 2020[6]), although EUR 4 billon were later recovered following discussions with the European Parliament. In parallel, research funding charities and non-governmental organisations that rely on donors are also being affected by a decrease in donations as companies and individuals face an uncertain financial future. By late June 2020, the Association of Medical Research Charities in the United Kingdom, whose members sent GBP 1.9 billion to biomedical researchers in 2019, was already reporting an average 38% drop in fundraising revenue; other countries are seeing similar situations (Cahan, 2020[7]).

On the other hand, this pandemic may underline the importance of science in preparing and reacting to upcoming crises, possibly translating into stronger and more lasting support for research. For example, the United States and the United Kingdom have pledged new funding for research for the coming years. The announced US federal R&D budget for 2021 shows a 6% increase over the fiscal year (FY) 2020 budget. Meanwhile, the United Kingdom remains committed to raising public R&D expenditure to GBP 22 billion by FY 2024/25 and increasing its total R&D expenditure to 2.4% of gross domestic product by 2027. Korea also announced a new science and technology policy initiative "post corona, science and technology policy direction for a new future" that identifies 30 promising technologies which will have high priority for government R&D funding. National strategies and funding commitments are likely to differ widely between countries, adding to future uncertainty for all the actors in research ecosystems, with important implications for the research workforce (see Chapter 3).

Effective mobilisation of research infrastructures

Research infrastructures (RIs) are facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields. They cover major scientific equipment or sets of instruments; knowledge-based resources such as collections, archives or structures for scientific information; enabling information and communications technology-based infrastructures such as grid computing, software and communication; or any other entity of a unique nature essential to achieve excellence in research. They play a major role in modern research in all scientific domains. The COVID-19 crisis has seen an unprecedented, rapid mobilisation of RIs to support the research community. This effort covers several key aspects, as described in the following sections.

Fast-track access

To facilitate research on COVID-19, many RIs have fast-tracked access to their equipment or services without the need to undergo regular (and often lengthy) evaluation procedures. Many access requests were granted within one month of the proposal's submission. Box 2.1 provides an example of fast-track access to an RI for research related to COVID-19.

Box 2.1. Example of fast-track access to research infrastructure for COVID-19 research

The Paul Scherrer Institute (PSI) is a Swiss multi-disciplinary research institute for natural and engineering sciences that operates unique and world-leading large scientific equipment. Immediately at the onset of the crisis, PSI created a dedicated website for research related to COVID-19.[10] PSI was quickly able to contribute to various aspects of the underpinning COVID-19 science, from structural biology to pulmonary pathology and epidemiology.

In July 2020, scientists from the Goethe University in Frankfurt, Germany, published results on the papain-like protease (PLpro), an essential enzyme of SARS-CoV-2. The structural biology work was performed at the PSI electron synchrotron Swiss Light Source (SLS), following the opening of the "Priority COVID-19 call". The crystallographic data collection happened on 9 April 2020, after the planned Easter shutdown of the SLS was cancelled to allow performing this specific experiment, along with an X-ray imaging COVID-19 experiment.

Data-sharing

The dissemination of research data on COVID-19 has been of paramount importance.[11] Many RIs provide access to data (e.g. biological, environmental and societal) that are of direct interest to COVID-19 research. Most of these data-RIs have set up dedicated portals and structures to facilitate access and use of data on COVID-19 that are relevant to the research. For example, the Korean Bioinformation Centre[12] centralises and makes available all biological information relevant to COVID-19. Some RIs have developed crowdsourcing initiatives that help open up and link COVID-19 data. The European research infrastructure ELIXIR, for instance, co-organised a virtual COVID-19 Biohackathon in April 2020[13] to develop new tools for working with COVID-19 data. In the United Kingdom, the national institute for health data science, Health Data Research UK (HDR UK), has actively championed the use of health data to address the COVID-19 challenge. Although digital infrastructure is needed to share and link data, this was not fully in place in the United Kingdom. To remedy this, HDR UK convened a number of organisations to fund the International COVID-19 Data Alliance (Health Data Research UK, 2020[8]), which focuses on sharing de-identified/population-level data. In other instances, RIs that possess substantial computing and data-analysis capacities for use in particular research fields (e.g. particle physics) have opened them up and offered their experience to facilitate data-mining on COVID-19. For example, CERN has mobilised its open-source technologies, established open-data repositories and developed a number of co-operative initiatives building on its in-house capacities.[14]

Co-ordination

A number of biomedical RIs have created co-ordinated mechanisms to facilitate research on COVID-19. For example, the German high-performance sequencing centres set up co-ordinated access to their facilities,[15] and in Canada, Genome Canada launched the Canadian COVID Genomics Network (CanCOGeN) in partnership with CGEn (Canada's national platform for genome sequencing and analysis), national and provincial health labs, hospitals, academia and industry. At the international level, the COVID-19 Fast Response Service was established in Europe as a co-ordinated and accelerated procedure for researchers to access the academic facilities, services and resources of three medical RIs – the European Research Infrastructure for Translational Medicine,[16] the European Clinical Research Infrastructure Network[17] and the European research infrastructure for biobanking,[18] working together under the umbrella of the Alliance of Medical Research Infrastructures.

New COVID-19 dedicated research

While many RIs are service-oriented facilities geared towards external users, others also conduct internal research using their own staff. In response to the crisis, a large number of service-oriented RIs developed specific tools and programmes to facilitate COVID-19 research for their external users. They also developed additional services, such as project management tools. Many of those RIs that have conducted internal research with some relevance to the pandemic have undertaken dedicated actions to generate and provide data and information related to the crisis. For example, the European Social Survey[19] launched new modules to address pandemic-related societal issues, such as public attitudes towards government responses to the pandemic, on the support for conspiracy theories, and on the willingness to be vaccinated. In Japan, RIKEN began early operation of the new supercomputer "Fugaku" to support the search for therapeutic drug candidates for COVID-19. The initial plan was to begin sharing access to the supercomputer in 2021, but Fugaku began to exploit some of its functions as a matter of urgency in the second quarter of 2020, during the adjustment phase. In July 2020, a team of researchers from RIKEN and Kyoto University announced they had discovered dozens of substances that could be candidates for treatment of COVID-19, after performing in about ten days calculations that would normally have taken more than a year based on conventional supercomputer performance (The Japan Times, 2020[9]).

In conclusion, RIs have demonstrated considerable flexibility during the crisis

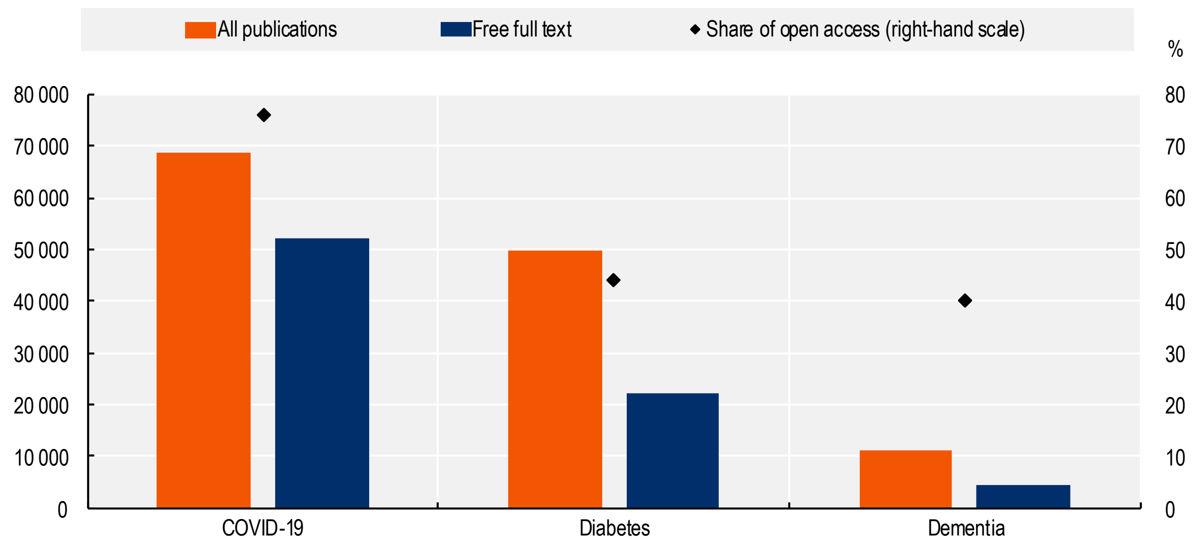
As these examples show, RIs have demonstrated considerable flexibility in adapting their facilities to meet urgent needs. Japan's Fugaku's computing capacities mentioned earlier were thus also used for societal-epidemiological projects to simulate and predict virus transmission indoors, and to model disease propagation under various policy containment measures. This proved to be extremely influential for health authorities (to determine the best containment policies based on scientific facts) and for the public in raising awareness about government guidelines and their acceptability. At the same time, the crisis has led many RIs to update their processes, as recommended in a recent OECD report on the operation and use of national RIs (OECD/Science Europe, 2020[10]). For example, RIs have had to both clarify and better inform potential users of their access rules, and open up their facilities to a broader community of users. Many such actions undertaken during the COVID-19 crisis were initiated by the RIs themselves, with support from their governing institutions and other stakeholders. Science policy makers may have an important role to play not only in supporting RIs financially, but also in developing the framework conditions that enable them to mobilise effectively and co-operate internationally in crises. This includes careful consideration of mandates and incentives, and a willingness to invest in RIs to maintain a degree of resilience and flexibility for reacting to future crises, balancing short-term efficiency gains with longer-term preparedness and flexibility.

The challenge of scientific dissemination in times of crisis

The COVID-19 crisis has spurred new practices in scientific communication as rapid sharing of data and scientific discoveries worldwide has become essential (OECD, 2020[11]). Many traditional constraints have been lifted or relaxed to accelerate the production, publication and dissemination of scientific results relevant to the pandemic, notably by lifting publication paywalls for a fixed period or making COVID-19 research fully open access (Nature, 2020[12]) and (Elsevier, 2020[13]). These efforts have been reinforced by various initiatives. For instance, the "COVID-19 Publishers Open Letter of Intent" aimed to speed up peer review and publication while maintaining the quality and integrity of published articles through a cross-publisher rapid-review process (OASPA, 2020[14]). Furthermore, to facilitate international access to relevant scientific results, the WHO is maintaining a global database of publications on COVID-19 research.[20] Various COVID-19 repositories and databases for articles or data were also created[21] or added to existing platforms, such as Github and Researchgate.[22] The combined effects of new funding streams, data openness and fast-track publication has had an immediate impact on scientific production. By 1 June 2020, 42 700 scholarly articles had already been published on COVID-19, 3 100 clinical trials launched, 420 datasets created, and 270 patents filed (Hook and Porter, 2020[15]). Moreover, three-quarters of COVID-19-related scientific publications are open access, compared to 43% for diabetes research and 40% for dementia research (Figure 2.7).

Figure 2.7. Open access of COVID-19, Diabetes and Dementia publications, January-October 2020

Total and free full text PubMed publications



Note: Publications include the following types of peer-reviewed articles: Books and Documents, Clinical Trials, Meta-Analysis, Randomized Controlled Trials, Reviews and Systematic Reviews.
Source: OECD calculations based on US National Institutes of Health PubMed data, https://pubmed.ncbi.nlm.nih.gov (accessed 30 October 2020).

StatLink https://doi.org/10.1787/888934223289

While these various initiatives have greatly facilitated the dissemination of scientific information, they have also potentially increased the likelihood of less rigorous research results entering the public domain. This issue can be exacerbated in times of crises, as any misleading information can quickly spread over social networks.[23] Preprints, i.e. articles published on the web before they have been peer-reviewed and accepted for publication by a scientific journal, accounted for around one-quarter of COVID-19 research outputs by the beginning of May 2020. While preprints can be useful in disseminating scientific information quickly, there are risks associated with the potential release of misleading or faulty information into the public domain without third-party screening (Dinis-Oliveira, 2020[16]). Owing to the speed of their release, preprints rather than peer-reviewed literature may have a disproportionate influence on policies, shaping the public discourse on the crisis (Majumder and Mandl, 2020[17]). At the same time, this widespread dissemination can also help quickly detect errors and block poor-quality research. For example, the mistaken claim that COVID-19 contained human immunodeficiency virus (HIV) "insertions" was one of the first retracted preprints, in this case withdrawn by the authors themselves (Pradhan et al., 2020[18]). It should also be noted that traditional peer review, even in the most prestigious journals, is not in itself an absolute guarantee of scientific rigour: the paper regarding the effects of hydroxychloroquine for the treatment of COVID-19 published in June 2020 in the prestigious *Lancet* journal had to be retracted after a serious international controversy (Mehra, Ruschitzka and Patel, 2020[19]). The COVID-19 pandemic has demonstrated not only the strengths and weaknesses of traditional publications and preprints, and also raises questions of how peer review works, its importance and its limitations.

What has emerged is the need for an in-depth rethinking of the way scientific information is disseminated (Taraborelli, 2020[20]):

- New best practices need to be developed to help reporters evaluate what they find in preprints and other scientific publications, and report on their findings responsibly (Khamsi, 2020[21]). The creation of rapid-response review venues (Eisen and Tibshirani, 2020[22]) could help connect reporters with independent scientists and offer on-demand expert views on new preprints of interest.
- New community mechanisms may be required to facilitate the translation of scientific publications for a more general audience.
- New technologies may be developed that would help analyse the connection between results, methods, data and resources, for example, as supported by initiatives such as ASAPbio (Accelerating Science and Publication in biology).24

These new "overlay services" could be built on top of existing repositories of scientific information, bringing value to scientists and facilitating online collaboration and peer production in a more transparent scientific publication system.

Lessons learned from the COVID-19 crisis

The mobilisation of the scientific enterprise during the COVID-19 crisis has been unprecedented. The swift response from many different fields of research will have a lasting impact on research systems and, most likely, on the relationship between science and society. While the global scientific effort towards solving climate-change issues remains much more significant than research targeting COVID-19, as illustrated by the extraordinary amount of scientific literature (about 10 000 peer-reviewed articles for physical science alone) analysed in Intergovernmental Panel on Climate Change reports, the climate emergency has not led to a dramatic readjustment of the science system itself or the rapid mobilisation of a major segment of the science community, as has happened for COVID-19.

The 2011 Fukushima disaster perhaps allows for a more direct comparison with COVID-19, albeit at a smaller scale. This major national crisis led to adjustments of the Japanese scientific system over time (Sato and Arimoto, 2016[23]; MEXT, 2012[24]). The longer-term changes were geared towards preventing similar events and mitigating their potential impact. Although the nature of the crises is very different, the Japanese experience may provide some important lessons for understanding the long-term implications of COVID-19 for science systems.

In its uniqueness, this COVID-19 crisis has revealed a number of positive and desirable characteristics of many science systems that have enabled an effective response:

- *Flexibility of research funding and the ability to allocate or reallocate resources quickly as needed*: the dedicated processes set up by research funders deserve to be analysed in depth. Not only is this relevant to future crises, but if the research projects funded through these emergency processes prove to be high quality, there may be some very useful lessons to be learned on streamlining current procedures, which are often burdensome for both researchers and funding administrations. The pandemic has also highlighted the capacity of the scientific community workforce to adapt quickly to a constrained environment while maintaining the efficiency of the R&D system.
- *A capacity for rapid sharing of data and information, which is likely to accelerate the open science agenda*: this crisis has highlighted the need for an evolution in the publication and dissemination

of scientific information and data. The lessons learned from the crisis should help develop new policies and technologies that support the validation of early publications (preprints) and data, and facilitate their use and understanding by broader user communities. On the other hand, data sharing has also sometimes been hampered, for example, by a lack of common standards for the protection of health data. The crisis should spur relevant organisations to harmonise their standards.

- *Some capacity for international co-ordination on a few objectives, often with the help of large philanthropic organisations*: the crisis has shown the need for new models for scientific research collaboration. The pandemic has triggered many valuable international scientific collaborations that produced valuable contributions to solving the crisis. However, there has been duplication of efforts (particularly in the field of clinical trials) and wasted resources. Some of the new collaborative models are being developed and tested already, offering an opportunity to build on these experiences (see Chapter 5).
- *An important role for RIs from many different domains in supporting the research community to conduct emergency research*: RIs are increasingly called upon to support research targeting societal challenges. The lessons learned during the crisis show their capacity to serve multiple research communities and to support policy decisions, but they will require support and incentives from their funders and hosts to maintain – and ideally strengthen – these capacities over the long term.

At the same time, the crisis has revealed some important future challenges:

- *Preparedness (before a crisis) is essential to accelerate the research system's response time during crisis*: Although the scientific system was able to respond quickly to the challenges raised by the pandemic, building on lessons learned from earlier epidemics, a series of unexpected issues emerged for which it was not fully ready, such as the need to overcome divergent approaches and regulations to sharing data and human samples between public and private partners. The crisis has shown the need to strengthen existing national and international structures that advise governments during emergencies.
- *It could exacerbate existing inequalities within research systems or create new ones, since the capacity to undertake research or raise funding is likely to be limited in some fields*: A full analysis of the impact and consequences of the crisis on the research system overall will be important to improve the resilience of the system to future events.
- *Ensuring the quality and rigour of scientific data, publications and communication*: this also raises questions about the current incentives driving hyper-competition and the "perish or publish" culture, with negative spill overs on researcher behaviour during crises (see Chapter 3).
- *Uncertainties regarding long-term funding for research once the immediate emergency has passed*: governments and research funding bodies should define and quickly communicate both their capacities to support research in the coming years and their strategic priorities, in order to allow research performing organisations to develop realistic long-term strategic plans.

These elements illustrate the need for a thorough analysis of the various response mechanisms implemented by different stakeholders in research systems during the COVID-19 crisis, as well as their relative efficiency and effectiveness.[25] Such an analysis could help improve the resilience and responsiveness of research systems, as well as integrate any useful practices that were successfully experimented with during the crisis.

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Notes

[1] Data were collected by the OECD either directly from funding agencies or from public sources, and pooled with data kindly provided by the NSF, which also collected similar data in parallel from other public sources. This data is not complete and does not cover all countries but can provide a minimal estimate of scale of investment in COVID-19 research. The national funding data can be accessed at the STIP COVID-19 Watch portal (https://stip.oecd.org/covid/).

[2] By way of comparison, the total amount of yearly R&D funding distributed by the European Union's Horizon 2020 programme in all disciplines is around EUR 10 billion.

[3] See, for example, the European Union-led worldwide pledging marathon planned to raise EUR 7.5 billion to end the current pandemic (https://ec.europa.eu/commission/presscorner/detail/en/ip_20_710).

[4] Note that the database is not exhaustive, and funding is unknown for many projects. Furthermore, the database registers funding already awarded and not the full amount pledged per funding programme. The database can be accessed at: https://www.ukcdr.org.uk/funding-landscape/COVID-19-research-project-tracker/.

[5] https://www.ukcdr.org.uk/covid-circle/covid-19-research-project-tracker/

[6] The focus on social countermeasures research and social science, as shown in the UKCDR tracker, also reflects patterns seen in previous crises, such as Ebola in West Africa.

[7] Feedback from expert discussion during the GSF workshop (https://www.oecd.org/sti/inno/global-science-forum.htm).

[8] https://covidinfocommons.datascience.columbia.edu; award OIA-2028999.

[9] See KT FO.

[10] https://www.psi.ch/en/psd/COVID-19.

[11] http://www.oecd.org/coronavirus/policy-responses/why-open-science-is-critical-to-combatting-covid-19-cd6ab2f9

[12] https://www.kobic.re.kr/covid19.

[13] https://elixir-europe.org/news/hacking-pandemic.

[14] https://againstcovid19.cern/articles/cern-and-lhc-experiments-computing-resources-global-research-effort-against-covid-19.

[15] https://ngs-kn.de/?page_id=70.

[16] https://eatris.eu.

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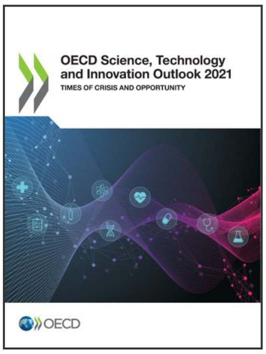
[22] https://github.com/open-coronavirus/open-coronavirus; https://www.researchgate.net/community/COVID-19

[23] https://read.oecd-ilibrary.org/view/?ref=135_135214-mpe7q0bj4d&title=Combatting-COVID-19-disinformation-on-online-platforms

[24] https://asapbio.org/ .

[25] In this regard, a project on mobilising science in times of crisis is ongoing under the aegis of the OECD Global Science Forum.



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