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Foreword

On 30 January 2020, the World Health Organisation declared the COVID-19 outbreak a Public Health Emergency of International Concern, which was the signal for an unprecedented mobilisation of the science community across the World. The pandemic has been not only a massive public health crisis but has affected all socio-economic sectors and all countries and changed many aspects of people's daily lives in a permanent manner. It has also changed many views on the roles of science and the way that it operates. Whilst the rapid development and deployment of effective diagnostic tools and vaccines has enabled most countries to emerge from the crisis and envisage a future living with COVID as a manageable endemic disease, there are many lessons that need to be learned to improve the resilience of science systems. The world is already in the midst of another complex global crisis that calls for rapid socio-economic transitions. New knowledge and new technologies are urgently required to address the challenges of sustainable development and environmental change and critical analysis of how science responded to COVID-19 should ensure that countries are better prepared to meet these challenges.

This is the second of three reports, exploring how science was mobilised in response to COVID-19 and the lessons that we can learn from this for the future. This report focuses on key activities at the interface between science, policy and society – agenda setting, scientific advice and public communication and engagement. It complements report 1, which focuses on policy for science and critical elements of science systems – data and information, research infrastructures and public-private partnerships. The 3rd report explores cross-cutting meta-issues and discusses their implications for resilience and transitions. The 3 reports have been written so that they 'standalone' although cross-referencing is included where appropriate, particularly in the concluding remarks and annex 1. Each of the reports includes policy recommendations and options as well as case examples. The context in each country is different and so the priority attached to these recommendations and the specific details of how they might be implemented will vary. They are provided as an overall framework for science policymakers and other actors, including research funders and research providers, to consider. They can also provide a starting point for national assessments of how science performed during COVID and how systems might be adjusted to respond more effectively to ongoing and future crises.

The "Mobilising science in response to crisis: lessons learned from COVID-19" project was initiated in October 2020 – several months after the start of the pandemic – and was conducted under the aegis of the OECD Global Science Forum (GSF).

Acknowledgements

This work was overseen by an international group of experts from 12 countries (see annex 2) and drew on input from a broader group of experts from policy and research, who were directly involved in the pandemic response in different contexts and contributed to a series of virtual workshops (see annexes 3 and 4). Without these people, who made time to contribute in the midst of the crisis, this project would not have been possible. This report, and the other two report in this series, were drafted by Jessica Ambler, working as a consultant to OECD, and edited by Carthage Smith, Head of the GSF Secretariat. The Expert Group and other members of the GSF secretariat – Frederic Sgard and Yoshiaki Tamura provided critical input and comments.

Executive Summary

The COVID-19 pandemic has presented an unprecedented global challenge. The scientific response has highlighted both the strengths and structural weaknesses of science systems. The willingness and capacity of science to work with policy actors and engage the public has been an important determinant of the effectiveness of different mitigation measures. Challenges, lessons, and good practices identified in this report relate specifically to three critical areas of activity that connect science, policy, and society: priority setting and co-ordination, scientific advice, and public communication and engagement.

The scope, scale, and complexity of the COVID-19 pandemic presented a formidable challenge for national and international efforts to establish and update research priorities. The difficulty of the task has been exacerbated by a lack of established good practice and limited attention to the lessons from past crises. Initial stages of the pandemic response were somewhat chaotic and, in many jurisdictions, insufficient guidance from policymakers and inadequate co-ordination across policy areas and STI agencies led to a shortage in scientific evidence that met policy needs. Policymakers were often required to make rapid decisions in the midst of significant uncertainty, conflicting information, and changing circumstances.

The general absence of effective mechanisms for aligning research agendas with policy needs has led, in varying degrees, to the inefficient allocation of funding, fragmentation of research activities, and insufficient attention to important areas of research, such as public health and social measures (PHSMs).[2] Despite PHSMs often serving as the first line of defence in public health crises, there has been a shortage of rigorous scientific evidence regarding their implementation and impact. This reflects the lack of priority initially attached to this area but also to challenges in implementing experimental evaluations of PHSMs. It is critical that research continues after COVID-19 to improve understanding of the effectiveness of PHSMs in different contexts. More broadly, it is important that policymakers embrace an interdisciplinary and multi-dimensional approach when defining crisis preparedness and response research priorities.

International agencies, most notably, the World Health Organisation (WHO), played an active role in the development of global research priorities from the outset of the pandemic. However, the primary focus of these efforts was on the development of medical countermeasures i.e., diagnostics, vaccines and therapeutics. By comparison, international co-ordination has been noticeably lacking for the socio-economic aspects of the response. Global priority setting activities enable the co-ordination, harmonisation, and standardisation of research activities and facilitate the adoption of learnings and good practices across borders. The international community should continue to invest in building the scientific capacity of low- and middle-income countries (LMICs) to improve their ability to contribute to international agenda setting and adapt and implement these agendas in their own national context.

With regards to science advisory structures, there has been significant variability across countries. Formal expert advisory groups have been an important part of most advisory systems, although these groups differed in number, structure and mandated responsibilities. Irrespective of design, it was critical that that these expert groups were able to leverage established structures, capacities, and good practices, to generate useful science advice. The provision of timely and pertinent interdisciplinary insights was crucial for decision-makers to understand the evolving pandemic and implement effective countermeasures.

Topics that required expert advice have ranged from the nature of the virus and its transmission, the influence of comorbidities, social and other determinants of infection and mortality, and the effectiveness of vaccines and PHSMs. However, in many jurisdictions, the initial advice was largely limited to the life and biomedical sciences. While the pandemic has been a complex and cascading social crisis touching all sectors of society, only a handful of countries were able at the outset to leverage advisory structures and networks that effectively transcended disciplinary and sectoral boundaries. Where additional *ad hoc* expert bodies were hastily established alongside pre-existing advisory structures, these tended to make the science-policy interface unnecessarily complex. In some jurisdictions, an overly *ad hoc* approach to advice enabled elected officials to simply select scientific information that aligned with their predetermined policies. Future action is required to ensure that science advisory structures and processes access a wide breadth of expertise.

Despite the global implications of the COVID-19 pandemic, there has been a significant lack of appetite across countries to exchange experience or co-ordinate response efforts. The pandemic has disproportionately impacted particular places and population groups based on their historic and cultural dynamics, access to health services and social determinants of health. This called for co-ordination and exchange between local, national, and international science advice activities and the integration of equity, diversity, and inclusion (EDI) considerations. In a similar vein, mutual trust between scientists, government actors, and the public is also shaped by historical legacies and culture and in many jurisdictions, long-term actions are required to ensure the trust of citizens in scientific and public institutions.

Public communication and engagement posed one of the most important and formidable challenges in responding effectively to the COVID-19 pandemic. In general, conventional top-down public communication strategies were ineffective because they failed to integrate and address underlying situational and scientific uncertainties. In many instances, the failure of official communications to openly address changing or conflicting scientific evidence damaged the credibility of authorities, making it more difficult to mitigate misinformation. The most effective communications addressed the needs, concerns, and lived experiences of targeted population groups. It was important also that messages were conveyed by representatives with credible scientific backgrounds who invested time and effort in communicating with empathy and relevance.

Despite its positive potential for public engagement, social media has been the primary source, or conduit, for mis- and disinformation and has facilitated the politicisation of science, and polarisation of views. Access to, and use of, social media, is far from universal and mainstream media – newspapers, radio and television - have been the main source of COVID-related information for many citizens. Effective communication efforts during the pandemic have had to use multiple approaches to both amplify science-based messaging and respond to mis- and disinformation campaigns.

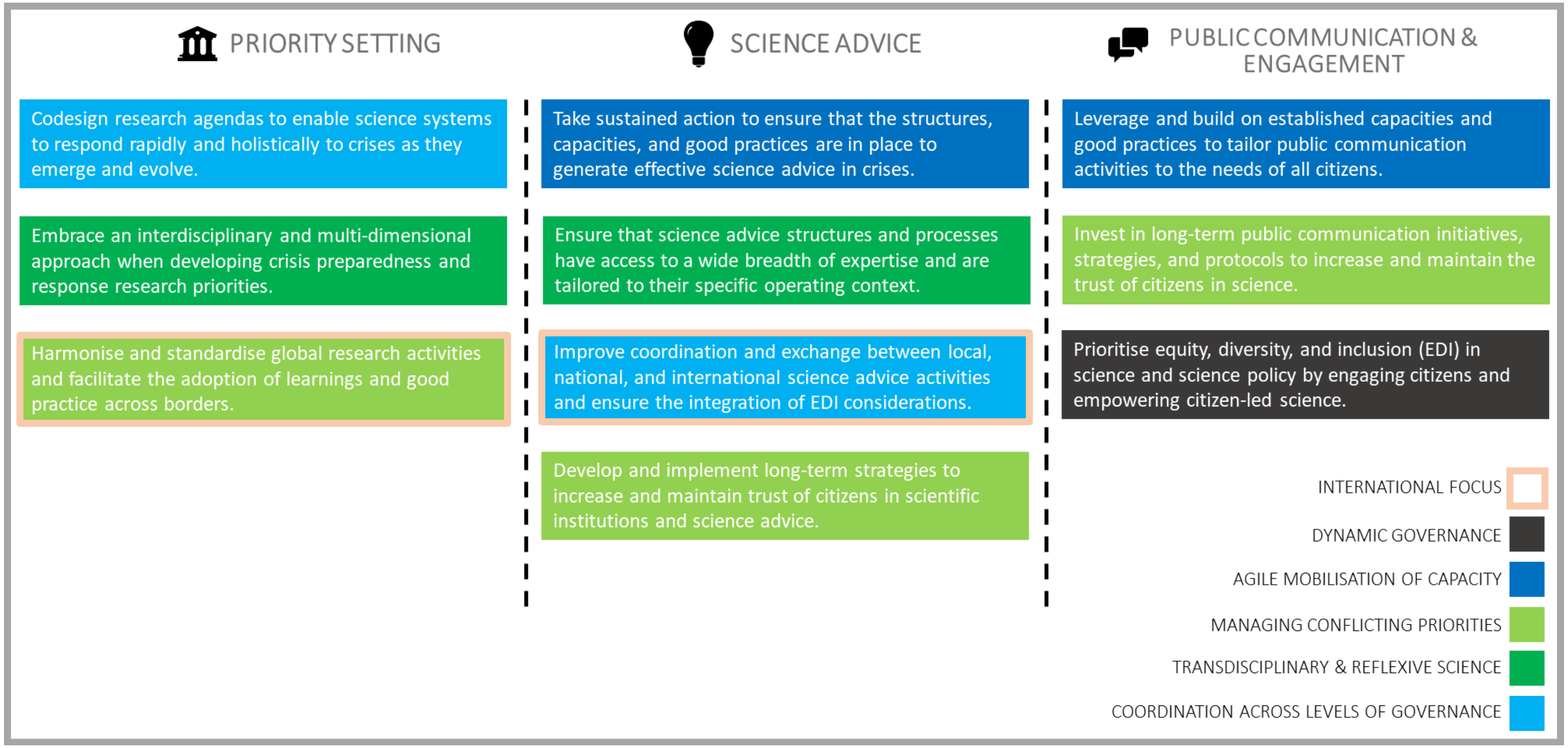
Recommendations

Fostering and maintaining the triangle of trust between science, policymaking/politics and the public has been critical throughout the pandemic response and has been impacted by a variety of factors beyond just the substance and form of scientific advice and communication. It is now widely recognised that people, including policymakers, need specific skills to navigate, validate, and make sense of scientific information. However, it is also important that researchers and policy makers are able to communicate in accessible language and formats. The perceived integrity of the science-policy interface and science advice mechanisms contribute to public trust. Partnerships between scientists and external stakeholders, such as journalists, technology companies, and civil society organisations can also positively influence public trust provided that potential conflicts of interest are carefully managed. The success of certain initiatives in engaging citizens and empowering citizen-led science to improve response efforts has illustrated the potential of public engagement to improve trust in science.

Efforts to set research priorities, deliver relevant scientific advice into policy decision-making, and communicate with and engage the public in science and science policy activities are interconnected and interdependent. Collaborative efforts to set research priorities in preparation for and during crises are crucial to ensuring that relevant evidence can be leveraged by scientific advice structures in informing policy and decision-making. At the same time, scientific advice can play a role in developing and improving systematic approaches to priority setting. Both activities stand to benefit from transdisciplinary insights through the engagement of experts from across scientific disciplines and sectors, including civil society. The COVID-19 response has emphasised the need to prioritise additional research to better understand and improve the dynamics of trust and public communication and engagement during crisis response.

Key recommendations from analysis of the science for policy and society aspects of the response to COVID-19 are summarised in Figure 1. More precise policy options for each of these recommendations are given at the end of each chapter and illustrative case studies are provided in boxes throughout the report. Although the challenges and key recommendations are broadly applicable across OECD countries, the national context differs considerably, and the applicability and importance of different policy options will vary accordingly. Similarly, the institutional responsibilities for implementing these options will differ across jurisdictions. A table listing all of the recommendations and policy options, illustrating how they relate to different stages of the crisis management cycle and to the policy for science topics that are discussed in report 1, is provided at Annex 1. The recommendations and policy options are provided to assist countries in advancing their science systems to prepare for, respond, and recover from health pandemics and other complex societal challenges more effectively in the future.

Figure 1. Science for Policy and Society: Recommendations by science activity type and system-level themes



Note: This figure summarises the key policy recommendations outlined for priority setting, science advice, and public communication and engagement illustrates their alignment with the system-level challenge that are introduced at the end of this report (Fig. 6) described in detail in report 3. Colours reflect principal connections between recommendations and system-level challenges. It should be noted that there may be individual policy options under each recommendation (see tables at the end of each section in this report) that align with other or multiple system-level themes.

Introduction

The mobilisation of science systems in preparation for and response to crises

The COVID-19 pandemic and resulting policy interventions have been a massive and prolonged disruptive force that has affected almost all aspects of a globally interconnected society. Responding effectively has required the rapid production of new scientific knowledge and tools and has served as a real-time test of science systems and their capacity to address a complex societal challenge. Even now, many countries continue to respond to COVID-19 as it evolves. However, looking back on how the pandemic has unfolded to this point provides an opportunity to identify and address key factors that impede the ability of science policy and science systems to function more effectively under normal conditions and support them to develop the resilience that is required to respond in the future.

The project on Mobilising Science in Response to Crises: lessons learned from COVID-19 was authorised at the 42nd meeting of the Global Science Forum and the Terms of Reference were approved in October 2020 – several months into the pandemic. The overarching question that has guided the work is: *What can we learn from the scientific response to the COVID-19 crisis to help science policymakers improve the contribution of science in preventing, preparing for, and responding to future crises?*

The objective has been to develop actionable insights that will aid policymakers and the research community in preparing for and responding to future crises. These are presented at the end of each chapter as a suite of policy recommendations and policy options. Policy recommendations can be interpreted as critical actions with universal relevance to the capacity of science systems to prepare for and respond to crises. Policy options represent potential measures which might be taken to achieve or progress towards the corresponding recommendation. Specific stakeholders, e.g., science policymakers or funders are named where relevant in policy recommendations, but it is recognised that roles and responsibilities and how options are implemented will depend on the national context in which they are applied. It should also be noted that at the time of writing, in many parts of the world the response to the COVID-19 pandemic is still ongoing and so the lessons to be learned at this stage are to some degree conditional on future events. The analysis undertaken includes learnings and good practices identified through a series of workshops (see Methodology). To maintain a manageable scope, the project has focused primarily on the role of public science. The role of private sector research has been limited to issues at the interface with public sector research and broader innovation policy issues are the focus of other ongoing OECD analyses.

As the second report in the series, this document looks specifically at national and international science activities for policy and society – priority setting and co-ordination, scientific advice, and public communication and engagement. It considers the interplays between policy, science, and civil society across different geographic scales and different phases of the crisis management cycle (preparedness, response, recovery). The main focus of the report is on science for policy and society during crisis response. In this regard, science for policy and society refers to measures to ensure that research agendas reflected policy needs and that research evidence effectively informed policy and decision-making. It also encompasses the effective communication of scientific findings and public engagement. The learnings have relevance to preparedness and prevention of future crises, as well as recovery from the current pandemic and improving long -term resilience.

Methodology

The 'Mobilising Science' project has been overseen and supported by an international Expert Group (EG) nominated by GSF (Annex 2). EG members have brought a diversity of national and institutional experience to the project and actively supported the development of international workshops through the identification of national information, case studies, and experts. The project's primary deliverable was initially proposed as a single report to capture challenges, learnings, and best practices identified during the workshop series. Due to the significant breadth and depth of the insights captured, this has been expanded to include a series of three reports, as described below in the 'Report Structure' section.

Six international workshops (Annex 3) were organised in partnership with other OECD working parties and organisations. These virtual workshops took place from April 2021 to April 2022, and focused on six key areas of interest related to:

1) **Policy for science**: access to data and information; research infrastructures; science-industry collaborations [the subject of report 1]
2) **Science for policy and society:** priority setting and co-ordination; scientific advice; public communication and engagement. [the subject of this report]

A symposium for research agency leaders was held also in October 2021 and provided valuable insights on the challenges faced by research funders and how they responded to these.

Workshops were designed to facilitate mutual learning and included a mix of case study presentations, expert panels, and moderated discussions. Background materials, including agendas, videos, and summary reports are available online at https://www.oecd.org/sti/inno/global-science-forum.htm. Information and insights gathered from workshop participants, most of whom were actively engaged in the science response to the pandemic, form the primary knowledge base for this project. Illustrative case studies and quotations from workshop attendees have been included in the reports to provide background context.[1] While quotations have not been attributed to individual contributors, a list of workshop presenters and panellists is provided at Annex 4. Workshop case studies have been supplemented with additional examples to expand on points raised during discussion and to broaden the geographical coverage, where necessary.

The OECD Science, Technology, and Innovation Policy COVID-19 Tracker (https://stip.oecd.org/covid/) was launched in late 2020 as an open access resource that tracks the implementation of policy initiatives that address the pandemic. At the time of writing this report, it included over 900 policy initiatives from 56 countries and the European Union. The tracker was initially populated using a survey of STI policy responses to COVID-19 in October 2020 and has since been updated through the integration of targeted questions into the OECD's biennial survey of national STI policies (https://stip.oecd.org/stip/). This data has been used to provide additional context, in terms of the policy landscape and has helped validate or supplement assertions and insights from the workshops. A detailed analysis of the OECD COVID-19 Tracker data up to the end of 2020 has been published previously (Paunov and Planes-Satorra, 2021[1]) (Paunov and Planes-Satorra, 2021[2]) and the Mobilising Science reports expand and deepen this analysis, from a science policy perspective.

In addition to the expert workshops and STIP COVID-19 data analysis, the 'Mobilising Science' project reports include references to other relevant OECD and GSF work on COVID-19, crisis response, and science systems more broadly. Additional academic and grey literature has been cited where appropriate. Due to the depth and breadth of related literature and the scale and speed at which it continues to expand, this report does not pretend to constitute a comprehensive review.

Report structure

This report is the second in the *Mobilising science: lessons learned from COVID-19* series of policy reports. The first and this (the second) reports target the components of science systems that enable their effective operation. Underlying components are grouped in terms of report 1) policy for elements of science systems – access to data and information, research infrastructures, and science-industry collaborations – and report 2) science activities for policy and society – priority setting and co-ordination, scientific advice, and public communication and engagement. The third report explores meta-issues and that cut across elements of science systems and activities for policy and society (see Figure 6 at the end of this report). It should be noted that while similar trends and challenges were experienced across many countries, national contexts can be very different. The effectiveness of science policy initiatives can be enabled or inhibited by a diversity of contextual factors and all national science systems have their own specificities. Illustrative case studies and policy options have been included in this report to support policymakers in translating and applying recommendations to their local contexts.

1 Priority setting and co-ordination of research agendas

Key Messages

- Efforts to establish and update research priorities during the COVID-19 pandemic were complicated by the urgency, scale, and complexity of the crisis, as well as a lack of established processes and good practices.
- Due, in part, to insufficient guidance from policymakers and inadequate co-ordination across policy areas, there was a shortage of scientific evidence, particularly in the initial stages of the pandemic, to answer key policy questions. Where there has been success in tailoring science activities to specific policy needs, it has depended on having flexible processes in place to address issues as they have emerged.
- In many instances, science policymakers have launched research funding calls without adequate consultation or information exchange. Globally and within countries, this has resulted, at times, in the inefficient allocation of funding, fragmentation of research activities, and insufficient attention to important areas of research, such as public health and social measures (PHSMs).
- While PHSMs serve as a first line of defence in most public health crises, there is not currently sufficient scientific understanding of how to deploy them most effectively in different contexts. During the COVID-19 response, the effective use and scientific evaluation of PHSMs has been inhibited by multiple factors, including insufficient capacity or political will and rigid interpretation of ethical safeguards. To prepare for future crises, these factors need to be addressed through the development of a long-term research agenda for PHSMs.
- International agencies, such as the WHO have played a significant role throughout the COVID-19 pandemic in co-ordinating the development of global research priorities. At the same time, global priorities may not fully reflect regional or national priorities. In this regard, it is crucial that the international community continue to invest in building the scientific capacity of LMICs.

Setting research priorities and agendas is critical for determining the structure and direction of science systems and affects both their preparedness for crisis response and the nature and direction of the response when a crisis arrives. Research agendas have far-reaching implications for all aspects of science systems, including research providers, infrastructures and science-industry collaborations. The processes that are used to establish these agendas and define priorities have important implications for how science relates to policy needs across multiple sectors and how these in turn relate to societal expectations. When multiple agencies or institutions are involved in setting different research agendas with different priorities, as is the case in most OECD countries, then co-ordination and overall system governance can be complex and any weaknesses in this regard are accentuated in crisis situations, when rapid adjustment of priorities is required.

There is significant variability in the approaches that are routinely used in different jurisdictions and research fields to establish research agendas and set priorities. Many different methodologies exist, from formal mechanisms, such as the use of Delphi surveys, to informal mechanisms based on expert consultation (Tan et al., 2022[3]) (Terry et al., 2018[4]). While there is no consensus on best practices, it is likely that the most appropriate methods depend on the specific situation (Viergever et al., 2010[5]). Very little systematic analysis appears to have been done around science priority setting processes in terms of crisis preparedness and response or public health emergencies. At the same time, it has been recognised that clear and systematic approaches to establishing research agendas and allocating resources during health emergencies are increasingly needed, in a world where the prevalence, severity, complexity, and volatility of health crises appears to be on the rise (Kapiriri et al., 2021[6]) (WHO, 2014[7]).

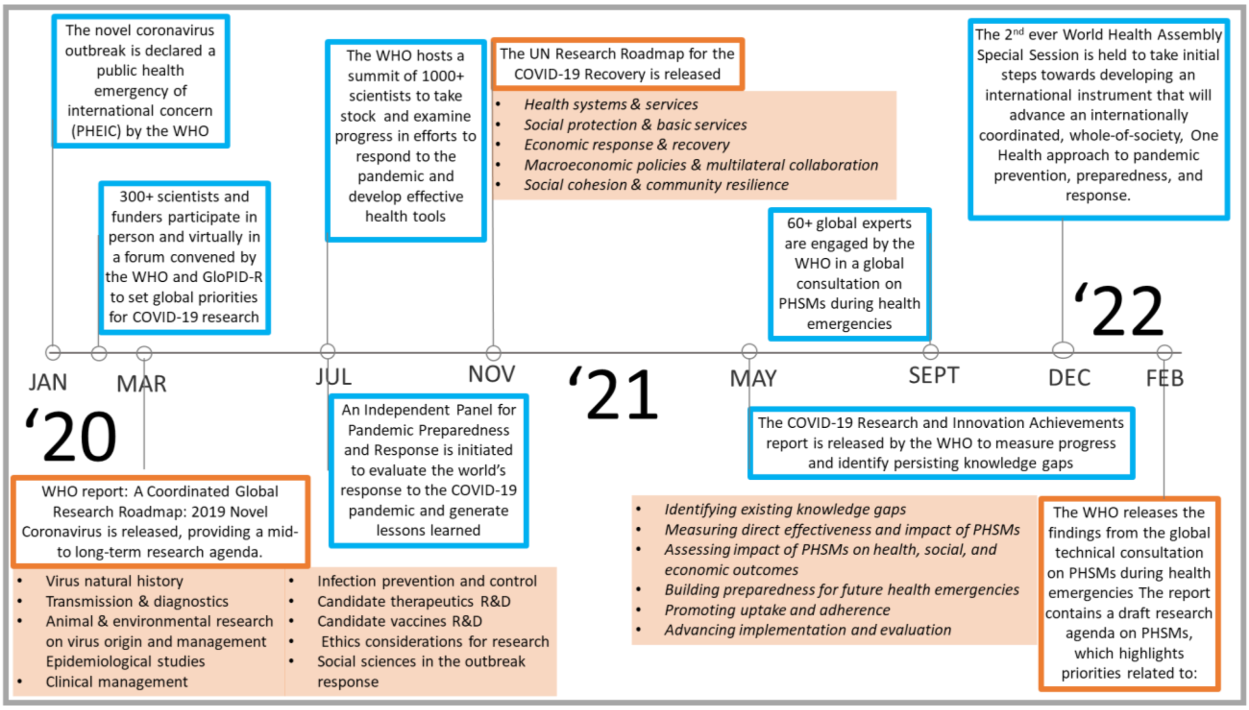
Prior to COVID-19 pandemic, work undertaken to identify good practices in health research priority setting under normal conditions highlighted a number of common themes in relation to preparation, methodology, and implementation (Viergever et al., 2010[5]). These themes include but are not limited to: the adoption of a structured methodology and an inclusive and transdisciplinary approach; identification of knowledge gaps; and the transparent presentation of priorities and the underlying methodology used for their development. More recently, the WHO developed a guide for internal staff, containing advice on how to develop research priority setting processes (Tan et al., 2022[3]). However, it has been noted that this does not include recommendations to support stakeholders in institutionalising a systematic approach to priority setting or facilitating the exchange of lessons or good practices among peers, or across aspects of public health or jurisdictions – all of which are considered important in other contexts.

The global nature of the COVID-19 pandemic prompted international bodies, such as the World Health Organisation (WHO), to initiate international priority setting exercises (See Figure 2). However, it is likely that the lack of clear and consolidated guidelines for the implementation and evaluation of priorities in responding to crises limited the effectiveness of these international efforts. The scale and complexity of the pandemic has, in many ways, required an approach that is both broader and more direct than normal research agenda setting processes (Luo, Chai and Pan, 2021[8]). Recognising and acting on priorities as they have evolved in different contexts and at different stages of the pandemic has been a mammoth undertaking for scientists and science policymakers. As such, it is not surprising that gaps in research agendas and their implementation have endured throughout the response and that there has been some duplication of the research effort due to incoherence across countries and actors.

It is also important to recognise that during crises, research priority setting takes place within a broader context in which resources and funds are allocated across various facets of the response. Decisions can be made using systematic processes, which generally requires their integration into pandemic preparedness planning, or through other approaches, such as the ‘rule of rescue’ (Kapiriri et al., 2021[6]). The rule of rescue relates to the idea that instead of using ‘rational’ economic-based thinking, systems and decision-makers will work to protect individuals and groups that can be identified as being in immediate danger, regardless of the expense (Kapiriri et al., 2021[6]) (McKie and Richardson, 2003[9]). While systematic priority setting during health crises would likely enable more optimal and equitable resourcing and resulting health outcomes, previous studies indicate that the rule of rescue is generally the dominant methodology used to prioritise issues during crisis response.

The rule of rescue has real implications for research priority setting. In the context of the COVID-19 response, this was illustrated by the significant resources that were allocated, throughout all stages, to activities of immediate relevance to response efforts, while scientific activities to inform mid- to long-term response decisions were lacking in many countries. For example, most countries prioritised funds for the daily testing of symptomatic people. At the same time, the use of randomised control trials (RCTs) to evaluate the effectiveness of PHSMs or longitudinal studies on the impacts of infection or duration of natural immunity, were not prioritised early on.

Figure 2. Setting global research priorities during the COVID-19 pandemic



Note: These initiatives are illustrative and are not a fully comprehensive representation of all established international initiatives mobilised to set global research priorities during the COVID-19 pandemic response. Events listed in orange represent times when formal priorities were released in reports. Summarised priorities are listed. Source: Adapted primarily from the timeline of the WHO's COVID-19 response (WHO, 2022[10]).

1.1 Co-designing research agendas to enable a rapid response to crises

"Initial calls were not informed by policy needs because we needed to respond quickly but policy-makers were engaged in subsequent funding calls"

"Rapid response calls need to fund what cannot wait"

"Rapid response funding processes were in place before COVID and we were able to learn from past experiences"

"The research community was informed that there would be a special funding call and engaged to provide guidance on priorities and ensure alignment without excessive overlap"

"Questions of decision-makers should be anticipated by researchers and adequate studies should be in place to provide the evidence that is needed to develop policies"

"Changes in genomics and other scientific fields need to better integrated into priority setting processes and how we approach public health and emerging infectious disease research"

"The research agenda should be updated before, during (according to pandemic phase), and after the pandemic in collaboration with public health authorities, research agencies, and government decision-makers"

"Agility and urgency is needed in regulatory processes to accommodate the rapid pace of change. New information was emerging constantly regarding COVID-19 and therapies"

"The agency anticipated consequences to accelerating funding processes. Gender discrimination was exacerbated in research funding by reducing the time given to apply"

"There has been co-ordination between researchers and authorities but a lot of research is not linked to the management of the crisis. It doesn't necessarily address issues that need to be addressed" "

"To set research priorities, broad input was solicited from civil society, academia, and other actors across the country and analysed to identify what had already been funded and where needs were being met or not met"

"When you have priorities, you also need to revise them often. This can be difficult because there is so much work to do already"[1]

Note: A curated selection of significant quotations was taken primarily from the 'Priority setting and co-ordination of research agendas' workshop held in October 2021. A complete list of workshop participants is available in Annex 4.

During normal times and crisis response, science and policy actors co-operate – to a greater or lesser degree depending on the specific context - to identify and address knowledge gaps through co-designed research. Long-term collaboration and engagement of both policymakers and scientists in crisis preparedness and response exercises can ensure that relationships are in place and that science actors have the experience required to prioritise and manage conflicting information requests appropriately. One of the earliest and most important observations from the COVID-19 response has been the extent of the disconnect between policymakers, scientists, and health practitioners in many countries (Wu et al., 2021[11]). This divide limited the ability to align scientific evidence, public health operations and policies, and political action in responding to the pandemic. Many of the obstacles to effective collaboration between scientists and policy-makers are not new and include differences in career goals, incentives, attitudes towards evidence and the use of language (Choi, 2005[12]) . A variety of intermediary bodies can help facilitate more effective exchange and interaction between different actors, bridging the gap between science and policy needs (See Box 1).

Box 1: Intermediaries

Improving the interface between policymakers and researchers

The European Observatory on Health Systems and Policies (https://eurohealthobservatory.who.int/home is a WHO-hosted partnership mandated to enable and encourage evidence-informed policymaking in European health systems. The Observatory was designed to act to broker knowledge and bridge gaps between scientists and policymakers and between academia and practice. Its activities are steered through partnerships to identify and address the needs of European decision-makers operating in the health systems and policies arena. The organisation's analyses provide multidisciplinary and comparative studies and policy briefs on key and emerging challenges to the function of national health systems across Europe. In response to the COVID-19 pandemic, the Observatory took systematic action to monitor and evaluate national COVID-19 pandemic responses in relation to health systems and broader public health programmes. This work has been connected to and builds on existing and ongoing activities to document country-specific health system information. COVID-19 resources produced by the agency include: a COVID-19 Health System Response Monitor that captures updates on national policy responses; COVID-19 cross-country analyses; and, policy briefs.

Formalising the authority and autonomy of public agencies to respond to crises

During the COVID-19 pandemic response, the government took steps to restructure the Korea Centers for Disease Control and Prevention (KCDC) into the Korea Disease Control and Prevention Agency (KDCA), which expanded the mandate of the organisation and increased its autonomy (Asian Development Bank, 2021[13]). With its new independence, the agency has proposed or been involved in the creation and operation of several new outbreak management initiatives, including the development of a 24-hour monitoring facility and a COVID-19 smart management system; instalment of 5 regional disease response centers; and a Central Disaster and Safety Countermeasure Headquarters, which KDCA presides over. Based on past learnings, the primary purpose of the smart management system is to limit socio-economic damage by enabling accelerated and accurate epidemiological investigations. The system was launched in March 2020 and integrates Big Data from over 25 organisations to allow epidemiological investigators with access rights to analyse the mobility of confirmed cases and areas with confirmed outbreaks (Asian Development Bank, 2021[13]). The system has reduced the time required to identify the routes of confirmed cases from 24 hours to 10 minutes and also enables instant information exchange between institutions.

It is critical for science actors to be able to foresee and address the policy questions that are likely to arise in a crisis. In this respect, the ability of scientists to proactively set a policy-relevant research agenda is important. Those aspects of the crisis that are emphasised and evaluated by scientists have direct implications for the type of response strategy adopted by policymakers. The initial stages of the COVID-19 pandemic response were somewhat chaotic and clear direction from policymakers was generally lacking. In many national contexts, policymakers struggled with a shortage of relevant scientific information to support their decision-making, whilst research funders struggled to quickly put together and implement research agendas that would address emerging policy issues. Flexible and agile agenda setting mechanisms are required to accelerate crisis response and ensure the necessary reassessment of priorities and reallocation of resources as a crisis evolves. At the same time, it is critical that in adapting their operations, policy and science actors work together to identify and mitigate potential unintended consequences or biases (See Box 2).

Box 2: Accelerating priority setting and research

The Canadian Institutes of Health Research (CIHR) were able to leverage experience with two previous international public health crises - Zika and Ebola - to accelerate emergency funding. Several actions were key to moving quickly and enabling the research community to prepare for the funding call as it was being prepared. Working with the World Health Organisation to develop an initial research agenda, the CIHR pre-announced to researchers that there would be a special funding call on February 5, 2020. Five days later, draft priorities were made public and these were finalised a week later. At this point, 4 days remained for researchers to submit applications with decisions anticipated for the end of the month and funding amounts accessible retroactively from February 1, 2020. Roughly 1,200 applicants submitted research ideas in the nine-day application window. The rapid review process engaged 150 volunteer peer-reviewers to consider 227 applications over 5 days. In the end, after a turn-around of roughly three weeks to put together and process the funding call, CAD 26.7M was allocated to 47 projects. One unexpected negative effect of the accelerated timeline for this first competition was gender bias and subsequent funding rounds were adjusted to mitigate this. Lengthening the period given for application and relaxing some of the submission requirements were sufficient to raise the proportion of successful female grantees from 22% in the first funding call to 45%.

The CIHR launched over 20 funding calls in the first 2 years of the pandemic to address specific research questions as they arose. Over this time, a funnel framework was utilised to establish funding priorities. Initial inputs were informed through environmental scanning, international and domestic science advice structures, and targeted outreach across the Government of Canada and CIHR Institutes. Potential research areas were then prioritised based on previous funding and current need, policy relevance, research gaps, and scientific validity.

In most OECD countries, STI governance is distributed across ministries, agencies, and subnational organisations, which have varying degrees of autonomy (OECD, 2012[14]). In addition, different parts of government have different priorities and requirements for scientific inputs. Even under normal circumstances, this distribution and variability can pose challenges for co-ordination and representation of the full range of policy requirements in research agendas. However, the rapid response necessitated by the COVID-19 pandemic further exacerbated existing structural siloes within and between different national and subnational authorities. In many situations, decision-makers had to take action in the face of changing and conflicting evidence and, on occasions, before there was time for sufficient consultation with experts (OECD, 2020[15]). Lack of cross-government and cross-agency co-ordination resulted in narrowly defined and overlapping research funding calls, fragmentation of research activities, and insufficient attention to some areas, such as PHSMs.

To improve crisis management, it will be important that whole-of-government mechanisms are developed to facilitate co-ordination and collation of scientific needs and inputs. Greater emphasis on harmonisation and information sharing can reduce duplication and enable more efficient allocation of resources, facilitate the consideration of a greater diversity of potential solutions, and improve situational understanding and the development of more effective policy (OECD, 2020[15]). There are a variety of tools that policymakers can use to address overlap or discrepancies between sector-specific priorities. At the level of research funding, the centralisation of funding information and the development of joint research programmes can promote cross-agency and cross-sector collaboration and concentrate resources towards shared priorities (see report 1, re. science-industry partnerships). It is also important that experts and policymakers from across government and different scientific disciplines participate in strategic foresight and planning activities (See Box 3). Joint participation in emergency preparedness planning exercises can enable the reciprocal integration of evidence into policy development processes and social and policy imperatives into scientific research agendas.

Box 3: Using strategic foresight to inform research priorities

In 2020, the WHO's Western Pacific Regional Office (WPRO) integrated strategic foresight and back-casting into its pandemic response efforts. The WPRO includes health authorities and other stakeholders from 37 countries, including the People's Republic of China (hereafter China), Korea, Japan, Australia, and New Zealand. From March to June 2020, several teams worked to produce future-based recommendations for equity, PHSMs, non-COVID mortality, and ethics (Gariboldi et al., 2021[16]). The School of International Futures (SOIF) provided guidance and teams were also able to consult with experts. The use of multidisciplinary teams was found to be critical to cut across traditional policy areas in a way that facilitated the consideration of issues which might otherwise fall between, or outside, the operation of WHO programs. Participants engaged in six exercises over two phases of activity. The first phase was designed to 'brainstorm' information through the identification of trends, the assessment of potential consequences, and the analysis of interactions between trends and events. In the second phase, participants synthesised information into more concrete products, such as scenario narratives, a roadmap to desirable futures, and considerations for the WHO at national, regional, and international levels. The 'divergence' and 'convergence' of the thinking of contributors is key to considering the complexity of potential futures and discovering new issues while also exploring those which have already been recognised. For example, in evaluating established public health definitions and paradigms, the exercise identified several important challenges that became evident during the pandemic response, including the marginalisation of certain population groups by increased digitalisation, geopolitical dimensions of COVID-19 countermeasure supply, and the changing relationship between employees and their employers (Gariboldi et al., 2021[16]).

1.2 Embracing an interdisciplinary approach when setting research priorities

"Diversity is important from the scientific point of view."

"We must think about how different types of research and different designs can answer different questions"

"Randomised control trials provide good evidence of the effectiveness of different interventions and effort was made to initiate many, but there are difficult political, ethical, and social barriers"

"The burdens of PHSMs are complex. There are many and they are difficult to quantify. A more systematic approach would have been possible if we had been better prepared"

"Effective policies and interventions require compliance and an understanding of behaviour in different contexts"

"The interface between ethics, law, and individual responsibility is an important determinant in undertaking randomised control trials"

"There was a co-ordination problem with PHSMs because it was unclear which public agency was responsible"

"Hazards require regular review and updating to develop multi-hazard information systems. Users and sectors must be engaged for greater alignment and consistency of hazard definitions"

"Nowcasting can help officials strike a balance between social and economic costs of PHSMs and health threats posed by an unmitigated epidemic"

"We could have had consensus on human challenge trials before the pandemic"

"The science of implementation needs to be better understood"

"Secondary impacts on human health are an important aspect of PHSMs that must be considered"

"We need to examine why there have been so few studies on PHSMs in the pandemic response"

"PHSMs are needed before effective vaccines"

Note: A curated selection of significant quotations was taken primarily from the 'Priority setting and co-ordination of research agendas' workshop held in October 2021. A complete list of workshop participants is available in Annex 4.

Prior to the COVID-19 pandemic outbreak, the international community had already recognised the need for a multi-sector and multidimensional approach to hazard surveillance and long-term agenda setting. Intergovernmental initiatives, such as the Sendai Framework (2015-2030) and its associated hazard information profiles (HIPs), promote the use of an 'all-hazards' approach by nations to assess comprehensive risks and uncertainties and prepare for potential future shocks (See Box 4). Development of the HIPs has yielded several key learnings. It has highlighted that most hazards are complex and multidimensional, and their accurate description requires close cross-disciplinary collaboration and iteration between a wide range of organisations due to the evolving nature of the underlying science. Development of the HIPs also emphasised the need for collaboration between contributing organisations and experts to develop a multi-hazard information system that accommodates diverse user needs, local hazard terminology, and potential relationships between hazards.

Box 4: Crisis preparedness

Adopting an 'all-hazards' approach to crisis preparedness and response

The Sendai framework was introduced by the UN Office for Disaster Risk Reduction (UNDRR) to provide guidance on preventing new risks, reducing existing risk, and increasing resilience (UNDRR, 2015[17]). It is a critical tool to inform the priorities of the science community in: 1) understanding disaster risk; 2) managing disaster risk; 3) reducing disaster risk and strengthening resilience; and, 4) enhancing disaster preparedness. It also emphasises the need for policymakers to be able to take an interdisciplinary and co-ordinated approach to crisis preparedness and response. The framework is supplemented by a common set of hazard definitions and hazard information profiles (HIPs), of which there are more than 300 divided into eight types: meteorological and hydrological, extra-terrestrial, geohazards, environmental, chemical, biological, technological, and societal (UNDRR, 2021[18]).

Co-ordinating of public health monitoring and research

The United Kingdom Health Security Agency was created in 2021 to co-ordinate system actions related to health security, including environmental, chemical, and biological threats to health (Thornton, 2021[19]). It consolidates aspects of its predecessor, Public Health England, with the Joint Biosecurity Centre, and NHS Test and Trace with ambitions of fostering an agile body capable of working seamlessly with the public research system, industry, and communities. Since its inception, the agency has supported scientists in creating several novel surveillance systems to advance understanding of the SARS-CoV-2 virus by tracking cases, detecting variants, and assessing transmissibility and virulence. Studies include:

1. The Office for National Statistics COVID-19 Infection Survey (CIS) provides regular data on the prevalence of COVID-19 infections across the country and includes socio-demographic data for individuals and households. Reports provided weekly statistics on mortality and fortnightly assessments related to COVID-19 antibodies and vaccinations.
2. The SARS-CoV2 Immunity and Reinfection Evaluation (SIREN) is a National Institute for Health Research (NIHR) priority study, which was initially introduced to analyze the impact of antibodies on COVID-19 incidence in healthcare workers. Its remit has since been expanded to include the impacts of vaccination on COVID-19 immunity in the healthcare community. Since June 2020, over 45,000 NHS healthcare workers have participated, undergoing regular PCR and antibody testing.
3. The VIVALDI study has been implemented in parallel to SIREN to collect similar data on care home staff and residents in over 300 homes in England. Analysis has provided insights into critical questions regarding the impact of the SARS-CoV-2 on the humans, including re-infection levels, variants of concern, duration of immunity from vaccination and infection, and vaccine efficacy.

In periods between crisis response, it is important that science research agendas prioritise a diverse suite of research activities. Multiple competing priorities must be balanced with recognition of the potential contributions that can be made by a variety of different types of research. This requires science policymakers and scientists to weigh the need and potential impacts of basic versus solution-oriented research, when selecting which activities to pursue. There is also a need to balance research activities capable of generating short-term benefits, such as financial returns and prestige, and exploratory activities requiring longer term investment but with the potential to result in radical innovation or improved societal resilience.

mRNA-based COVID-19 vaccines have drawn on the basic research contributions of hundreds of researchers over several decades. (Pardi et al., 2018[20]). (Dolgin, 2021[21]). At the same time, increases in coronavirus-related research over the last 20 years have been driven by the need to respond to SARS, MERS, and now, COVID-19 (Zhang and Shaw, 2020[22]). Most of this research has focused on biomedical areas, such as virology, epidemiology, and vaccinations. However, the COVID-19 pandemic has made it clear that more research is required to address non-biomedical aspects of infectious disease management including, social interventions, risk communication and behaviour, which had not previously been high on research agendas. Similarly, there has been little research to date focused specifically on disaster response, recovery, and long-term preparedness for pandemics.

Box 5: Transdisciplinary research to support local pandemic response efforts

In Buenos Aires, a team from the National University of La Plata ran a study to implement a community-level pandemic healthcare model during the COVID-19 pandemic (Marin et al., 2022[23]). The project introduced activities to target the distribution of basic supplies to socially vulnerable populations in parallel to the implementation of Argentina's strict quarantine measures. Professors and students from the faculties of Social Sciences, Health Science, and Computer Science contributed to the study, as well as sociologists, geographers, doctors, computer scientists, and economists. Participation of the community was integral to the study as patient contributions were integrated from the design stages through a 'permanent participatory territorial work round table'.

One of the study's main interventions involved actions to ensure that residents of the neighborhood were able to access the benefits of social programmes introduced by the Argentinian government in response to the COVID-19 pandemic (Marin et al., 2022[23]). Analysis shows that various structural barriers impact the ability of Puente de Fierro residents to access many of these programmes. Community stores generally lack card reader devices required to purchase food through subsidised 'money card' programs and food aid delivery and distribution also points lack proximity to the neighborhood. To address these barriers, the study supported informal stores in having virtual payment devices for food cards and supported a member of the community in obtaining food from the established distribution center and making goods accessible to other residents through development of a new distribution center within the neighborhood. Study results suggest that reducing the unnecessary movement of community members contributed significantly to a reduction in COVID-19 infections and deaths.

During the COVID-19 pandemic response, the initial research effort in most countries focused primarily on understanding the virus and its transmission or developing medical countermeasures. The design and effectiveness of PHSMs received less attention, although these measures have been universally implemented throughout all stages of the pandemic response. These measures can be targeted at individual behaviours, such as wearing masks and observing recommended handwashing techniques, or collective actions, such as physical and social distancing or restrictions on citizen mobility. They also include a variety of special protection measures for vulnerable groups (Wang and Mao, 2021[24]).[2] Observational data indicate that PHSMs have been effective overall in reducing the transmission of COVID-19 (Brauner et al., 2021[25]). At the same time, interactions between pandemics, PHSMs, and overall public health, including secondary effects related to mental health and domestic violence, are complex. Many factors contribute to the course of a pandemic and the effectiveness of the policies and countermeasures introduced in response. Political climate, hospital capacity, socio-economic situation, population demographics and comorbidities, and voluntary behavioural change all have implications for viral transmission, mortality, and policy decisions. Several studies carried out during the pandemic indicate that the effectiveness of different PHSMs changes over time and in relation to various aspects of the underlying context, such as population vaccination rates and coronavirus variants (Brauner et al., 2021[25]) (Sharma et al., 2021[26]). For example, while school closures are cited as one of the most effective measures in the first wave of the pandemic, they were apparently less effective during the second wave, although very little follow-on research has been undertaken on this topic.

There are several reasons for the scarcity of reliable information on the effectiveness of PHSMs. There are significant challenges in implementing PHSMs successfully during crisis response as well as in the use of rigorous methods, such as randomised control trials (RCTs) to evaluate them. Primary factors hindering implementation include: lack of resources, lack of proper communication between health advisors and the public, and limited willingness of the public to adhere to safety guidelines (Maqbool and Khan, 2020[27]). On the other hand, the insufficient evaluation of PHSMs seems to stem primarily from barriers to the expedited implementation of experimental population studies or RCTs. The limited ability of researchers to launch RCTs or other evaluation studies in parallel to the introduction of PHSMs is, in many ways, a function of the crisis situation and the need for rapid policy action that does not align well with timelines and protocols for research studies. It is rooted also in a lack of preparedness to address foreseeable practical and political hurdles (See Box 6). However, perhaps the most significant challenge to evaluating PHSMs in many countries has been strict and rigid research ethics frameworks, which require scientists to secure the consent of every individual participant.

Developing a deeper understanding of PHSMs requires a significant increase in targeted financial support and research into their various dimensions, including economic, social, and mental health impacts and costs. It will be important that efforts continue during recovery from the COVID-19 pandemic and in normal times to streamline approval processes for RCTs and to understand the effectiveness of different PHSMs in different contexts. Baseline data should ideally be in place for future public health crises. In addition, having common indicators, standards, and protocols, including ethical approval processes, can support the acceleration of robust studies during emergencies and the generation of results that are relevant and comparable across jurisdictions. Increasing the effectiveness of policy interventions will also depend on improving scientific understanding of behaviour and building societal trust to mitigate inhibiting factors, such as hesitancy.

Box 6: Public health and Social Measures (PHSMs)

Formalising and centralising responsibilities for PHSMs

The Centre for Epidemic Interventions Research was established in July 2021 under the Norwegian Institute of Public Health. The new agency's mission is to address the dearth of knowledge on PHSMs and non-pharmacological infection control measures, such as school closures, curfews, or employee testing. It is charged with: 1) preparing for the conduct of PHSM impact studies, 2) carrying out impact studies, and 3) supporting the use of scientific evidence in policy decisions during health crises and improving the public's health literacy. The creation of the agency was a response to the challenges that were experienced during the COVID-19 response in introducing randomised control trials (RCTs) to evaluate the effectiveness and impact of the PHSMs. The majority of the RCTs that were proposed were not able to go ahead for a variety of reasons, including lack of political will, risk aversion, rapid changes in national policies, lack of capacity, and legally binding ethical requirements. In Norway it is necessary to secure the individual consent from all participants in human subject studies, which is a major logistical challenge, particularly when attempting to expediate such studies during a crisis.

Using randomised control trials to address gaps in knowledge on designing and implementing effective PHSMs

A study in Bangladesh has been widely recognised for its scale and its contribution, as a randomised control trial, to the otherwise scarce evidence-based around PHSMs. The study was developed to address whether masks protect against COVID-19, referencing the WHO's hesitation in recommending mask adoption until June 2020 due to lack of evidence from RCTs (Abaluck et al., 2022[28]). The study engaged nearly 350,000 people across rural Bangladesh from November 2020 to April 2021 and found that surgical masks reduced transmission of SARS-CoV-2, while cloth masks were less effective. Data suggests that surgical masks can filter 76% of airborne particles capable of SARS-CoV-2 transmission, even after 10 washes (Peeples, 2021[29]). On the other hand, 3-payered cloth masks had a filtration efficiency of roughly half that before washing. In addition, targeted interventions designed to increase the adoption of masks were successful in increasing mask usage from 13% in the control population to 42%. The study found no evidence that mask-wearing undermined physical distancing guidance (Abaluck et al., 2022[28]). Findings from the study indicate that a variety of interventions to increase mask-wearing (e.g., text message reminders, incentives for village leaders, altruistic messaging, and verbal commitments from individuals) can be linked to increased uptake. Based on non-experimental evidence, the single largest contributor to mask wearing appears to come from active mask promotion, which included advocacy by local leaders, including religious figures, and peer pressure - asking non-masked individuals to put on a mask.

Analysing the confounding relationship between pandemics, PHSMs, and health effects

An observational study with affiliations to Australia, Denmark, the United Kingdom and the United States looked at whether lockdowns and other interventions designed to restrict population mobility have had more damaging impacts on national mortality rates and disease, than the pandemic itself. The study examines the impact of lockdowns on different aspects of public health from routine health service usage to mental health, suicide, and general mortality (Meyerowitz-Katz et al., 2021[30]). Findings relate to:

1. Short-term mortality: locations that implemented lockdowns without first experiencing large COVID-19 epidemics did not have significant excess deaths.
2. Health service disruptions: with currently available data, it is not possible to establish whether reduced attendance of health services is primarily due to lockdowns, the health sector operating past capacity, or the public's fear of infection at health facilities.
3. Suicide and mental health: it is possible that both large outbreaks and government action contributed to extended periods of social isolation, which may have led to declines in mental health and wellbeing. Mental health is also multifaceted and impacted by various other context-specific factors, such as unemployment rates.
4. Global health programmes: while it is certain that global health programmes have been impacted, it is not currently possible to ascertain the relative impacts of the COVID-19 pandemic and government interventions.

The analysis recognises that while it can often be difficult to extricate the impacts of lockdowns from the impacts of ongoing outbreaks, there is strong and clear evidence that government interventions have been impactful against COVID-19 transmission and deaths. The authors also emphasise that attempts to identify lockdowns or an unmitigated pandemic as the greater of two evils generate a harmful and false dichotomy. Rather, it is important that policymakers recognise their duty of care to act to minimise the negative impacts and provide support to individuals impacted by both.

1.3 Harmonising and standardising global research activities during crises

"Capacity development is required across disciplines and collaboration between the Global North and South to build on what was started during the pandemic to prepare for and respond to the next crises"

"We ran to monoclonal antibodies, which are not useful on a global scale, and came late to cheap oral therapeutics"

"We need international priorities and the institution that has the mandate to do this is the WHO"

"There is a big will to co-ordinate but a lack of tools"

"Priorities at the global level don't always cover regional priorities. Regional prioritise in Sub Saharan Africa may be different from the European Union and United States and this must be dealt with better in the future"

"Communication of information between global and regional co-ordinating bodies can be one-way but information should

"We can't set international bodies up and have them work efficiently in the midst of a crisis. Pre-existing institutions need to be set up that establish and co-ordinate priorities regionally and internationally"

"At the national, regional, and international level, the first thing we need to consider is that there's been a lot of duplication and inefficiency"

"When the WHO makes a decision on guidance or standards it sets a precedent for local decision-makers. There needs to be room for consideration of the local context"

"Much of the data that has informed priority setting has been generated by Western nations. For countries without pre-existing R&D infrastructure, global priority setting is critical"

flow both ways” “It is important that global needs are addressed over those of a particular country” “Many people work at the country level and we need to move to the regional level”	“The WHO is overloaded with lots of things. What is feasible for an agency like that to do and do we need another mechanism to support it? “There is very little standardisation in terms of what constitutes a serological study and how to run one”

Note: A curated selection of significant quotations was taken primarily from the ‘Priority setting and co-ordination of research agendas’ workshop held in October 2021. A complete list of workshop participants is available in Annex 4.

International agencies and effective co-operation mechanisms are needed to guide research efforts in a global crisis that does not recognise national borders. Mandated international organisations, like the WHO, played a key role early in the response to COVID-19. Following the declaration of a Public Health Emergency of International Concern (PHEIC) in January 2020, experts convened at the Organisation’s headquarters in February to develop global research priorities and establish collaborative mechanisms to expedite and support research. More than 400 participants from funding agencies, member states, the public health sector, the private sector, and public research systems contributed (WHO, 2020[31]). The resulting COVID-19 research roadmap leveraged an already existing R&D Blueprint (https://www.who.int/teams/blueprint/) which had been introduced in 2016 to serve as a global strategy and preparedness plan and accelerate the mobilisation of science systems to respond to public health crises. The Blueprint sets out an evolving list of priority diseases with the potential to result in future epidemics, each of which has an R&D roadmap (Kieny and Salama, 2017[32]). In March 2020, the WHO’s Co-ordinated Global Research Roadmap for the Novel Coronavirus was made public. It has two overarching goals of 1) containing the spread of COVID-19 and improving care for those affected and 2) developing sustainable global research platforms to prepare for the next epidemic. In total, 9 mid- and long-term research priorities were identified (see earlier, figure 2).

In contrast to the biomedical research domain, international co-ordination was largely absent from early research efforts to address the broader socio-economic dimensions of the pandemic response and recovery or efforts to study, develop, and implement PHSMs (see Box 6). Although the WHO released interim guidance on the design of PHSMs against COVID-19 in May 2020, there has been marked variability in the policies implemented across countries (Wang and Mao, 2021[24]). In February 2022, the WHO also released a report on the results of a global technical consultation on PHSMs during health emergencies (WHO, 2022[33]). The report highlights the need to invest in local capacity to collect PHSM data and to improve the interface between scientists and decision-makers in the generation of related actionable evidence. The complexity of PHSMs requires the development of global multidisciplinary teams and collaboration that engages actors across sectors and within communities before, during, and after emergencies. The changing nature of the pandemic and lack of systemic action to monitor and document changes in national policy interventions has meant that there has been little success in sharing and adopting good practices for the implementation of PHSMs across countries.

Box 7: Inclusive global agendas

Designing a global research agenda for pandemic recovery

The UN Research Roadmap for the COVID-19 Recovery was developed to identify the most pressing research priorities to enable an equitable global socio-economic recovery from the COVID-19 pandemic and advancement of the Sustainable Development Goals (SDGs). The roadmap was developed through a comprehensive participatory process where contributors from six continents and 37 different research funding agencies came together across five steering groups related to 1) health systems, 2) social protection, 3) economic recovery, 4) multilateral collaboration, and 5) social cohesion (CIHR, 2021[34]). In addition, ad hoc insights were provided by UN Resident Co-ordinators, civil society organisations, and members of the International Science Council. Many of the priorities emphasised by COVID-19 are not new but have been made newly essential. Priorities are interlinked across populations, systems, and time and dependent on science and scientific ecosystems.

Following release of the UN roadmap in January 2021, the Trans-Atlantic Platform for Social Sciences and Humanities Research introduced the Recovery, Renewal and Resilience in the Post-Pandemic World research initiative, which has launched several calls for international research proposals. The initiative aimed to advance understanding of the medium and long-term societal impacts of the pandemic in order to mitigate these effects and support recovery.

Ensuring the representation of LMICs in activities to set global research priorities

During the COVID-19 pandemic, several initiatives were established to ensure that the challenges and needs of LMICs were represented in global research priorities. These initiatives recognise that the pandemic has had both explicit and indirect implications for the public health systems in these countries as a result of their structural fragility. The Global Research Collaboration for Infectious Disease Preparedness (GloPID-R) and the United Kingdom Collaborative on Development Research (UKCDR) came together to establish the COVID-19 Research Co-ordination and Learning Initiative (COVID CIRCLE). The Drugs for Neglected Diseases initiative (DNDi) has created the COVID-19 Clinical Research Coalition (https://covid19crc.org/) The coalition aims to support COVID-19 research and ensure equitable access to science-based solutions in LMICs. UKCDR, GloPID-R, the COVID-19 Clinical Research Coalition, and partners convened in March 2021 to discuss COVID-19 research needs in LMICs (GloPID-R, UKCDR, and COVID-19 Clinical Research Coalition Cross-Working Group on COVID-19 Research in LMICs, 2021[35]). They identified research priorities and system needs for COVID-19 and epidemic response and preparedness in low-resource settings. In so doing, they recognised that established approaches to planning, funding, and implementing research in LMICs must be reformed to facilitate expedited action and improved collaboration.

Priorities at the global level do not necessarily directly match or align with local or regional needs and challenges and it is important that the research agendas set by international organisations are appropriately adapted to align with the regional and national context. For example, variability in household structure and social dynamics may limit the applicability of the results of household transmission studies across countries and regions (Azim et al., 2022[36]). Close co-ordination and two-way communication between global and regional institutions can provide the necessary support to enable the adaptation of research priorities to different contexts and their evolution in line with the changing situation. However, the effort required to co-ordinate and act on changing research priorities during the COVID-19 pandemic response was difficult to maintain. The iterative follow-up that might have updated global research priorities as the pandemic progressed was largely neglected, although regional leadership did play a role in supplementing global research priorities with actions of relevance to local responses (See Box 8). Regional and national leadership has also been critical in the implementation of co-ordinated research agendas. Acting on global research priorities requires domestic stakeholders to allocate resources and capacity and to adapt research questions to align with the local context (Viergever et al., 2010[5]).Within regions, countries with similar contexts or challenges stand to benefit from efforts to unite resources and co-ordinate activities to address common research priorities and this happened to some extent – most notably in Europe and also in Africa and South-East Asia (See Box 8).

Box 8: Regional co-ordination

Developing regional research priorities that are representative of national needs and capacities

In alignment with the WHO strategy on research for health, the WHO Regional Office for South-East Asia conducted an exercise in late-2020 to identify research priorities for the region. An established science-based methodology was adopted, the “wisdom of crowds” recommended by the Child Health and Nutrition Research Initiative (Azim et al., 2022[36]). Preliminary research ideas were solicited from country office research and emergency focal points and programme managers via an anonymous online survey. Initial participants were also encouraged to share the survey with other relevant office members who had contributed to the national COVID-19 response. Research ideas were independently reviewed and prioritised by a core co-ordination team using six parameters: regional relevance, time for results to be available for decision-making, relevance to the pandemic response, feasibility based on regional capacity, likely impact on clinical or public health practices, and consideration of equity, diversity, and inclusion (EDI) and human rights. The exercise resulted in the initial identification of over 200 research priority ideas from 48 contributors, which were consolidated and prioritised into 27 items across 7 categories of: health systems, public health interventions, disease epidemiology, socioeconomic and equity, basic sciences, clinical sciences, and pandemic preparedness.

On the African continent, a regional initiative to set research priorities has been led by the African Academy of Sciences, WHO regional Office for Africa, and the African Union Development Agency (GloPID-R, UKCDR, and COVID-19 Clinical Research Coalition Cross-Working Group on COVID-19 Research in LMICs, 2021[35]). However, it has been noted that other regions, e.g., Latin America, struggled to establish regional research priorities.

Centralising regional emergency preparedness and response activities

The European Union’s Health Emergency Preparedness and Response Authority (HERA) was created in September 2021 in response to the COVID-19 crisis and has been mandated to prevent, detect, and rapidly respond to health emergencies. HERA provides a centralised mechanism to co-ordinate the development, production, and distribution of countermeasures during crisis response, including the development of European Union-wide clinical trial networks and platforms. The agency is expected to serve a critical role in improving the European Union's preparedness to respond to health emergencies. HERA has a flexible governance structure to enable it to target activities depending on whether it is operating during the preparedness phase or in response to a crisis. During preparedness, HERA carries out surveillance and threat assessments to identify and act on potential high-impact threats and support relevant research and innovation. During crisis response, HERA can activate emergency funding and mobilise mechanisms for surveillance and the development and procurement of countermeasures. In July 2022, the authority identified its first set of significant cross-border health threats: 1) pathogens with high pandemic potential; 2) chemical, biological, radiological and nuclear threats; and 3) antimicrobial resistance. Priorities were set in collaboration with the European Commission, relevant European Union Agencies, and international experts. The agency's 2022 budget includes EUR300 million to support research into countermeasures and other innovations against emerging health threats, the development of a real-time health threat detection and intelligence system, and a dedicated digital platform for threat assessment and prioritisation.

National research priorities have changed across countries and over time, which has made international co-ordination even more challenging. In the first months of the pandemic, many countries introduced accelerated research funding calls with unprecedented short submission times for potential applicants. The speed of the process often led to inadequate co-ordination across relevant ministries and agencies both within and between countries. Although much excellent research was funded, there was inevitably some overlap and unnecessary duplication. More than 2,900 COVID-related clinical studies had been registered by May 2021; however, many were underpowered due, in part, to an inability to attract the necessary numbers of participants and the majority have been unable to generate robust, statistically significant scientific results (Pearson, 2021[37]) (Seidler et al., 2021[38]).

During the COVID-19 pandemic, obstacles to the successful development of international clinical trials went beyond unco-ordinated priority setting. While several synchronised international initiatives, such as the Solidarity therapeutic trial initiative and the Discovery antiviral clinical trial, were introduced these frequently struggled to recruit adequate patients and were delayed due to differing regulatory requirements and protocols across participating countries (OECD, 2020[39]). These challenges are not new and were the rationale behind the OECD's 2012 Recommendation on the Governance of Clinical Trials, which advocates for consistent and risk-based clinical trial regulations and standardised requirements across countries. While from the pandemic response, it seems that implementation of this recommendation and similar efforts to harmonise clinical trial requirements have not been fully effective, new efforts are now underway, at least at the regional level (See Box 10). In the meantime, several other bottom-up initiatives, have overcome co-ordination challenges by building on and expanding established international networks and developing flexible protocols that can be adapted to different contexts and different interventions. For example, Randomised Evaluation of COVID-19 Therapy (RECOVERY) is an international clinical trial, led by the University of Oxford with almost 200 hospital recruitment sites, that has provided rigorous evidence for four effective treatments for severe COVID-19 (https://www.recoverytrial.net/).

International collaboration is important also to ensure that countries are able to learn from the experience of others in responding to the COVID-19 pandemic. This is true both with regard to effective strategies for the deployment of mitigation measures as well as for the design of specific measures. During the pandemic, interventions were implemented and repealed in a patchwork of policy action with limited co-ordination or collaboration across countries. At the same time the impacts of many national policies, and the science that underpinned them, transcended borders (See Box 9). Both the science and policy communities need to think and operate simultaneously at different geographic scales when responding to crises and they need to leverage existing international co-operation mechanisms to achieve this.

Box 9: International co-ordination and PHSMs

Tracking and evaluating the use of PHSMs across countries

A bilateral collaboration between higher education institutes in the United Kingdom and United States was undertaken from 2020-21 to evaluate the effectiveness of national PHSMs from over 180 countries in addressing the COVID-19 pandemic (Hale et al., 2021[40]). Researchers attempted to address a significant gap in the understanding of policies that were being implemented worldwide. However, the study encountered several obstacles. Many of the policies implemented, as well as the underlying inputs and methods used to make policy decisions have not been made publicly available. Transparency has varied across countries and even changed in some jurisdictions as response efforts have unfolded. The deployment of PHSMs evolved rapidly in most countries and significant and dedicated human capacity was required to keep up with how fast things were changing. Learning was facilitated through informal virtual meetings; however, it was difficult to take a systematic approach when using this type of *ad hoc* engagement.

The study looked at a variety of PHSMs, including school and workplace closures, cancellation and size restrictions of public events, stay at home requirements, public transit closure, within-country and international mobility restrictions, public information campaigns, contact tracing, and diagnostic testing policies (Hale et al., 2021[40]). Results revealed that while there was relatively universal adoption of containment measures, there was variability in when countries adopted PHSMs in relation to local transmission. Furthermore, as the pandemic progressed, variability in PHSMs across countries increased. There was a strong tendency for certain measures, such as information campaigns, international mobility restrictions, and testing and contact tracing measures, to remain in place. However, lockdown interventions have often been the first interventions to be reduced or repealed as case numbers have ebbed, often being reintroduced as new waves of infections emerged. Findings indicate that, across countries and over time, the effectiveness of PHSMs has varied, although overall the use of PHSMs correlated with a statistically significant reduction in COVID-related deaths. This result is consistent with other studies. For example, in New York PHSMs are estimated to have reduced case numbers and deaths by over 70% (Yang et al., 2021[41]).

Standardising PHSM classifications to enable comparison of the severity and timing of national response efforts

An initial effort was made by the WHO during the COVID-19 pandemic to standardise PHSM classifications and compare national response efforts in relation to epidemiological data. The PHSM Severity Index reflects the severity and timing of national measures (WHO Regional Office for Europe, 2020[42]). Six indicators – mask wearing, school closures, closures of businesses, offices, institutions, and operations; gathering restrictions, domestic movement restrictions, and international travel restrictions – were considered. An ordinal scale was used to score indicators based on the intensity and scope of the policy and the average of all six forms the composite score for each country. The intention of the index was to capture the dynamics of individual PHSMs to reflect the overall national policy suite and how this has changed over the pandemic response. Standardising the cumulative severity of national policy suites also allowed for a longitudinal cross-country comparison of the PHSM suites that were in effect throughout the pandemic. The index builds on elements of the Oxford COVID-19 Government Response Tracker, which has been used to collect data on indicators related to PHSMs as well as economic and health system policies.

Priority Setting Policy Recommendations

Recommendation[3]	Policy Options
1. Science policymakers, scientific experts, funders, and relevant institutions should codesign research agendas to enable science systems to respond rapidly and holistically to crises as they emerge and evolve.	1.1. Ensure that science actors have the autonomy to set the research agenda during early stages of crisis response and the necessary strategic intelligence and capacity to anticipate the information needs of policymakers. 1.2. Introduce flexible and agile agenda setting processes to foster preparedness and accelerate the reassessment and reallocation of priorities and resources based on urgency and impact. 1.3. Nurture long-term collaboration between and among policymakers, scientists, and other actors to ensure that national STI activities are co-ordinated across different agencies and levels of government. Joint participation in strategic foresight and crisis preparedness exercises is important to improve agility and resilience. 1.4. Integrate and embed scientific evidence into policy development processes and social and policy imperatives into the scientific research agenda to support long-term preparedness, agility, and resilience.
2. Policymakers and funders should embrace an interdisciplinary and multi-dimensional approach when developing crisis preparedness and response research priorities.	2.1. Adopt an all-hazards methodology to surveillance and long-term agenda setting to improve the preparedness of science systems to respond to crises. 2.2. Support a diverse suite of research initiatives in periods between crises and during crisis response to balance existing and new research priorities and short-term returns – prestige and financial returns – and long-term benefits – the generation of societal value and resilience. 2.3. Prioritise cross-disciplinary collaboration and challenge driven research that focuses on solutions to complex societal challenges and helps establish networks and expertise that can be deployed during crises. 2.4. Address knowledge gaps in the development and implementation of PHSMs to optimise their use during crisis response. Proactive action is required to conduct rigorous randomised control trials and establish baseline data on effectiveness before the next crisis.
3. Policymakers, scientists, and international bodies must work together to co-ordinate and harmonise research agendas and activities during crises and facilitate the adoption of learnings and good practice across borders.	3.1. Improve collaboration and communication between international agencies and regional or domestic bodies to co-ordinate research priorities across countries, addressing the entire crisis management cycle. 3.2. Ensure that global research agendas are inclusive of the needs and challenges of disproportionately affected regions and populations. Where required, jurisdictions should be supported, potentially via regional intermediaries, to translate global priorities to the local context. 3.3. Increase international co-ordination, collaboration, and standardisation of clinical and population research to effectively generate robust and statistically significant results and reduce duplication. 3.4. Leverage learnings and good practice from across countries, disciplines, and sectors to improve the design, evaluation, and adaptation of PHSMs.

2 Scientific advice in crises

Key Messages

- There has been significant variability in the types of science advisory structures adopted by countries during the COVID-19 response. Design differences were notable regarding the use of permanent or ad hoc structures, single or multiple groups of experts, and centralised or distributed translation of science advice into policy and decisions.
- Due to the complex and continuously evolving nature of the pandemic, it was crucial that policy and science actors were able to leverage established science advice frameworks and structures and that robust and relevant resources – in particular, data and analytical capacity and tools – were readily accessible to experts.
- The initial focus placed on experts from the life and biomedical sciences likely resulted in missed opportunities for effective deployment of social interventions and their adaptation to specific demographics. Over time there was greater recognition that the societal dynamics of the pandemic and the resulting response required insights from the social sciences and humanities, as well as other stakeholders from outside of academia.
- The pandemic response has required co-ordination and collaboration between national and subnational actors. The governance of key policy areas, such as public health, is often distributed across national and subnational actors. However, the communication and exchange between these different actors with regards to science advice and related decision-making has often been less than optimal.
- Established international science collaboration mechanisms, notably those linked to the World Health Organisation (WHO), provided significant global guidance and co-ordination throughout the COVID-19 response but could have been better supported and used. While major impacts of the crisis have been universal, science advice has remained primarily domestic. There has been a significant lack of action taken to co-ordinate policy interventions and to share or integrate learnings and good practice between countries.
- Mutual trust between scientists, government actors, and the public is context-dependent and can be shaped by historical legacies and culture. At the same time, several common factors undermined public trust in scientific institutions during the pandemic. Among the most significant of these was the lack of a clear distinction between the roles of policymakers and scientific advisors.

Over the past two decades, globalisation and technological advancements have made many aspects of national and international governance significantly more complex and interconnected. Urbanisation, interdependent global value chains, and increased mobility have increased the risk of unexpected and unprecedented global crises (OECD, 2015[43]). This is coupled with greater public scrutiny through news and social media platforms. As a result, policies and decision-making during crises are informed by a broad suite of inputs and this requires the synthesis of diverse - and sometimes conflicting - insights from science and other sectors of society. As has been the case for the response to COVID-19, this can result in different jurisdictions taking different approaches to respond to the same situation, using the same scientific inputs. Important as it may be, scientific knowledge is only one input to policymaking.

Scientific advice (or science for policy) encompasses the processes, structures, and institutions used by policy-makers to solicit and reflect on data and information required to develop policies that will support government, society, and the scientific community in preparing for, mitigating, understanding, and responding to emergencies (OECD, 2018[44]). Science advice is used to inform policies across many sectors of government. This is distinct from policy for science, for which science policymakers may seek input from scientific experts but the focus is on improving the internal operations of science systems, and issues such as access to data, research infrastructures, and science-industry collaborations (as discussed in report 1 in this series).

There are many different types of scientific advisory bodies, including permanent or ad hoc expert committees; specialised agencies; academies, professional societies, and research organisations. Some countries also have one or more dedicated Chief Scientific Advisors (CSAs) at ministerial or central government level. In other countries individual advisors in less formally identified roles play an important role. During COVID-19 Chief Medical Officers (CMOs) played a critical role in advisory and/or decision-making functions in many countries. However, titles, roles and remits vary considerably across jurisdictions. During the COVID-19 response, expert groups were the primary tool used by national governments to provide scientific advice for policy decisions (OECD, 2021[45]). In some cases, these were created as part of existing mechanisms and in other cases they were established ad hoc. In some jurisdictions, a chief scientific, public health, or medical officer served as a liaison between scientific experts and policymakers or the public. Several countries also leveraged specific public health or science agencies or institutions to play a lead role in providing advice. The responsibilities that science advisory structures were tasked with varied from generating and presenting evidence to providing recommendations, overseeing the implementation of policies, and communicating with the public. Regardless of the structure or specific remit, expert groups were instrumental to COVID-19 national policy responses[4].

While scientific advancements facilitated the rapid development of effective vaccine countermeasures, PHSMs - such as mask-wearing or lockdowns - were the first line of defence during the pandemic. To design the most effective and least disruptive interventions, it was important for policy actors to understand key aspects of transmission, including where and how the virus was being spread and also to have information on societal attitudes and behaviour (Kucharski, 2022[46]). The most effective use of test, trace, and isolate (TTI) programmes required foresight and were often based on pre-existing mechanisms or recent experience with managing epidemics. For example, the initial 'Zero-COVID' strategies of Australia, China, Viet Nam, New Zealand and Korea were informed by experience with MERS and SARS and were based on a precautionary approach that focused on elimination through the prevention of community transmission (Hassan et al., 2021[47]). Other economies adopted risk-based decision-making to suppress transmission, which was informed predominantly by the case fatality rate (CFR) metric, with other indicators, such as hospitalisation rate and hospital capacity, providing important context (Hassan et al., 2021[47]). Both approaches were based on scientific evidence but the breadth and weighting of this evidence varied considerably.

2.1 Ensuring the development of structures, capacities, and good practices required to generate science advice in crises

"There was time pressure from officials. If these structures had been set up in preparation, it may have been different"

"There needs to be a culture difference between emergency response and peacetime operations in terms of the speed in which things are done"

"Investments in social sciences infrastructure allowed us to draw on extensive networks and conduct community surveys on the response and public attitudes towards health and non-health interventions"

"Scientific bureaucracy must be nimble. We were only able to accelerate data sharing and approval processes through emergency use operations. New routine practices are needed to bring down barriers to open data and implement necessary science while protecting privacy"

"In almost no case is one set of data a magic bullet. Multivariate, multidisciplinary data are needed at pace to address questions that people need answered in a way that is transparent to the public"

"Crisis preparedness did not involve scientists enough to prime the ability to engage scientists in decision-making on the fly and to get information in the right hands in real-time"

"Dedicated people are required to review huge amounts of publications and preprints. Science advice groups cannot be expected to do this alone"

"Ad hoc structures tailored to one crisis may not necessarily be right for the next one""

"Traditional biomedical advice is already dealing with the next infectious disease issues. The pandemic is exceptional, but that doesn't mean that the standing structures all need to be changed"

"Science production requires modernised approaches. The world is rapidly changing where speed is central and we have enormous amounts of data"

"We need to look at how we can transform and modernise our own processes to make them more nimble, transparent, equitable, and fast"

Note: A curated selection of significant quotations was taken primarily from the 'Scientific advice in crises' workshop held in March 2022. A complete list of workshop participants is available in Annex 4.

Data, infrastructures, partnerships, and expertise are required to effectively anticipate, respond to, and recover from crises. In particular, robust and timely data provide the foundation for an effective response and are key to understanding an evolving situation. During the COVID-19 response it has been critical for the scientific community to provide rapid and up-to-date insights regarding many aspects of the pandemic, including: the nature of the virus and its transmission; the effectiveness of policy interventions and their potential secondary impacts; and, the influence of comorbidities, social and other determinants of infection and mortality (See Box 10). Countries have adopted different approaches to the collection and use of personal data (see Access to Data, in report 1 in this series). Many East Asian countries were able to leverage learnings from previous crisis response efforts (See Box 11). In general, they have been celebrated for their early success in acting swiftly and aggressively to identify cases and minimise transmissions; even though, the adopted measures were initially deemed 'an unacceptable invasion of privacy' by other nations (Kucharski, 2022[46]). Regardless of the strategy, it is important that trade-offs between data openness and privacy in the context of crisis response are considered and integrated into frameworks and regulations, ideally before a crisis takes place. In addition, human capacity and technological and institutional infrastructure are required to ensure that a broad range of scientific evidence and data can be collected to answer specific questions and be translated into context specific information for use by policymakers and the public.

Box 10: Adapting routine population data collection

Leveraging established community survey mechanisms

The science advice that informed the development and implementation of policy interventions in the United Kingdom utilised an established and robust national system for the collection of census and other population-centered data. For example, the Opinions and Lifestyle Survey (OPN) managed by the Office for National Statistics (ONS) is a monthly survey that is normally administered 8 months per annum. From March 20, 2020, the frequency of the OPN became weekly, later being readjusted to fortnightly in response to the easing of most social restrictions (Office for National Statistics, 2021[48]). At the start of the weekly campaign, the sample size was roughly 1,500 respondents per week, but this was increased to 4,000-4,500 respondents per week to allow a more granular analysis. During the COVID-19 pandemic, OPN questions have related to people's experiences and opinions of the crisis and have included physical and mental health measures, wellbeing, loneliness, climate change attitudes, understanding of official COVID-19 information campaigns, adherence to COVID-19 guidelines, attitudes on vaccines and mass testing, and impacts on work and education. Questions changed weekly to reflect the evolving situation and priorities. In conjunction with the OPN, the Annual Population Survey (APS) was also used to generate estimates of personal wellbeing on a quarterly basis. This allowed policy and science actors to track personal wellbeing measures and integrate them into their activities. Both surveys indicated that personal wellbeing worsened when the United Kingdom implemented its first national lockdown (Office for National Statistics, 2021[48]). While the scores for happiness and anxiety subsequently improved by the end of 2020, feelings of life satisfaction continued to decline.

Developing guidance for household surveys

In response to the COVID-19 pandemic, the United Nations Economic Commission for Europe (UNECE) released guidelines to support national statistic offices (NSOs) in adapting household surveys during pandemic situations (UNECE, 2020[49]). These were based on an analysis of the approaches taken across member countries. Responses to a survey of NSOs early in the pandemic revealed a divide in the approaches that had been taken across countries, with 48% of respondents indicating that they had not received special requests for COVID-specific statistical information, 24% signaling that COVID-specific information had been prepared based on existing statistics, and 28% indicating that special surveys had been created and implemented at the request of government agencies (UNECE, 2020[49]). Over 65% (17/25) of participating NSOs did not target specific demographic groups in their activities. The UNCE guidelines include good practices for developing new surveys, improving methodology, and improving openness and awareness of citizens.

In addition to being dependent on the elements that underlie and enable the effective operation of science systems, effective science advice requires that robust crisis management frameworks, processes, and good practices are in place to guide the actions of policy and science actors. Ideally, these will designate core capabilities, roles, and responsibilities and define objectives and measures of success for different bodies at different crisis management phases: preparedness, response, and recovery. Novel and complex crises, like the COVID-19 pandemic require responders to make sense of the situation rapidly, despite significant uncertainty, and apply science advice that is “relevant, timely, trusted, and actionable” (OECD, 2018[44]). In this respect, it was crucial that established expert networks and science advice structures could be leveraged immediately and ideally that these transcended sectoral, disciplinary, and geographic boundaries (OECD, 2015[43]).

While established public health or science agencies may have ready access to much of the data and capacity required to effectively advise on issues that routinely fall within their remit, complex or cascading crises, such as COVID-19, require input from the broader scientific community and beyond. This broad expertise is more difficult for policymakers to effectively harness (OECD, 2018[44]). It is also true that the science advice structures or processes in many countries lack mechanisms to engage national institutions in clear and formalised roles. Routine science advisory processes are often inadequate for responding in an effective and timely manner to the demands of specific crises and informal information exchange often plays a significant role, particularly in initial ‘sense-making’. Previous work has emphasised the importance of having a central contact point – a designated individual, structure or institution - with direct connections to policy development to co-ordinate the solicitation, collection, and curation of actionable information beyond in-house scientific capacities (OECD, 2015[50]). In a similar vein, it is critical that robust crisis management frameworks can be adapted to align with evolving crisis situations, particularly as complexity, uniqueness, ambiguity, and uncertainty have become key characteristics of modern crises. Prioritising co-ordination across government, public agencies, and the broader science system over the long-term can facilitate the scaling up of capacity as it is required during crisis response. This includes putting more onus on retention of key personnel in relevant roles and having processes in place for accelerated recruitment and training.

Scientific knowledge is crucial to improve crisis preparedness and this has been a central and reoccurring theme in previous work on risk management and scientific advice (OECD, 2018[44]) (Baubion, 2013[51]). Several different types of activities can contribute towards preparedness, including the creation and operation of early warning or disaster risk surveillance systems, and developing and running routine crisis response drills and training, and foresight exercises. Collaborative participation of science and policy actors in all three of these areas is necessary to ensure that mutual understanding and trust is in place to facilitate the uptake of science advice during crisis response. Very few of the science advice initiatives introduced or reported on by OECD countries in relation to COVID-19 were explicitly described as being permanent or referenced foresight, preparedness, risk assessment, or resilience (OECD, 2021[45]). This is perhaps not entirely surprising, as the main focus has been on responding to urgent needs rather than preparing for the next crisis. However, it will be important to build on the COVID experience in looking to the future.

Early warning systems for public health emergencies and other crises have benefitted from several technological innovations, including: Big Data; improved modelling, simulation and visualisation capacities; and, digital crowdsourcing platforms (Box 11) (OECD, 2015[43]). At the same time, continued engagement of a diversity of scientific expertise is required to ensure that the increased data and information access that is afforded by these digital technologies contributes to the effectiveness of surveillance capacities rather than inadvertently detracting from them. Subject matter experts from different domains have played a critical role during the COVID-19 response by supporting policymakers in identifying and integrating the most important considerations for policy and for navigating concerns related to ethics, privacy, and civil liberties. Data and models – no matter how good and comprehensive – need to be interpreted and contextualised by scientific experts before they can be translated into scientific advice.

Box 11: Improving crisis response capabilities by learning from previous pandemics

Co-ordinated planning across sectors

The Korean pandemic response has benefitted extensively from learnings and structural changes implemented following past crisis response efforts. The Infectious Disease Control and Prevention act was created in 2010 and subsequently adapted, leveraging experiences from the 2003 SARS, 2009 swine flu, and 2015 MERS outbreaks (Asian Development Bank, 2021[13]). For example, lessons from the MERS outbreak related to how opaque situation analysis and a slow government response contributed to public distrust, anxiety, and ultimately heightened transmission levels. Learnings have been integrated into the Prevention Act to ensure a prompt and effective response from government, the release of information on cases, and clarity for patients on their obligations. The legislation also charges the Minister of Health and Welfare with developing and renewing a plan for infectious disease control and prevention on a five-year cycle, which forms the foundation for the country’s integrated system for preparedness. By adopting the vision and objectives set by the Minister’s ‘Basic Plan’, local governments have established enforcement plans for municipalities.

Based on learnings from the H1N1 outbreak response, the national government mandated the creation an Infectious Disease Control Center for each province/state to conduct related education and training, establish a local response system, provide surveillance and epidemiological investigation, and provide policy advice (Asian Development Bank, 2021[13]). Control centres provide an interface between the government and non-government actors, involving local universities and hospitals in outbreak response. At the national level, preparedness, prevention, and response activities are also informed by a standard manual, first developed by the Korea Centers for Disease Control (KCDC) and Prevention in 2010. The manual provides guidelines to support the operation of a pan-government crisis management system and delegates specific responsibilities to relevant institutions.

Integrating data collection

Much of the foundational preparedness that Chinese Taipei leveraged in its response to the COVID-19 pandemic came from experience in 2003 with a SARS outbreak. In 2004, the National Health Command Center (NHCC) was established under the island's Centers for Disease Control (CDC) (Kornreich and Jin, 2020[52]). Following the SARS outbreak the authority of the CDC and local health authorities was strengthened and an infectious disease prevention and control strategy was developed. NHCC guidance is based on intelligence from an integrated information system capable of gathering up-to-date information from various sources including National Health Insurance records, the Taiwan National Infectious Disease Statistics System and media reports. Based on strategic exercises to identify and address weaknesses in the island's crisis response capacities, the information sharing system was modernised from paper to digital in 2017. Apps were also developed to facilitate contact tracing and enable 'trusted users' to access civilian travel data.

In 2004, Chinese Taipei introduced the Enforcement Regulations Governing the Central Epidemics Command Center, which gives the Ministry of Health and Welfare the authority to establish an ad hoc Central Epidemic Command Control (CECC) during a crisis (Kornreich and Jin, 2020[52]). For COVID-19, a CECC was established on January 20, 2020. This co-ordinated response efforts across various associated ministries and agencies through the development of policy and integration of resources. It is staffed by teams of public officials and specialists from across ministries and agencies, which enables policy decisions to be implemented in a strategic and co-ordinated way.

2.2 Developing interdisciplinary and context-sensitive advisory structures

"We need to also focus on mental health, domestic violence, etc. to have a broader perspective on the impacts of the pandemic"

"In synthesising knowledge, different weights should be given to different inputs in different contexts in relation to their relevance but there's not a lot of theory on how"

"Officials are assumed to have the capability to be able to take all of these different types of knowledge and synthesise them appropriately but there is a significant lack of methodology and skills to do this kind of work well"

"It often seems that scientists agree on the science but different normative views (e.g., risk tolerance) shape how we go about responding to crises"

"How advice from groups looking at socioeconomic issues came together and made it into the debate was unclear and it was less visible than medical advice"

"Asking the same questions to several different bodies takes more time, potentially wastes resources, and does not necessarily ensure agreement. It can allow politicians to make decisions based on what they want to do anyway"

"It may be better to only have one, transdisciplinary science advice group to cover different recommendations. The social sciences and civil society should be represented"

"What is an expert? They need to have an open mind to build consensus and understand different conclusions. Lots of researchers know how to be a 'scientist' but do they know how to be an expert?"

"Time pressure may require that certain decisions be advanced without complete consensus"

"Science advice requires a bespoke approach. There is often no overlap between the type of advice required during response versus what is required in recovery"

"We should be careful about reducing the complexity of the human experience and society to the single field of behavioural sciences"

"There are layers of scientific evidence. Some actors simply need the conclusion but it's important that the details of how decisions were made are transparent"

"An awareness of ethics is required to understand how different aspects can be merged across disciplines while integrating universal values"

"It is difficult for policy-makers to consider a range of different science advice and it is difficult for scientists to accept reduced weighting of their advice"

"Bodies developed for the pandemic may not have the right make-up for future crises and may require adjustment"

Note: A curated selection of significant quotations was taken primarily from the 'Scientific advice in crises' workshop held in March 2022. A complete list of workshop participants is available in Annex 4.

Various factors, from globalisation and technological advances to ecological, demographic, and societal changes have contributed to an increase in complex and novel crises. Interdependencies between the natural, human, social, political, economic, and technological aspects of crises within and across countries require the collation and synthesis of input from a diversity of scientific disciplines and sectors. This enables policymakers to make decisions based on a comprehensive understanding of the situation and can help mitigate the risk of cascading or domino effects (OECD, 2018[44]). However, only a handful of countries have established knowledge management systems or expert networks that transcend disciplinary and sectoral boundaries. This lack of knowledge integration has been evident during COVID-19, when even in countries with well established, centralised crisis management structures, science advice had to be solicited from multiple sources, often in an ad hoc way. Co-ordinating and integrating these different inputs, in the absence of previously tested processes and mechanisms, has not always been easy.

Many of the advisory groups that were established in the early days of the COVID-19 pandemic had a strong biomedical focus and included expertise primarily related to epidemiology, virology, and infectious diseases (OECD, 2021[45]). Some of these same groups were often involved in both setting research agendas (see chapter 1) and providing scientific advice. During this period, there was a comparative lack of representation of other research fields in scientific advice structures (Colman et al., 2021[53]). Over time, it became more widely accepted that the pandemic was also a social crisis with secondary implications touching all sectors of societies and that advice for policies required the engagement of a much broader range of scientific disciplines (Box 12). It is likely that critical opportunities for effective policy intervention were foregone during initial response efforts in many countries with persistent longer-term consequences. Many countries have had significant problems in targeting PHSMs and public communication efforts to address the challenges, needs, and concerns of citizens (OECD, 2021[54]). Strict adherence to standardised universal approaches, down to the language in which official guidance was provided, may have contributed to increased transmission and more severe outcomes for certain groups (O'Sullivan, Rahamathulla and Pawar, 2020[55]). As response efforts have transitioned to recovery in most countries, the composition of advisory boards has begun to change to reflect emerging priorities and needs but it is unfortunate that many of these were not foreseen and addressed earlier.

Box 12. Including social and behavioural insights in science advice

Early in the Dutch COVID-19 response, policymakers prioritised the use of science to better understand how young people could be motivated to adhere to PHSMs. It was understood that young people had a key role to play in minimising transmission but were less likely to be directly impacted and thus less motivated to adopt official recommendations. In response to the crisis, the Dutch National Institute for Public Health and the Environment (RIVM) established a targeted corona behavioral unit in March 2020 to support policymakers in integrating behavioral insights (BIs) into policy (Leurs, 2020[56]). The team has been guided by an advisory board of 15 behavioral science professors with no direct affiliation to RIVM and was incorporated rapidly into the national science advice structure (Buijzen et al., 2021[57]). However, it has been noted that it took much longer for members of the team to be included in science advice functions that are supporting medium- and long-term planning The corona behavioral unit has provided expertise for a large-scale study co-developed by RIVM and the Netherlands Municipal Public Health Services and Medical Assistance in Accidents and Disasters (GGD GHOR) on how communication and policy during the COVID-19 pandemic have affected knowledge, attitudes, behavior, and physical, psychological, and social wellbeing over time. A study survey of around 50,000 people was repeated every few weeks over several months with the co-operation of all 25 of the country's municipal public health services (Leurs, 2020[56])..

There appears to have been a relatively even split between countries using one primary advisory structure and those using multiple groups to inform the development of policy during the pandemic response (OECD, 2021[45]). Ad hoc expert groups have been convened in many countries to address targeted tasks, such as surveillance and the development of science-based countermeasures or PHSMs, although only two countries, namely Finland and Canada reported more than five separate national science advice initiatives. In some situations where multiple advisory groups were given a formal role, science and policy actors faced difficulties in directing questions to the appropriate body. Using multiple bodies also required the integration and synthesis of potentially conflicting advice. In short, the ad hoc way in which science advice structures were developed and augmented in many jurisdictions made the science-policy interface needlessly complex and time consuming. It also created opportunities for policy-makers and elected officials to 'shop around' for science advice aligned with predetermined courses of action (Zaki and Wayenberg, 2020[58]) (Hodges et al., 2022[59]). In responding to future crises, it will be important that mechanisms to co-ordinate scientific inputs from distributed science advice structures are developed and tested in advance to ensure visibility, co-ordination, and synthesis of inputs for the development of timely, relevant, and robust policy.

On the other hand, scientists working on individual advisory groups with diverse expertise also faced difficulties. Despite later stage efforts to engage the social sciences and humanities, already established views regarding the hierarchy of science advice and how it should be prioritised tended to persist. For example, some social science experts reported feeling pressured to adapt how they communicated their research and methodologies to ensure acceptance by other disciplines (Colman et al., 2021[53]). This relates partly to considerations of what is objective versus what is subjective, and it is important to acknowledge that regardless of the discipline, scientific knowledge develops within a value-rich context (OECD, 2015[50]). How scientific questions are framed can significantly impact both quantitative and qualitative data and analyses. Advisor testimonials point to several ways in which collaboration across disciplines can be improved, including: leveraging pre-existing collaborations; creating a community- and consensus-based working environment; practicing respect for others' specialist knowledge; and having time to learn, broaden scientific horizons, and build trust (Colman et al., 2021[53]). These conditions are not easily created over-night and long-term investment in interdisciplinary networks and dialogue can be an important enabler of interdisciplinary advice for future crises.

Close engagement between conventionally siloed scientific disciplines during the COVID-19 response also highlighted more general challenges of interdisciplinary knowledge generation. Collaboration between disciplines using different or conflicting theories or terminologies can generate tensions that require mediation. There is a need to prioritise the development of skills and methodologies that enable the equitable consideration of alternative views and promote a culture of mutual understanding and trust across disciplines, geographies, and other boundaries (Mulgan, 2021[60]). When appointing or soliciting members of advisory boards, it is important to keep in mind that the qualities of a good scientist do not always equate to those of a good expert or advisor, particularly during an emergency. While science advice does require strong and relevant scientific expertise, a variety of other characteristics are critical, including, communication skills, diplomacy, having an open mind and policy-making experience or knowledge (OECD, 2015[50]) (OECD, 2018[44]). These skills are not always evident, as current incentives in the public research system have led to an increasing emphasis on specialised knowledge and, in some ways, reinforced siloes between disciplines. Approaches to science advice taken by several jurisdictions during the COVID-19 pandemic illustrated that effective and timely integration of different inputs may also benefit from the clear designation of central contact points (individuals or institutions). In some instances, chief science advisors or chief medical officers have acted as designated and experienced champions operating at the science-policy interface to guide the process of knowledge synthesis (OECD, 2015[50]). Depending on their responsibilities, actors in these roles can be instrumental in bridging boundaries between scientific evidence, societal values, economic considerations, and policy decisions.

Deconstructing a complex situation into different and interrelated dynamics and more basic scientific elements enables science and policy actors to engage in 'sensemaking' or the meaningful interpretation of research, data, and information into actionable knowledge and understanding (Box 13) (OECD, 2012[61]) (OECD, 2018[44]). It appears that in most pandemic advisory processes, evidence synthesis was primarily an informal and dialogue-driven process targeted to reaching consensus. In contrast, when a systematic and evidence-based approach is taken, there is potential to organise and weigh different inputs in relation to the context and in alignment with the context-dependent nature of knowledge, in general. There is also an opportunity to effectively focus multidisciplinary expertise towards dealing with 'unknown unknowns', which requires conceptual rather than technological tools to assess intertwined economic, social, environmental, and political dynamics (Box 13) (OECD, 2015[43]). This approach requires a full picture of the domains, disciplines, and types of knowledge that are relevant to a particular situation. It also requires tools and/or methods to appropriately organise and weigh different elements in relation to the context. In the absence of these conditions, such a systematic approach to evidence synthesis was rarely adopted in response to COVID-19.

Box 13. Data and knowledge synthesis

Leveraging multiple data sources to predict the early course of the pandemic

Initial policy decision-making in Wuhan was informed, in part, by epidemic nowcasting, a specific short-term forecasting methodology which integrates pathogenic, epidemiologic, clinical, and socio-behavioural data to understand the unfolding nature of an ongoing outbreak (Wu et al., 2021[11]). Nowcasting aims to consider a comprehensive suite of factors with the potential to impact how a situation will unfold. In the case of COVID-19, relevant factors included origin of the virus, the presence of human-to-human transmission, transmissibility (R factor), virulence, epidemic size, PHSMs, treatment options, and social behavior. On top of situational information, such as the size the local epidemic, experts used a variety of other data, including national mobility data from airlines and location-based services to support national authorities in China to implement stringent, timely, and relevant lockdown procedures (Wu, Leung and Leung, 2020[62]). For example, early analysis indicated that dozens to hundreds of cases had already been exported from the Wuhan region to multiple large cities, leading to a high likelihood of sustainable human-to-human transmission outside of the outbreak zone. Many of the cities identified were global transportation hubs, suggesting the immediate need for significant and global public health interventions, such as lockdowns, work-from-home arrangements, and school closures.

Integrating inputs from across disciplines

Recent work of the International Public Policy Observatory (IPPO, https://covidandsociety.com/) has been drawing attention to the use of scientific methodologies to more effectively integrate interdisciplinary knowledge into scientific advice and policy decisions. IPPO is a collaboration between several United Kingdom universities, the International Network for Government Science (INGSA), and the academic news publisher, The Conversation. The collaboration has identified gaps in synthesis capacities that might be addressed through more conscious attention to the necessary skills, structures, and processes. A related report speaks to different types of synthesis and outlines a staged approach that can be taken to create additional value to scientific information in the form of insights or options (Mulgan, 2021[60]). The analysis distinguishes synthesis from aggregation, positing that the purpose of synthesis is to integrate inputs to develop a product that is more useful than what would result from the simple aggregation. Furthermore, synthesis for the purpose of understanding differs from that which prioritises action. Seven steps are proposed:

1. Mapping related inputs and insights, relationships, models and other elements in a common language
2. Ranking elements in relation to explanatory, causal, and predictive power
3. Merging or combining different elements
4. Identifying trade-offs and synergies between elements
5. Identifying how systems of knowledge and power might impact the synthesis or resulting actions
6. Developing novel concepts, perspectives, models, or insights that transcend individual elements
7. Interrogating and assessing novel insights and options and the degree to which they may create or destroy value

The use of effective synthesis is recommended to assemble multiple actions to address a complex problem more successfully. With regards to COVID-19, this relates to the importance of science and policy actors understanding how various aspects of response efforts interact to leverage mutual synergies and prevent unintended consequences. This work also makes several recommendations for centres of government: 1) facilitate skills development for senior decision makers to enable them to integrate complex information; 2) develop capacity, such as multidisciplinary teams of specialists to complement advisory committees; and 3) promote integration and synthesis mechanisms capable of establishing a common language across disciplines and incorporating lessons and feedback.

Improving skills and capacity to integrate science and data into policy

The United Kingdom's national data strategy sets out commitments to improve data literacy across the public sector, from analysts to public servants and senior officials, and other actors, including companies and the general public (Open Data Institute, 2022[63]). Several initiatives have been introduced to implement this strategy. The Government Skills and Curriculum Unit was set up in September 2020 to provide learning and training across government and the Government Statistical Service offers a range of courses and resources. In particular, a Data Masterclass for Senior Leaders has been important to supporting non-analyst senior leaders in developing the knowledge and skills necessary to integrate science-based data and evidence into their decision-making processes, including during the COVID-19 pandemic response. The masterclass was launched in 2021, covering data-driven decision- and policymaking, communicating compelling narratives through data, and new frontiers of data science. In its first year, 3,000 learners enrolled.

2.3 Co-ordinating local, national, and international science advice activities

"Individual data on cause of death was not available promptly and had to be collected manually from local governments"

"There is sometimes a lack of integration between responses at different levels"

"Science and evidence is global but science advice is treated as if it is only national and is used to inform

"Once decisions impact those outside the national zone of responsibility (e.g., with border controls), sound decisions must also consider those impacts rather than simply maximising benefits or mitigating risk in the local context. Vaccine inequity is central to this point"

"Destruction of collaborative mechanisms has been a lost opportunity during the pandemic. Individual countries didn't want to compare notes on risk and consequences" decisions taken within jurisdictions"

"There has been disparity between federal and state governments. State responses have pushed things forward in a lot of cases"

"There is much work needed at the African regional level to develop science advice that is useful for the continent"

"Lack of collaboration between national science advice structures has served the world badly and cost an enormous number of lives"

"The WHO has done well in comparison to several national governments but it is also an organisation that is spread very thin and has too little expertise in the social sciences"

"We looked worldwide to what was happening to make a decision on whether second vaccinations would be prioritised over giving more people the first dose. Good data wasn't yet available to support a decision"

"We can have our own policy but if we don't act together and share science advice, the impact of policy will be limited and potentially counterproductive"

"Science diplomacy and science advice structures for policymaking are necessary at the global level and should be a priority for future global crises"

Note: A curated selection of significant quotations was taken primarily from the 'Scientific advice in crises' workshop held in March 2022. A complete list of workshop participants is available in Annex 4.

Approaches taken by national governments to co-ordinate with sub-national and local governments and public agencies have been highly variable across countries during the COVID-19 response. Public health and other socially oriented roles and responsibilities are often allocated differently across levels of governance based on multiple factors, including mode of government, constitutional division of powers and statutes (Greer et al., 2022[64]). Co-ordination across levels of government was a critical element of the pandemic response efforts of many countries and the importance of this has been emphasised by the WHO (WHO, 2020[65]) (OECD, 2021[54]). When done effectively, it can prevent the implementation of conflicting measures and limit the ability of authorities to shirk or deflect accountability. Co-ordination also has the potential to support policy and science actors in leveraging synergies between national and subnational resources and access local insights to help target PHSMs and medical countermeasures to specific territorial needs. At the same time, it is an area that requires concerted attention. In a 2020 survey in Europe, only half of subnational government respondents indicated that vertical co-ordination mechanisms had been effective in managing the COVID-19 pandemic (OECD-CoR, 2020[66]) (OECD, 2021[54]).

The severity of the COVID-19 crisis has been influenced by local dynamics and the pandemic has disproportionately impacted particular places or population groups. This has been the case, for example, for densely populated areas with less robust public health capacity or less financially secure populations (OECD, 2021[54]).The pandemic response has reminded the global science community and national policy-makers that social determinants of health and disparities in healthcare access across states or cities are high in many countries. For example, based on disproportionate mortality rates in more deprived areas of England and Wales, the United Kingdom's Office for National Statistics (ONS) found that poverty and population density contribute significantly to the risk of death due to COVID-19 (Iacobucci, 2020[67]) (OECD, 2021[54]). Unfortunately, this is not an outlier and similar case studies can be pointed to across many countries. It is imperative that policymakers improve co-ordination between local and national science advice activities and take account of social disparities in policy development processes.

The issue of co-ordinating response activities within and across governments is generally dealt with one of two ways (OECD, 2018[44]) (OECD, 2017[68]). Centralised administrations tend to use top-down and vertically co-ordinated crisis response processes, with mechanisms in place to scale activities when local capacities are overcome. Alternatively, in decentralised institutional systems or federalist jurisdictions, subnational governments tend to have the primary responsibility for crisis management and may request support from the national administration when necessary (See Box 14). Over the course of the pandemic response, some countries introduced new legislation, such as emergency laws, to increase the authority of the federal government or its capacity to act without consensus among elected officials (OECD, 2021[54]). Others chose to temporarily allocate additional powers to subnational governments. Both methods have benefits and drawbacks. While centralisation can improve the capacity of policy-makers to implement a rapid and uniform response, potentially addressing inequalities across states, a decentralised system offers more flexibility and opportunity for experimentation when dealing with complexity and uncertainty (OECD, 2018[44]) (OECD, 2021[54]). Where networks of experts have been pre-established in decentralised systems, it is likely also that a certain amount of duplication or redundancy can provide some element of quality control. Regardless of the approach taken, the OECD has put forward several recommendations regarding multi-level governance in crises.[5] Important takeaways include: clarifying roles and responsibilities, maintaining continuous dialogue, and sharing evidence and data to address place-based impacts (OECD, 2021[54]). These three issues proved to be highly pertinent in relation to COVID-19.

Box 14. Intra-national co-ordination of science advice and policy

Switching between bottom-up sub-national and top-down federal decision making

The pandemic response strategy adopted by Germany was highly dependent on the severity of the situation, fluctuating between a distributed, territorial-focused approach to more centralised control. During the first phase of the response, from the end of January to mid-March, in accordance with the Federal Law on the Prevention of Infection, the federal government served mainly in a consultative capacity (Kuhlmann and Franzke, 2021[69]). The implementation of restrictions and service delivery and ensuring vertical co-ordination of monitoring and prevention were primarily managed by subnational authorities – 16 state governments and local governments. Similarly, a distributed suite of institutions was engaged to provide science advice, including the Robert Kock Institute, a national Ethics Advisory Board, and a broad network of autonomous institutions from the public research sector (Hanson et al., 2021[70]). Several research institutes developed their own advisory boards to feed into the process. This approach aligns with the general structure of the German healthcare system, which is highly decentralised and managed by a collection of local institutions. Local 'Corona Crisis Teams' were created in all counties and several major cities to aid local governments and ensure the integration of local capacities across a variety of functions. Some deficiencies in this approach have been noted, including limitations in the capacity of local health authorities. In some regions, outdated digital tools and IT systems also challenged the local response, requiring officials to share data by phone or fax, which resulted in avoidable delays and inconsistencies.

When the country reached its first peak in cases in March-April 2020, there was a shift in governance-style, with increasing top-down intervention, hierarchical co-ordination across governance levels, and an agreement between the Bunderstag and Lander to streamline and unify decision-making (Kuhlmann and Franzke, 2021[69]). At this time, it was decided at the federal level that the rising infection risk level required a uniform national containment strategy. The authority of the Federal Ministry of Health was temporarily enhanced through new legislation, which gave the Minister the ability to issue unilateral mandates without approval from parliament or the Lander. When the first wave of infection declined, discretionary decision-making powers were returned to the local level. Federal and state governments jointly decided to extend most restrictions, but it was left up to local governments to determine implementation parameters. A small number of common guidelines were embraced across states, including a 'uniform regional response model' requiring counties to register increased infection rates with the federal government.

Co-ordinating national and local response efforts

While other federalist countries did not take such a decentralised approach as Germany, efforts were made to co-ordinate initiatives taken at the national and sub-national levels. Canada established a Special Advisory Committee on COVID-19 to advise federal, provincial, and territorial health departments across the country regarding the technical content of health policy related to the outbreak and to facilitate co-ordination across local policies as well as between local and national policies. Similarly, the Australian Health Protection Principal Committee is a longstanding mechanism with the capacity to make decisions during health emergencies. It acts as a mechanism to bring together all of the country's sub-national chief health officers and is chaired by the national chief medical officer. The committee's mandate is focused on mitigating emerging health concerns stemming from infectious disease, the environment, and natural and human made disasters. It advises the Australian Health Ministers' Advisory Council during periods between crises and on an ongoing basis on matters of national priority and public health.

The pandemic has been a 'global shock', i.e. "a rapid onset event with severely disruptive consequences covering multiple continents" (OECD, 2011[71]) (OECD, 2018[44]). Effective response has necessitated global action, co-ordination, and collaboration as the geographic scale, complexity, and novelty of the situation has exceeded the capabilities of any single country. The importance of international information exchange had already been evident in past coronavirus pandemics. For example, limited communication of scientific advice between the Middle East and Asia during the 2014-15 Middle East Respiratory Syndrome (MERS) outbreak led to significant delays in diagnosing and managing the infection in Korea (OECD, 2018[44]). Despite these earlier experiences, a number of obstacles to international co-operation persisted during the COVID-19 pandemic, including: legal issues, national security concerns, data interoperability, cultural differences, and political, economic, and commercial interests. Such obstacles impacted the generation of science advice directly, and also had implications for the types and topics of evidence requested by and adopted by policymakers.

The overall impacts of the pandemic and the use of countermeasures and policy interventions have considerable commonality across countries but there has been a significant lack of action or appetite from national policy and science actors to share information on how national response efforts evolved (Bump, Friberg and Harper, 2021[72]). There has been limited exchange of experience and good practice, which has prevented mutual learning. National scientific advice has been limited in its international scope, including its capacity to leverage learnings from other jurisdictions.[6] Limited consideration of the whole picture has increased the risk that the policy decisions made in one jurisdiction will undermine or conflict with interventions in other countries. Rolling national border closures provide an illustrative example. Co-operation has been made more difficult by mobility restrictions, which are also a sensitive political issue, particularly for regions with high numbers of cross-border workers (OECD, 2021[54]). Many countries have failed to consider or act to co-ordinate policy interventions, instead adopting and phasing out unilateral measures to create a patchwork of policy which has become increasingly difficult to keep track of, contributing to the confusion and apathy of citizens (Hodges et al., 2022[59]). Border closures also raised a significant issue when South Africa was penalised after its scientists identified a new strain of the virus, Omicron, in November 2021 and rapidly made this information available worldwide ((n.a.), 2021[73]). Several countries banned travel to and from South Africa despite the scientific consensus that this was not an effective countermeasure and would inhibit countries from sharing valuable scientific information in the future

International collaboration can take many forms, from the communication and exchange of data, information, and expertise to more formal mechanisms, such as agreements, frameworks, or even the development of transnational agencies. Global organisations and advisory mechanisms serve an important leadership function, supplementing and assisting national science advice structures through a variety of activities. It has been noted that the roles nominally filled by international advisory bodies appear to be expanding in line with the growing number of transnational issues, including climate change, energy, food security and emerging infectious diseases (OECD, 2015[50]). In each of these areas, it is clear that the authority and effectiveness of the international structure depends on its links to national scientific and policy communities.

Box 15. International co-ordination and exchange

Developing global inter-governmental advice and guidance

WHO teams have been proactive in developing, releasing, and updating guidance and educational materials targeted to health decision makers, clinicians, civilians, and others over the course of the pandemic. The organisation has published over 100 documents, with more than half providing detailed technical guidance on various aspects of the response, including targeting care to illness severity, contact tracing and quarantine, minimising transmission, and protecting healthcare workers. The OpenWHO platform (https://openwho.org/) provides users access to more than 100 free online courses related to COVID-19 for different stakeholders. In response to question about the origin of the COVID-19 virus, the WHO convened a Scientific Advisory Group for the Origins of Novel Pathogens. The focus of the advisory group is broader than COVID-19 and it will support the development of a global framework to inform studies on the sources of emerging and re-emerging pathogens with potential to evolve into epidemic- or pandemic-scale crises.

Previous analysis of the WHO's use of scientific advisory committees (SACs) noted that technical needs are generally the primary mandate but broader strategic objectives can be included. In either case, the effectiveness depends on a number of key issues (Gopinathan, Hoffman and Ottersen, 2018[74]):

1. independent committees require autonomy from convenors, employers, and those who will receive the advice;
2. trade-offs between quality, relevance, and legitimacy must be balanced;
3. supporting staff must balance the prevention of undue external influence and brokering interactions between experts and the external environment; and,
4. there must be balance between engaging stakeholders capable of implementing recommendations and protecting the neutrality and integrity of the scientific process.

Mutual learning on science advice in a non-governmental network

The International Network for Governmental Science Advice (INGSA, https://ingsa.org/) provides a global forum or community of practice for science and policy actors to come together and share experience. It has 5,000 members from ~100 countries. The network responded to COVID-19 by creating an information hub to facilitate information sharing and collaboration. One of the hub's main initiatives was a global evidence-to-policy tracker to provide longitudinal insights into how policy interventions evolved across national and sub-national governments.

The World Health Organisation (WHO) is the principal international body with responsibility for health, including infectious diseases. It has played a significant role in the global COVID-19 response, providing support in three primary areas: co-ordination, normative guidance, and technical steering (Hassan et al., 2021[47]). Its responsibilities and authority are set out in the International Health Regulations. Following the declaration of a pandemic, the WHO has provided regular, initially daily, press briefings, updates on the evolution of the scientific understanding of the virus and its transmission, and guidance on PHSMs (See Box 15). However, the Organisation has been criticised for failing to mobilise resources earlier, which relates to the underlying challenges posed by the high threshold for activating crisis response procedures and reliance of international agencies on the co-operation of member states. This latter challenge also impacts the up-take of scientific advice from the WHO and willingness of countries to accept and acknowledge the WHO as a legitimate global voice and formally contribute to its advisory processes.

In any case, countries need to reframe many aspects of international guidance to align with their local context before it can be used to inform policy. Not all countries have the scientific capacity required to undertake this and it is important that the international community continues to invest in and assist nations in developing their domestic science systems and science advice structures (See Box 16). Such assistance can often be integrated into established international partnerships. Informal network like the International Network for Government Science Advice (INGSA) or the Foreign Ministries Science and Technology Advisors Network (FMSTAN) can also play a role (Box 15).

Box 16. Investing in crisis response capacity to advance preparedness

Several countries in Western Africa have mobilised emergency operation centres established for previous public health crises to address the COVID-19 pandemic. Nigeria is one such example. In 2012, the Nigerian Presidential Task Force on Polio Eradication took initial steps to address the country’s limited capacity to respond to public health crises (Shuaib et al., 2017[75]). The result was the polio Emergency Operations Centre (EOC), which was funded by the Bill and Melinda Gates Foundation. When Ebola emerged in 2014, the Ebola EOC was modelled on the polio center and the polio incident manager and technical officers were engaged to support in managing the outbreak. Specifically, the Lagos State government, the epicenter of the Nigerian Ebola outbreak, developed emergency preparedness policies, invested in specialised human capacity, developed a robust monitoring system, and created a Level 3 biosafety laboratory and biobank. The allocation of financial and human resources to the response were prioritised by policymakers. After rapid success in containing the disease, the model was replicated across West Africa.

Faced with COVID-19, Lagos developed a response plan that explicitly leverages and builds on good practice and existing capacities strengthened in previous outbreaks. A month prior to the state’s first identified case, an Incident Command System was established to support the government (Abayomi et al., 2021[76]). As a result, diagnosis of the first case of COVID-19 in Lagos was made within six hours of arrival rather than the three days required to diagnose the first Ebola case in 2014. A COVID-19 Think Tank was also established to enable the government to leverage insights from a multidisciplinary team. Preparedness and accelerated deployment of the initial response enabled the Lagos government to allocate capacity to other strategic areas that would also serve to improve the effectiveness of the local response. For example, risk communication and capacity development were advanced through a suite of complementary initiatives. Various stakeholders, including from the private sector, religious and youth organisations, were engaged through meetings and training to ensure bottom-up risk communication would be responsive and proactive. Community focus group discussions were used to inform official public communication campaigns. Training and capacity development were also prioritised in areas like active surveillance, contact tracing, and laboratory diagnostics and testing capacity.

2.4 Increasing and maintaining the trust of civil society in scientific institutions and advice

“There were considerable security issues for science advisors. This is an ongoing issue and there are concerns people will be deterred from taking these roles in the future”

“Perceived autonomy of health officials can be undermined when they are made government spokespeople”

“Often times, politicians say something was scientific when it was political to avoid accountability”

“Avoid diminishing respectability and trust in science by averting aggressive conflict between different disciplines”

“Facts alone don’t speak for themselves. Legitimation of the process legitimates facts and not vice versa”

“Polarisation and pandemic fatigue and confusion led to scientific advisors being threatened”

“Several times, recommendations were only made public 3-4 weeks after decisions had been made”

“Politicians should feel fine with disregarding the science but they need to be transparent about it”

“Politicians and science advisors need to be able to explain

"If you want trust in science, you need to trust the public. People can deal with complexity, uncertainty, and unpleasant information" "Assigned roles and codes of conduct are needed between science and policy communities. These groups have different values, timeframes, cultures, and mindsets" "Inappropriate political interference directly altered the science advice process" "People want to engage with science that confirms their biases and then there is the issue of foreign governments pushing bad narratives intentionally"	their conclusions in plain language" "It's the role of scientists to provide an understanding of the costs and benefits associated with different actions" "Critical voices have played an important role both in challenging and improving science advice" "Public health recommendations have always been political but are increasingly thrown into partisan battles" "None of the scientific advisors have changed but there should be a process where advisors are exchanged"

Note: A curated selection of significant quotations was taken primarily from the 'Scientific advice in crises' workshop held in March 2022. A complete list of workshop participants is available in Annex 4.

In addition to the effective operation of science advice structures, efforts to build and maintain public trust in science advice have been critical to national COVID-19 response efforts (See ahead, Figure 4). Public communication and engagement in science contribute significantly to this, but the composition and public perceptions of science advice structures also play a role. Formal and transparent governance mechanisms for science advisory structures have been lacking across many jurisdictions. This deficiency likely relates to the rapid action that was required to set up and mobilise expert networks in the early days of the pandemic (Jarman et al., 2022[77]). In theory, clear, merit-based, and transparent processes would be used for the selection and turnover of science advisory experts to ensure legitimacy, independence, and the representation of different perspectives. However, it appears that procedures used to solicit or select advisors in most jurisdictions were relatively opaque and generally lacked any formal guidelines, e.g., on when or how new experts should be incorporated. This heightens the risk that certain high-profile experts or commonly held perspectives are privileged, while others are excluded (Hodges et al., 2022[59]). In addition, while many advisory groups required participants to disclose conflicts of interest, there were noticeable limitations in terms of procedures to validate declarations or manage conflicts ((n.a.), 2020[78]). Potential conflicts of interest for those involved in advisory processes need to be clearly defined and registered with transparent provisions in place to manage potential tensions (OECD, 2015[50]).

Legal frameworks can help to provide clarity regarding the formal liabilities of experts participating in science advice structures. Such frameworks, as well as support from government or academic institutions for legal advice or counselling, can provide experts with some protection from the verbal and physical threats that can arise in situations characterised by heightened polarisation or politicisation (Wright et al., 2022[79]). This has been a significant issue in several countries during the COVID-19 response. In many instances, scientists have become the face of national or local response efforts, including, at times, highly contentious PHSMs, and have had to contend with being the targets of abuse and threats. There is a risk that as science becomes more prominent in the development and justification of policy, it may also become more political (Gaieck et al., 2020[80]) (Suhay and Druckman, 2015[81]). Indeed, to a certain extent this is inevitable, and the potential dangers need to be mitigated through effective public communication and engagement. It is imperative that the societal concerns and issues that underlie and exacerbate polarisation and identity politics are considered and integrated into scientific research and advice. At the same time, it is also important to safeguard the independence, neutrality, and accountability of the processes through which science advice is developed and translated (or not) into policy. During the COVID-19 response, recurrent considerations included: maintaining a clear and visible distinction between scientific experts and policymakers; the need to distinguish between scientific expertise and personal opinions of scientists; maintenance of scientific integrity and rigour despite accelerated timelines; and being transparent about uncertainty.

Box 17. Formal and informal scientific advisory structures

In the United Kingdom, the Scientific Advisory Group for Emergencies (SAGE) provides scientific and technical advice to support government decision-makers during emergencies (Government Office for Science, 2022[82]). The group is dormant during periods between crises and is re-established at the request of the government's Civil Contingencies Committee (COBR) to support collective cross-government responses to serious emergencies (Cabinet Office, 2012[83]). The COVID-19 activation of SAGE has been supported by several subject-specific sub-groups and SAGE also receives input from a variety of additional expert groups or organisations, as necessary. Sub-groups have included, the Scientific Pandemic Influenza Group on

Modelling (SPI-M) and the Independent Scientific Pandemic Insights Group on Behaviours (SPI-B). SAGE advised on a wide range of science topics relevant to the pandemic response, although it did not provide economic or clinical advice, as this was provided to government via other advisory routes.

Participants in SAGE are experts from a broad range of disciplines from both inside and outside government. Experts from outside government are brought in to provide insight and expertise, as well as to challenge and debate. Experts inside the government who observe and participate include chief scientific advisors and members of scientific advisory groups across departments (Government Office for Science, 2022[84]).

During the initial stages of the pandemic, public concerns were raised about the transparency of SAGE and its membership, operation, and outputs. During previous emergencies, the practice was to put information into the public domain after the incident of concern had concluded, as SAGE activations tended to be short lived. Due to the nature of the COVID-19 emergency, its duration, and the intensity of the public's interest, the Government Office for Science (GO-Science), who are responsible for the SAGE secretariat, began to release SAGE information on a continuous basis from May 2020. This included SAGE minutes and papers, information on governance and participant details (Department of Health and Social Care, 2021[85]).

The perception of insufficient transparency may have been a factor in the creation of a science advice group that is entirely separate from the United Kingdom government, Independent SAGE (sometimes referred to as Indie-SAGE) ((n.a.), 2020[78]). The group livestreamed its first meeting on YouTube in May 2020. It was originally comprised of 12 members and a Chair but was expanded to include a behavioural science group of 9 members. The Chair, former government Chief Science Advisor, Sir David King, has pushed back against concerns about the group being viewed as a rival of SAGE, indicating that the practice of science is founded on the importance of peer review and maintaining distinctions between science and political decisions. Independent SAGE has presented itself as a group of scientists who are working together to provide independent scientific advice to the United Kingdom government and public. The group operates based on the idea that openness and transparency lead to better understanding and better decision-making, and that it is the responsibility of scientists and those with specialist knowledge to engage with the public and policy-makers to ensure that science benefits all of society (McKee et al., 2022[86]).

It is an ethical concern when weak or discredited hypotheses are used by scientists to support or advance their views and publicly undermine policies. This has occurred in relation to various aspects of the pandemic response from theories regarding virulence and transmission to social distancing guidelines, vaccines, and therapeutics, such as hydroxychloroquine.[7] It is critical that scientific experts distinguish between rigorous scientific knowledge (with all its uncertainties), and personal convictions, particularly when disseminating information through news or social media platforms (See Box 18). In this respect, communication professionals also have a role to play in distinguishing between commonly held and fringe perspectives. While academic freedom must be protected, it is a privilege granted by society that implies responsibilities in the way that science is conducted and communicated (Colman et al., 2021[53]). It is important that the public communication responsibilities for those involved in scientific advisory processes are clear from the outset. To complement this, existing codes of conduct and guidelines for good scientific practice might need to be extended to incorporate science advice and public communication as these becoming increasingly important functions for scientists.

The complexity and uncertainty characteristic to a crisis do not justify by-passing the standard procedures and requirements of good scientific practice or obscuring the gaps in knowledge being used to make decisions. On the contrary, these challenges make the reliability, rigour, and transparency of scientific evidence even more important. Regardless of the need for experts to mobilise and provide evidence in an accelerated capacity, there is also a need for quality assurance. Distributed science advice structures benefit here from built-in redundancies that can inherently provide the means to help validate advice being generated by different groups (OECD, 2018[44]). Peer review, while often not possible in a formal sense during crisis response, can also be valuable in addressing complex, multi-factorial issues and can occur informally through consensus building processes - the aim of such processes not being to reach absolute consensus but rather to clarify where there is, and is not, agreement. Perhaps most important, is that there is openness between scientists and with policymakers and the public regarding assumptions and uncertainties.

Box 18. Safeguarding scientific integrity during crisis response

The French National Centre for Scientific Research (CNRS) has advocated strongly for the scientific community to maintain research integrity and good ethical practice in responding to crises, in both undertaking scientific studies and communicating with the public. The organisation's ethics committee, COMETS, published a report in 2021, "Scientific Communication During a Health Crisis: Profusion, Value and Abuse" (COMETS, 2021[87]). COMET and the CNRS Mission for Scientific Integrity also released a joint statement to emphasise the importance of respect for ethics and a scientific approach that guarantees reliability, rigour, and honesty during crises. The report is a general response to violations of scientific integrity and ethical standards that took place during the pandemic and the publication, amplification, and subsequent retraction of studies with questionable underlying data and/or methodologies It also speaks to the sensitivity that is inherent to the interface between scientific advice and policy decisions during crises. Several recommendations are put forward for researchers, journalists, and research institutes regarding the communication of science to the public. These include:

- When expressing themselves to the public, researchers are responsible as scientists and must provide information on their professional background and the capacity in which they are communicating.
- Working hypotheses should be distinguished from knowledge that has been validated through scientific methods and peer review and margins of uncertainty in results should be presented transparently.
- Exchanges between scientists and journalist should be improved, including efforts to foster a mutual understanding of the operating environments and constraints of both professions.
- Science journalists must be better recognised and valued to mitigate the critical decline of the profession despite its importance to the dissemination of scientific results.
- Research institutes should encourage researchers to participate in training on science mediation
- Science communication activities in research and higher education institutes must include the development of strategies to combat disinformation in the media and within respective organisations.

Transparency can help mitigate reputational risks to science, such as perceptions of the public that scientific actors are responsible for contested political decisions. However, this also requires wider understanding around how science is translated into policy. Scientific evidence is just one of the many inputs that policy actors must consider when making policy decisions, a process which is inherently normative and political as these decisions are based on the prioritisation of certain values over others (OECD, 2015[43]). While many national governments implemented stringent PHSMs, such as lockdowns, to mitigate relatively small case numbers in the early days of the response, in many jurisdictions these were subsequently relaxed despite continuing waves of infection (and even in the absence of effective vaccination rates). The initial focus on lowering mortality rates was shifted by concerns about other socio-economic factors (Shimul et al., 2021[88]). While ethical and normative dilemmas can be informed by science advice in terms of the costs or benefits of one course of action rather than alternatives, it is ultimately the responsibility of politicians and policymakers to select which options to implement. At times during the pandemic, this required advisors to cope with frustration or disappointment when the scientific evidence provided was not the dominant factor in the policies that were developed (Colman et al., 2021[53]).

Box 19. Conflicting roles of Chief Medical Officers

An international study addressed the ambiguity, variability, and controversy surrounding how national Chief Medical Officers (CMOs) operated during the pandemic (MacAulay et al., 2021[89]). The CMO title is typically used to refer to an appointed doctor or civil servant engaged to advise the government and communicate to the public. There was disagreement during the pandemic regarding whether it was good practice for CMOs to act as independent contributors to shape policy, or act as civil servants. The responsibilities of CMOs are inherently conflictual, with those serving in these positions being accountable to the government, the medical and public health communities, and the public. Comparative analysis of CMO positions across Australia, Canada, the United Kingdom, New Zealand, and the United States found:

- The independence of CMOs in some countries has been safeguarded through statute, giving them the ability to issue reports without government approval. At the same time, enhanced powers of the CMO have been questioned regarding how long and to what extent unelected officials should be given the authority to make unilateral emergency decisions.
- There is variability across countries in terms of whether the CMO is drawn from the civil service or is engaged from outside of government. Where there is a lack of clarity between science advice and policy decisions, there is increased risk of policymakers and politicians 'hiding' behind the advice of CMOs. This has even been true where policy decisions deviated from the science advice.
- COVID-19 challenged legislation in many instances due to protracted timelines and the extraordinary engagement required. While the appearance of CMOs at government press conferences reflected positively on the credibility of government communication, it increased the risk that the CMO's personal credibility would be undermined.
- The capacity of CMOs to influence policy decisions is determined by several factors, including: their access to decision-makers, such as ministers, and the degree to which their advice is shared with others. Some have questioned whether having CMOs participate in science advisory processes, while mediating between experts and policymakers obscures the difference between science and policy.

Based on the results of the analysis, researchers advocate for national CMO roles to be developed using a nuanced and evidence-based approach. Context-specific factors should be examined, as well as the different objectives being targeted in the shorter- and longer-term.

Defining and institutionalising responsibilities between policy and science actors in legislation, as has been done in some jurisdictions, can provide an important reference point as to where the boundaries are between the two functions, which can help improve mutual trust (See Box 19). Clarity can also provide reassurance to external actors, including the news media and the public, regarding scientific credibility and make it more difficult for political actors to 'blame the science' for unpopular policy decisions (Greer et al., 2022[64]). During the COVID-19 response, many politicians adopted the justification that they were 'following the science', a statement that has conflated the practice of evidence-based policy development with its obfuscation and been used to avoid accountability and provide easy justification (Colman et al., 2021[53]). Clarifying and communicating the roles of science and policy actors is important for protecting scientific processes and the communication of science advice against inappropriate political interference.

Many jurisdictions experienced the politicisation of science advice to a lesser or greater degree. Sometimes it was relatively innocuous or even positive, such as the heavy reliance on science advice for 'sense making' that was common in the early stages of the pandemic response in most countries (Hassan et al., 2021[47]). In other instances, politicians ignored formal science advisory processes and spread 'scientific' misinformation based on personal convictions or potential political gains.[8] At its most extreme there was obstruction of science-based guidance or even intervention in the underlying systems providing data into science advice processes (see Box 20). Building a resilient science advisory system that can operate effectively in the public interest in the absence of political support is not easy but is critically dependent on society supporting academic freedom and scientists embracing the responsibilities associated with this freedom.

Box 20. Regulatory frameworks for science communication

Safeguarding federal science agencies from political interference and ensuring scientific integrity

The United States COVID-19 response has been criticised for the ability of the elected administration to interfere in the operations and communication of federal science agencies and the resulting negative implications for public trust and efficacy of the national response. Investigations have taken place into the involvement of White House officials in the dramatic relaxation of guidelines for reopening places of worship and schools, the revision and obstruction of publications, denigration of federal scientists and preventing their interaction with the news media (Piller, 2020[90]). It is possible that this level of political scrutiny and retaliation also contributed to several situations where official guidance was either quickly reversed or critically opposed by third-party experts.[9] As a result, public trust in the Centre for Disease Control (CDC) which plays a critical role in providing scientific advice on public health issues, dropped precipitously during the pandemic.

More structural in nature are the significant changes that political appointees were able to make to aspects of the response like data collection. The National Healthcare Safety Network (NHSN), the CDC system for collecting hospital data built over the previous 15 years, was discontinued in 2020 and responsibilities reallocated to a private hospital data management company (Piller, 2020[90]). The change was instituted due to the system in place being unable to meet demands to report 100% of COVID-19 data, daily. However, practices requiring the manual collection of the majority of data have largely been continued, while rates of missing data rose from 3-6% under the NHSN to 36-57% under the outsourced arrangement. In August 2022, the CDC resumed responsibility for the collection of COVID-19 hospital data.

The inauguration of a new United States administration in 2021 spurred the development of a report by the scientific integrity fast-track action committee, Protecting the Integrity of Government Science, in January 2022. This reaffirmed six principles or actions for ensuring scientific integrity that had previously been identified in 2009: staffing science and technology positions with candidates with appropriate experience; institutionalising integrity; prioritising peer review and transparency; addressing factors compromising scientific integrity and information; and ensuring the integrity of processes and information used to inform decision-making (Nelson and Lubchenco, 2022[91]). The report also identified six other critical areas for attention: benefits of dissent; a whole of government approach; science at the policy table; transparency in sharing science; and, accountability. The document identifies good practice for strengthening scientific integrity in several areas, including: handling scientific disagreements; engaging with the media and using social media; establishing trust between scientists and communication professionals; and engaging with emerging technologies and processes (National Science and Technology Council, 2022[92]). Next steps will include the development and implementation of a framework to make the recommended principles operational.

Regulating science-based communication

The Italian Law 150/2000 that was introduced in 2020 provides a framework for the communication of Italian public service employees to citizens. This Law addresses concerns about the roles of scientific experts in providing advice and communicating to the public during the L'Aquila earthquake in 2009. A government -employed scientist was condemned in a court case following the earthquake. The legislation aims to provide clarity on the role of civil servants in undertaking information and communication activities as well as institutional and political communication. The law defines information activities as those targeted to mass media to disseminate a narrative regarding the administration's business, services, policies, and regulations. External communication is intended to provide a means to engage with citizens and improve government services. Institutional communication is meant to be carried out by the press office, an autonomous unit connected with other information bodies, while political communication is the responsibility of government spokespersons. The law specifies that both employees of the press office and spokespersons are not permitted to undertake activities in radio, television, journalism, the press, or the public relations sector while in those positions.

Scientific Advice Policy Recommendations

Recommendation[3]	Policy Options
1. Policymakers and science organisations must take sustained action to ensure that the structures, capacities, and good practices are in place to generate robust and timely science advice in crises.	1.1. Ensure that sustained, long-term and strategic investment into science is made to provide the evidence base that is needed to manage future pandemics and other crises. 1.2. Involve the scientific community in long-term emergency preparedness activities to facilitate rapid mobilisation during crises and ensure alignment between scientific advice, policy needs, and crisis management processes. 1.3. Proactively establish mechanisms and processes to ensure that existing capacities can be rapidly leveraged and adapted as necessary and that scientific institutions are prepared and supported to effectively respond during crises.
2. Science and policy actors must work together to ensure that science advice structures and processes have access to a wide breadth of expertise and are tailored to their specific operating context.	2.1. Include and prioritise a diversity of expertise in science advice structures. Where a diversity of perspectives is obtained from multiple advisory groups, it is important that mechanisms are developed and tested in advance to ensure co-ordination and synthesis of inputs and their translation into policy processes. 2.2. Prioritise the development of the culture, skills, and methods required to synthesise insights from across different disciplines, geographies, and sectors in the development of science advice. In some situations, the integration of diverse inputs may benefit from, or require, guidance from designated and experienced champions. 2.3. Ensure that science advisory processes at different geographic scales are fully adapted to their particular context and reflect the history, culture, regulatory and administrative regimes in which they operate.
3. Policy and science actors must improve co-ordination and exchange between local, national, and international science advice activities. Equity, diversity, and inclusion are important considerations in this regard.	3.1. Improve co-ordination and communication between sub-national and national-level science advisory structures, ensuring clarity regarding divisions of responsibility and remits. This is of particular importance in federalist jurisdictions and where there are significant economic and social disparities across territories, which need to be reflected in policy. 3.2. Prioritise the use of established international agencies and collaboration channels to inform the development of universally relevant science advice and facilitate the dissemination and adoption of good practices across countries. 3.3. Invest in the long-term development of science and science advice capacities in LMICs and ensure that international science advice and policy development is representative of the challenges, concerns, and opportunities occurring across all countries.
4. Science and policy actors must develop and implement long-term strategies to increase and maintain the trust of citizens in scientific institutions and science advice.	4.1. Integrate formal and transparent governance mechanisms into science advice structures to ensure their legitimacy and independence. These can include the clear and merit-based selection and replacement of science advisors and the declaration and verification of conflicts of interest 4.2. Embed quality assurance processes into science advice structures that ensure that the scientific evidence, which informs policy, is robust, reliable, and aligns with ethical standards. 4.3. Clearly and transparently distinguish the roles of scientific experts and policymakers in the development and use of science advice; and protect the independence and autonomy of science, recognising that its translation into policy is an inherently normative and political process. 4.4. Clarify and codify the legal liabilities of science advisors, while establishing mechanisms to mitigate the politicisation of science and protect experts from verbal and physical abuse.

3 Public communication and engagement in science

Key Messages

- The evolving information ecosystem and increased access to a diversity of digital tools and platforms, pose both challenges and opportunities for public communication and engagement. Social media platforms open up new and exciting possibilities and, at the same time, are the source of most of the misinformation that was generated during the pandemic.
- The challenges for public communication and engagement in science are exacerbated by the complexity, uncertainty, and evolution of a cascading crisis like COVID-19. In this context, it is important that public officials and science communicators can leverage established resources and proven, evidence-based good practices.
- Effective efforts to convey official evidence-based information and mitigate mis- and disinformation have required more than just the dissemination of facts. Engaging with citizens using a variety of intermediaries has been important to addressing different populations. Messaging needs to align with the needs, and concerns of different demographics and social sciences can play an important role in designing appropriate communication and engagement strategies.
- A variety of factors exacerbated the propagation of mis- and dis-information and undermined trust in science and evidence-based policies. The relationships between policymakers, science, media, and the public were a critical determinant of effective communication and compliance with pandemic mitigation measures. Approaching scientific and situational uncertainties with transparency and openness was an important aspect of such communication.
- Efforts to actively engage citizens in research have varied across jurisdictions and scientific disciplines but, during the COVID-19 response, have often been limited to data collection. There are opportunities for stronger citizen engagement with benefits for both science and society.

Public communication and engagement (PCE) encompass a spectrum of activities ranging from passive information transfer to active participation of citizens in science.[10] Historically, interactions between science or policy actors and citizens have been dominated by the one-way communication of information to improve awareness or encourage behavioural change (the 'deficit model'). The idea of more active public engagement in science is still a novel concept in many jurisdictions and its integration into established scientific processes varies considerably across countries and scientific disciplines. The COVID-19 pandemic required scientific institutions and governments to act swiftly, relying heavily on existing resources and ways of doing things. The main focus and attention of science policymakers was initially on scientific communication, although as the pandemic progressed it became clear that more active citizen engagement could play a valuable role in understanding and responding to important aspects of the crisis.

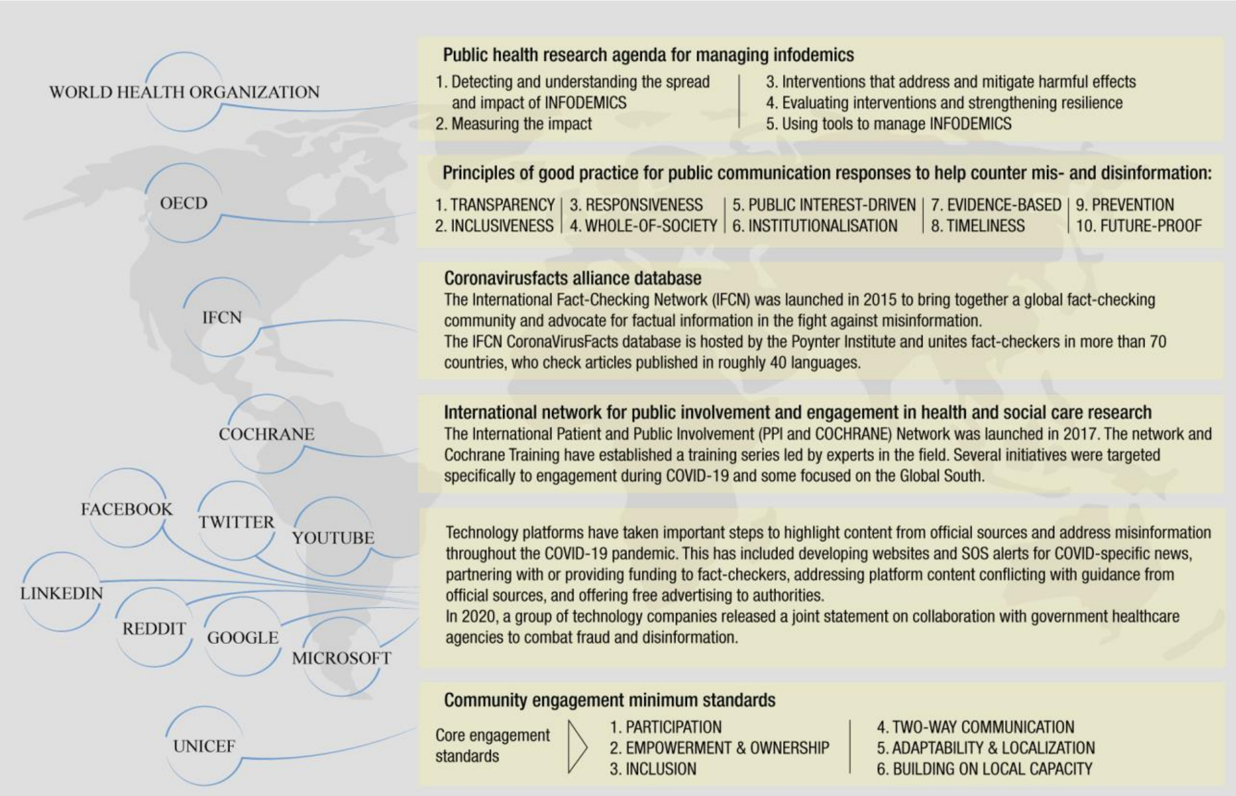
Communication efforts were critical for both amplifying evidence-based messaging and addressing misinformation and disinformation campaigns.[11] The complexity of the information ecosystem challenged the science community with multiple ‘scientific’ messages from different sources competing for the attention of citizens. Digital technologies, such as social media platforms presented both a challenge and a solution depending on how well they were incorporated into crisis communication strategies. Information distribution has historically occurred through a one-to-many approach, where communication has come from one source, e.g., a press release, and is taken up by multiple recipients. However, social media platforms allow many-to-many communication, where information can be put forward by multiple sources and is easily shared within large groups or networks. This change has increased opportunities to engage with and harness insights from the public, but it also enables individuals to produce and consume content, creating more competition for official sources of information and more opportunity for the spread of false and/or harmful narratives (OECD, 2021[93]).

Where it was strong or lacking, public trust became a critical enabler or barrier to effective crisis management. Analysis has shown that higher levels of interpersonal trust and trust in government institutions is significantly correlated with lower COVID-19 infection and higher vaccination rates (Tan et al., 2022[94]). Public trust in science and the predisposition of populations to accept, adhere to, or take-up science-based policies is rooted in cultural norms and historical legacies. One consequence of this is that effective communication strategies needed to be aligned with contextual factors, including science literacy, public attitudes to science and government institutions and political polarisation. These factors differ across countries but also within countries in relation to population demographics.

One of the aspects of the COVID-19 pandemic that significantly impacted effective communication was the novelty of the virus and its continuous evolution. The uniqueness of the situation and, as a result, the uncertainty and evolution of the scientific knowledge used to inform policy decisions was a major challenge for the science community and national governments. The communication of scientific successes, such as rapid development of effective COVID-19 vaccinations has strengthened overall public support for science in many countries. At the same time, quality control and transparency with regards to scientific evidence have been critical for maintaining this trust and limiting the impact of misinformation.

Experience with earlier public health crises due to infectious diseases, including HIV, Tuberculosis, Malaria, and now with COVID-19, has demonstrated the significant role that active public engagement can play in improving the effectiveness of mitigation and response measures (Tan et al., 2022[94]). The involvement of civilians at different stages of the research cycle - from research design and data generation to the development, communication, implementation, and evaluation of countermeasures and policy interventions, can play an essential role in crisis response. Such engagement can be important for understanding and addressing the needs and concerns of different groups and promoting the design and adoption of effective countermeasures. Effective public communication and engagement contributes to building trust between citizens, policymakers, and scientists, which can be particularly important when undertaking activities like contact tracing or fact checking. Targeted engagement of specific demographics can reduce the risk that response efforts will unintentionally exclude or negatively impact these populations. However, most science communication and engagement activities during COVID-19 have been concentrated at the passive end of the spectrum (Gilmore et al., 2020[95]). The seemingly limited capacity and appetite of both science and policy actors to fully engage and integrate insights from citizens has been a missed opportunity in many respects.

Figure 4. The global public communication and engagement landscape during COVID-19



Note: International initiatives to improve public communication and engagement. The graphic is illustrative and is not intended to be a comprehensive representation. Source: Information from several sources has been integrated (UNICEF, 2020[96]) (Poynter Institute, 2022[97]) (OECD, 2022[98]) (Cochrane Consumer Network, 2022[99]) (Shu and Shieber, 2020[100]).

3.1 Tailoring crisis communication to address questions, concerns, and needs of all citizens

"Two types of activity are important to improve vaccine confidence: amplifying accurate information and debunking misinformation"

"Journalists are important to keep policy-makers aware of what people are concerned about and to target the development of answers to their questions"

"Social media creates important opportunities for feedback to create an understanding of the situation and allows consideration of potential actions and policies"

"Good information is not just accurate expert information, but what resonates because it is personalised and addresses the existing needs of consumers"

"Lack of engagement with behavioural research, culture, and the social sciences has led to inappropriate communication, the development of ingroups and outgroups, and entrenched opinions"

"There has been a failure to address the public's emotional needs, partly due to the framing of uncertainty in terms of absolute certainty"

"It's not enough to be an expert. There is also a need to express empathy and to communicate with people on a human level"

"We need more flexible communication strategies that get at what people are concerned about in the moment"

"Greater responsibility needs to be taken by those communicating to the public. Rather than reporting what's happening in the moment, there is a need to look at it in context and in relation to what information has already been provided"

"Access to accurate information in not enough to motivate people to get vaccinated or tested. More effort is required to develop communication that resonates, which requires campaigns that address specific concerns"

"Trust drops when there are perceived political interests"

"In jurisdictions where the media receives public support, this should be tied to evaluation of the quality of reporting"

"Truth in science and the scientific discourse depends on context, time, and place"

Note: A curated selection of significant quotations was taken primarily from the 'Public communication and engagement in science' workshop held in April 2022. A complete list of workshop participants is available in Annex 4.

To be able to adequately address the complexity of the demand for public communication and engagement during crisis response, it is important that science and policy actors can leverage existing infrastructures, data, relationships, human resources, and learnings. A quick and effective response is required to both engage the public in science and to communicate compelling, evidence-based and timely information. Several analyses of the COVID-19 pandemic response have noted the important roles played by both Centres of Government (CoG) and Ministries of Health (MH) in leading and co-ordinating science-based public communication efforts. To be effective, this requires institutionalised communication and data policies, standards, and guidelines and human and financial resources (OECD, 2022[101]). A lack of skilled personnel has been a critical barrier, with over 75% of both the CoGs and MHs, in a survey of OECD countries, indicating that it was one of the top three challenges for communication (OECD, 2021[93]).

Limited financial and human resources have also inhibited the integration and formalisation of evaluation processes, preventing public officials from adopting strategic, rather than tactical, approaches to public communication. Only a handful of the science communication initiatives introduced during the COVID-19 response provided dedicated funding to support scaling up public communication and education capacities (OECD, 2021[45]). A notable example was the Government of Canada’s allocation of $50 million to a national public health agency expressly for COVID-19 communication and education efforts. The need for more, and more specialised, communications staff in public health and other government agencies (and in research institutions) is illustrative of the growing complexity of the information landscape, which is partly due to the impact of digital platforms on how people receive and engage with information.

Using a variety of communication mediums has been critical for connecting with diversified publics and overcoming disparities in access to, and comprehension of, information. However, the majority of national science communication initiatives implemented during the COVID-19 response appear to have focused on passive communication through official websites (OECD, 2021[45]). In many countries national government websites served as a centralised source for COVID-related news updates, which provided citizens with some level of consistency in a constantly evolving situation. Other common forms of communication included the use of news media platforms, press conferences and press releases. In addition, a number of national initiatives used social media platforms to try to expand beyond passive information dissemination and encourage two-way communication or target specific audiences. Other two-way communication initiatives included the use of telephone hotlines, government WhatsApp accounts, chatbots, and other mobile applications. There appeared to be less attention paid by science policymakers to the use of more visual communications, such as infographics or videos that might be more accessible or compelling to certain publics.

The use of a variety of communication tools during the pandemic reflects the fact that different mediums have different strengths and drawbacks, potentially making them more or less relevant for different situations. For example, both news and social media platforms represent established channels through which policymakers can quickly communicate to large groups. However, trust in both mediums is declining, which means that people may begin to use them more selectively in the future. While confidence in traditional media channels remains higher than social media, at 53 and 35%, respectively, trust in the news media declined between 2020 and 2021 and reached its lowest point in ten years (Edelman, 2021[103]). A communication strategy that focuses exclusively on these two media for mass communication may be efficient but will clearly not be effective for a large portion of the public.

In responding to COVID-19, it has been necessary to tailor messages and communications to different situations (See Box 21). This has required the integration of scientific evidence and policy decisions, with the needs, concerns, and lived experiences of a diversity of population groups. There are many contextual factors that need to be considered, including science and digital literacy, media preferences, and the perceptions and trust that different demographics have in science or government institutions. Where established messaging was simply recycled, such as with the reuse of materials from previous childhood vaccination campaigns as initially occurred in Japan, there was a noticeable lack of uptake from many groups. Re-cycled vaccine promotion strategies were largely unsuccessful as they did not adequately reflect the novelty of the COVID-19 vaccines nor address the different concerns or questions of civilians in a crisis situation. Insights from the behavioural and social sciences are key to better understanding how different communication mechanisms can be used effectively. For example, studies indicate that eliciting pride, joy, or hope is generally more effective in motivating behavioural change than negative messaging targeted toward fear, guilt, or shame (OECD, 2021[104]) (Brennan and Binney, 2010[105]). Some countries have developed specialised teams with behavioural insight (BI) expertise to advise crisis managers, although integration of these teams into formal communication processes has not always been straightforward.

Box 21. Understanding diverse needs and tailoring public communications

Understanding Factors driving vaccine hesitancy in different population groups

Dedicated behavioural research was undertaken to inform development of the South African COVID-19 vaccination campaign in May 2021. Results indicated only limited correlation between hesitancy and education level and that instead, youth, racial disparity, low monthly income, and government distrust were the critical variables (Katoto et al., 2022[106]). While perceptions of vaccination are complex and context-specific, the novelty of COVID-19 vaccines and associated uncertainties have contributed to hesitancy. Gaps in knowledge among key communicators, including political and community leaders and health workers, are likely to contribute to public uncertainty and vaccine hesitancy. The study found that action to address trust issues is critical to increasing national vaccination rates. Researchers recommended: 1) collaboration between health and government agencies; 2) use of credible and dialogue-based communication strategies; 3) direct interaction with all individual population groups calibrated according to the type and severity of vaccine hesitancy; and, 4) health literacy activities with messaging tailored to context-specific issues, such as economic and racial disparities.

Analysing immediate and longer-term human-centred impacts of the pandemic

In response to the COVID-19 pandemic, the University of Vienna has invested in developing the SolPan (Solidarity in times of Pandemic: What do people do and why?) research commons (https://digigov.univie.ac.at/solidarity-in-times-of-a-pandemic-solpan/team-solpan/). SolPan is a multinational, comparative, and longitudinal study that involves European and non-European countries and explores human-centred impacts of the pandemic and the pandemic response. The study uses qualitative interviews with citizens to explore, for example, the implications of digital practices like working from home, contact tracing applications, and the role of citizens in the pandemic response. SolPan+ Latin America is comprised of regional consortia from twelve Latin American countries, seven of which (Argentina, Bolivia, Chile, Colombia, Cuba, Ecuador, and Mexico) have committed to continuing the study from 2020-2027. The aim is to understand the social dynamics in Latin America during the COVID-19 pandemic and its response.

Combining diverse expertise and targeting communications

Various communication mechanisms have been mobilised by Canadian public health officials, policymakers, and other public actors. Two examples are from the Royal Society (RSC) and the Ottawa Public Health (OPH) official Twitter account.

Since March 2020, the RSC has engaged over 750 experts in 30 working groups to develop COVID-specific policy briefings, events, and partnerships and ensure access to independent and evidence-based science for the public (https://rsc-src.ca/en/covid-19) The Society establishing a task force on COVID-19 in April 2020, with members leading various policy briefing working groups. Task force membership includes 26 experts from a diversity of scientific disciplines, including targeted domains in the life and social sciences, from infectious disease studies to history, mental health, and household finances. Several working group topics have direct relevance to key challenges impacting effective public communication campaigns. Hence there are groups on: history of public health, the impact of COVID-19 on specific communities, Indigenous health and wellness, language and literacy, protecting public advice, representations of science, and vaccine acceptance. Over 150 opinion pieces have been published by engaged experts in national media publications and other outlets.

While politicians and public officials have been criticised for robotic, condescending, and sometimes even duplicitous messaging, OPH has used humour and empathy to win over and keep the attention of citizens, while providing explanations for public health measures and how they will contribute to ending the pandemic. In early 2021, OPH had become the premier North American local public health unit on social media, with a following of 107,000 people (Proudfoot, 2021[107]). Messaging was targeted to address the concerns being voiced by people in real-time. The agency uses comments as informal data to address common questions or concerns and analysis has been used to inform statements made by city officials.

People are less likely to respond to general vaccine information campaigns than they are to personal narratives (OECD, 2021[104]) (OECD, 2021[108]). Analyses of COVID-19 public communication efforts found a key difference in campaigns that focused on disseminating validated scientific information and those that went several steps further, first contextualising and curating timely information for different communities and second, delivering it in a way that was empathetic, trustworthy, and resonant. Various approaches can be used to ensure that public information is relevant to citizens, but it is important to ensure that the adopted approach aligns with the communication medium being used and the situation at hand. For example, engaging through social media platforms requires a more informal communication approach than traditional media. In many instances, scientists and policy makers benefitted from evidence-based guidelines or training in the use of social media for public engagement.

Many countries appointed public health officials, such as Chief Medical Officers (CMOs) or heads of national public health institutes, to hold regular, sometimes daily, press conferences and serve as the face of official communications during the response. Some jurisdictions have been more successful than others in the use of these positions for a variety of reasons ranging from structural to the personal characteristics of the public official. The effectiveness of communicators comes down to public trust. Actual and perceived independence of CMOs (see earlier, Box 19), CSAs and other scientific experts from policy and political actors is a critical factor, as political association strongly impacts credibility in the eyes of the public. Ultimately however, it is the personal characteristics and skills of individual messengers that often determines the effectiveness of their communications. Individuals with credible scientific backgrounds, who invested time and effort into communicating with empathy, meeting the emotional needs of different demographics, and answering questions that were relevant to people's lives, played an important role in many settings (see Box 22). In addition to written and oral communications, the use of videos and graphics proved to be valuable in communicating complex scientific messages to different audiences.

Box 22. Messengers and communication tools

Communicating science-based information with consistency and empathy

In Canada, the effective public communication of the British Columbia (BC) Provincial Health Officer (PHO), Dr. Bonnie Henry, was recognised with a national award. Public health messaging was deferred primarily to the PHO by the BC government to ensure consistent messaging, which meant that Dr Henry had a clear mandate from the outset (Ontario Hospital Association, n.d.[109]). Other crucial elements included her credentials as an expert and medical professional, as well as her ability to communicate with the appropriate authority, emotion, and empathy. Analysis has shown that her use of direct answers, which did not attempt to downplay the situation or shift blame, was better received by the public than other approaches adopted elsewhere, which were more likely to be perceived as condescending, political, and/or defensive. Holding daily briefings and engaging regularly with journalists and other communication professionals was important for keeping citizens informed of the changing situation (Ontario Hospital Association, n.d.[109]). In addition, the BC CDC released messaging that was targeted to sensitive demographics. Dr Bonnie Henry's Good Times Guide provided simple on-line information early in the pandemic aimed at people aged 20-40 years old, those deemed most likely to be the source of community outbreaks, to provide guidance on having a good time, safely. In July 2020, Dr Henry was awarded the annual Canadian Public Relations Society President's Award for Outstanding Public Relations and Communications Management.

Explaining the science behind public health and social interventions

The Fugaku supercomputer has been used to address a variety of analytical needs to inform Japan's national pandemic response. The first studies undertaken related to the effect of partitions in offices and ventilation in commuter trains and were published when people were preparing to go back to work (Ishikawa, 2020[110]). Additional work has been undertaken using simulations of COVID-19 droplets and aerosols to assess the effectiveness of face masks, demonstrating that masks combined with ventilation can significantly reduce the risk of COVID-19 infection. The simple video simulations that Fugaku generated, from a complex multifactorial modelling analysis of very large amounts of data, were made available on YouTube and proved to be very effective communication tools (https://www.r-ccs.riken.jp/en/fugaku/research/covid-19/msg-en/).. [See the Research Infrastructure section in report 1 of this series for more information about Fugaku.]

3.2 Investing in public communication to promote trust in science

"Transparency in where there are gaps in knowledge helps policy and science actors to fill these gaps and prevent them from being filled by nefarious actors"

"Do not assume that publics cannot understand"

"It's important that communicating coherently isn't prioritised over communicating doubts and uncertainties"

"There was a sense of unease caused by changes in vaccination mandates where there was a lack of explanation and default use of routine messaging"

"It was important that authorities provided direct answers and did not to downplay the situation or shift blame"

"Journalists were found to be useful in framing what was going on and communicating scientific uncertainty"

"In democratic societies there is no way to completely

"Science and policy actors should use narrative as a means of communicating in addition to quantitative data, which has been the default communication strategy"

"Vaccine attitudes are not normally only a reaction to vaccines, but are strongly correlated with an understanding of the disruption of citizenship"

"Social media poses a challenge because it does not enable different arguments or topics to be weighted differently"

"With contact tracing, publics may get the impression that their privacy is being invaded, but with a more trustworthy civic group, they may be more likely to be open-minded"

"Messaging can be made clearer by making clear distinctions between what is peer reviewed versus preprints or unreviewed scientific articles"

"Science is typically presented as the breakthrough at the end stop misinformation"

"Collaboration between scientists and journalists is essential to stop the spread of misinformation"

"Scientific language can cause misunderstanding"

"Top-down spread of misinformation creates polarisation and division. We must hold politicians accountable"

of the discovery process, but with COVID-19, the public was privy to contradictions that are inevitably part of the scientific process."

"It's important that scientists explain their background when speaking in the public media to provide context to what is being said and enable its interpretation"

Note: A curated selection of significant quotations was taken primarily from the 'Public communication and engagement in science' workshop held in April 2022. A complete list of workshop participants is available in Annex 4.

Many governments adopted strategies aligned with conventional, non-crisis communication protocols, and did not explicitly or transparently address the uncertainty under which decisions were being made. Instead, official messaging was presented as indomitable fact, scientific advice was used to justify policy decisions, and, rather than explaining changes in scientific knowledge or policy, these were often downplayed, or the blame shifted beyond the responsibility of public officials. There is considerable evidence from behavioural and communication sciences, to suggest that this approach was flawed from the outset. In situations of extreme uncertainty, government and science-based communication to the public should be consistent and transparent and avoid shifting blame or downplaying the concerns of citizens. Knowledge gaps should be expressly identified, and the activities being undertaken to address them should be communicated (OECD, 2020[111]).

Informing citizens so that they can make the best personal use of actionable advice means conveying what is known together with the uncertainties and associated risks that underly official advice and policies. The initial hesitancy by many governments and science advisors to communicate transparently and consistently about uncertainty during the COVID-19 pandemic had a catalytic effect. Not only did it create space for mis- and disinformation, but it also undermined the credibility of scientific and government institutions to address questionable or damaging claims and sometimes even served to validate them (OECD, 2020[112]). Lack of transparency erodes trust, particularly when there is a possibility that official statements may be proven wrong or require future adaptation in an evolving crisis. In many countries, the failure of scientists and government officials to acknowledge and explain major changes in public health guidelines or policy interventions increased polarisation and tensions with the public (Gu and Feng, 2021[113]). It is important that science and policy actors communicate and engage with the public on the basis that most people are capable of not only handling complexity, uncertainty and change but that they can also provide insights for more effective policy development (See Box 23).

Maintaining transparency around aspects of scientific research, advice and policy development that are not actively communicated can also contribute to public trust. Interested publics should be able to access the data, assumptions, and methodologies underlying science and other inputs used to develop public policy. There needs to be greater transparency about the lack of consensus and differing perspectives that often characterise the scientific process. Showing that multiple voices are behind a particular scientific perspective has been shown to quell public anxiety in some jurisdictions. At the same time, the communication of conflicting scientific messages can be confusing in an emergency. Bringing diverse experts and communication intermediaries, such as journalists, together in meetings to foster common understanding of important scientific evidence before it is made public can help to ensure that scientific credibility is maintained and that conflicting views are presented to the public in a constructive way.

Public trust in science can be improved through action to formalise and communicate the separation of roles between policymakers and scientists and political and scientific communication. Where actors have joint or overlapping responsibilities, such as CMOs in some jurisdictions, this can be challenging but transparency as to the limits of these responsibilities relative to other actors can help to allay misunderstandings (See earlier Box 19). While publics are often blamed, politicians and public officials, including scientists, have also contributed to the spread of misinformation when it was in their interest. Both the engagement of diverse perspectives and the separation of science and policy roles are key to mitigating the politicisation and polarisation of science advice and science-based policy. Both are covered in greater detail in the earlier Science Advice section of this report.

Box 23. Embracing openness and diversity in science communications

Being transparent about divergent views

Norway and Denmark have benefitted from high levels of public trust during the pandemic in comparison to other countries in the European region. To a certain extent, this relates to previously existing levels of societal trust but, COVID-specific analysis, also suggests that there have been important differences regarding transparency in the approaches adopted by public health authorities (Ihlen et al., 2022[114]) (European Social Survey Round 9 Data, 2018[115]). There were concerns and criticisms in early communication campaigns that transparency regarding potential worst-case scenarios might create unnecessary worry; however, long-term analysis has shown that the absence of information is perhaps the most significant contributor to fear. While information may create concern, it is manageable in that it improves trust and the ability of citizens to make informed and appropriate decisions. In this respect, there are several aspects of Norway and Denmark's communication strategy that have been important to relaying complete information and addressing evolving concerns of civilians.

- The Norwegian Directorate of Health used regular surveys and focus groups to understand how information campaigns were being received by citizens and to adjust messaging accordingly.
- Norwegian communication officials did not attempt to control or censor engagement of civilians or external scientists on social or news media platforms. Similarly, Danish officials have referenced the importance of having an open dialogue and trust in people being able to make their "own decisions on an informed basis" (Ihlen et al., 2022[114]).
- Norwegian public health representatives actively participated in televised debates, providing opportunity for accountability and to establish accessibility and admit mistakes.
- Public health authorities in both countries invested in social media, allocating dedicated staff to engage with the public through various platforms with the goal of generating valuable interactions and bidirectional dialogue. Agencies increased their communication capacity to engage effectively with the scale, uniqueness, and unpredictability of comments.

Transparency was also positively embraced by Norwegian public health experts as a way to maintain professional integrity when the government did not adopt science-based recommendations when making policy decisions. On the other hand, tighter political control in Denmark has been highlighted as a challenge for public health agencies in adhering to transparent practices.

Accommodating dissent and uncertainty

An Israeli study found that the limited diversity in expertise engaged by the government has limited the capacity of government officials to understand the complexity of the crisis situation. Controversy and differences of opinion were found to be important for challenging conventional and siloed ways of thinking and preventing misconceptions, misinformation, and ideological positions (Gesser-Edelsburg, Zemach and Hijazi, 2021[116]). Because coalitions of experts that were critical of government policy were treated as adversaries rather than potential contributors, dialogue between experts holding different views was limited and ineffective. Particularly controversial topics included: lockdowns, testing, vaccinations, transparency of official communication strategies, children and the school system, and restrictions imposed on older adults. Results of the study underscored that intolerance can often be exacerbated or mitigated at the top of hierarchical structures and that misconceptions or assumptions about what is true can cause the public and experts, alike, to approach topics of discussion in ways that overlook or dismiss conflicting views. A lack of diversity can result in 'groupthink' and neglect important, but differing perspectives. At the same time, public communication that is dominated by confrontation between what is true and what is false can fail to address questions and concerns that are most relevant to peoples' lives. Framing uncertainty in terms of absolute certainty is liable to fail to address the emotional needs of the public. More open and inclusive strategies to engage publics, such as the use of online citizen science projects or crowdsourcing solutions to specific problems, can help build trust as well as providing valuable insights for research and policy.

Engaging a diversity of perspectives to inform public communication.

The pandemic has highlighted the importance of engaging a diversity of expertise in developing policy interventions and communication strategies. This includes integrating knowledge from a variety of scientific disciplines as well as experts holding diverse perspectives. It is important to show the public that expert groups consider a variety of different opinions, while avoiding adversarial confrontation and presenting consistent messaging. In Japan, experts held interdisciplinary meetings every week for more than two years to discuss emerging scientific information and differences in the terminologies, definitions, and perspectives across disciplines before presenting this information in public venues. In addition, closed briefing sessions were held with journalists to strengthen mutual understanding between science and media actors and help mitigate misinformation. Denmark has also used forums to facilitate dialogue between experts from different domains and journalists with the aim of advancing a common understanding and more consistent public messaging.

On top of the inherent uncertainties associated scientific information relating to the pandemic, misinformation posed an unprecedented challenge for many countries. At the onset of the COVID-19 pandemic, less than 40% of governments had established guidelines to support public officials in managing mis- and disinformation (OECD, 2021[93]). There has been little progress on this during the pandemic and two years later, many countries were still struggling to establish evidence-based procedures to prevent and respond to questionable information. One potential reason for this is that much is still not known about how to mitigate misinformation and the effects of various context-specific variables on different mitigation strategies. At the same time, almost a quarter of the novel science communication initiatives introduced during the pandemic response were focused on addressing misinformation in some form (OECD, 2021[45]). Strategies have ranged from amplifying or promoting trusted sources of information to identifying fraudulent schemes and educating citizens on how to identify and assess questionable claims (Box 24). The transparent disclosure of scientific uncertainty and timely, relevant, and consistent scientific messaging are considered to be critical measures in limiting 'infodemics' but, as discussed earlier, these conditions are not always easy to achieve and maintain.

It is now widely recognised that people need specific skills to navigate, validate, and make sense of scientific information and that translation of scientific concepts into understandable terms can aid in this regard (OECD, 2020[112]) (OECD, 2020[111]) (Tan et al., 2022[94]). Science literacy is important for understanding the scientific process as well as for assessing the value and limits of different types of scientific information. It can help citizens to understand 1) that science is not, as it has often come to be represented, a 'one-dimensional provider of truth' but is very often rooted in conflicting perspectives; and 2) that not all scientific outputs are equal and caution should be applied in interpretation, particularly in the absence of peer review. Science and data literacy are important for the constructive participation of citizens in dialogue around scientific evidence and in empowering people to make informed decisions. To address the rising prevalence of COVID-19 misinformation, several countries have leveraged or introduced campaigns to develop the scientific skills and literacy of civilians (See Box 24). In some instances, initiatives have actively targeted digital or media literacy to improve the capacity of the public to navigate conflicting information and share and consume content responsibly (OECD, 2020[111]). At the same time, it is not solely the responsibility of the public to take the initiative to access and analyse scientific communications. More can and should be done to improve the capacity of researchers to communicate scientific processes, conclusions, and impacts in language and formats that are more accessible to the general public.

Box 24. Mis- an dis-information

Building on established capacity and partnerships to fact-check COVID-19 information.

Japanese scientists, public officials, and other relevant stakeholders have been able to leverage a variety of established and novel initiatives to ensure effective public communication during the COVID-19 pandemic. Efforts have focused on amplifying official validated information and mitigating misinformation. FactCheck Initiative Japan (FIJ, https://en.fij.info/about/) is an example of an established initiative that the country was able to leverage. It is a coalition of academics, journalists, and non-profit organisations, launched in 2017. Building on prior experience FIJ focuses on the factual basis of claims, false reporting, and misinformation that pose the greatest risk to society, such as the social media posts of prominent individuals. This strategy allows the organisation to target resources where they will make the biggest impact, while promoting free and open debate. Fact-checking activities validate COVID-19 information originating in Japan, as well as checking questionable claims before they spread. Volunteers and staff use a 'fact-checking console' system developed by SmartNews Inc. and the Natural Language Processing Lab of Tohoku University to monitor questionable information on social media platforms. The system leverages artificial intelligence to identify misinformation, which is then fact-checked and countered, where appropriate, by media partners.

During the COVID-19 pandemic, FIJ expanded partnerships to include overseas fact-checking entities to address the borderless nature of the crisis and the spread of digital information. Some of these partnerships have also been leveraged by a COVID-specific initiative, COVID-19 Navigator (COV-NAVI), a vaccine information group which was formed following concerns about contamination of COVID-19 vaccines.

Tracking the impact of false narratives

Over the course of the pandemic, the United States Centers for Disease Control and Prevention (CDC) have used 'social listening' and other monitoring tools to develop and publish monthly reports on citizen perceptions of national vaccination efforts (OECD, 2021[104]). These reports (https://www.cdc.gov/vaccines/covid-19/vaccinate-with-confidence.html) have allowed policy and science actors and other interested parties, including journalists and social media platforms to better understand the extent to which false narratives had spread, creating vaccine hesitancy, and preventing uptake. Reports also provided valuable intelligence regarding interventions which had been used successfully to address misinformation and disseminate clear science-based messaging. For example, early warning that vaccinated individuals were concerned about the effectiveness of vaccines against new variants of COVID-19 enabled public officials to tailor communications to address this issue.

Co-ordinating across government to respond rapidly to misinformation and provide understandable data analyses

The United Kingdom government developed specialist units to combat COVID-19 misinformation - ranging from harmful claims from self-proclaimed 'experts' to phishing scams. Following the identification of false narratives, a Rapid Response Unit was tasked with co-ordinating with the appropriate government departments to develop and action a targeted response. Communication science and misinformation experts from academia and civil society work closely with the Rapid Response Unit. In addition, a checklist for citizens was developed to provide basic guidelines on how to check sources and analyse facts before sharing them. The checklist was made available online (https://sharechecklist.gov.uk/) as part of a wider campaign, Don't Feed the Beast, aimed at decreasing disinformation.

The United Kingdom has approached COVID-19 as an opportunity to advance the implementation of the 2019 national data strategy and its focus on open data and data literacy. Data literacy was factored into communication strategies, with statisticians and public health practitioners tailoring their public communications accordingly. Simple graphs accompanied by strong narratives were co-produced by the National Health Service (NHS), Public Health England, Health and Social Care (Northern Ireland), public health practitioners, and the media. As the population was increasingly engaged in the collection and use of data, data literacy grew, resulting in a virtuous cycle that increased the use of open data and engagement with public decision-making (Middleton, 2021[117]). From the beginning of the pandemic response to October 2021, a publicly accessible COVID-19 dashboard was redesigned eleven times, evolving from a handful of line charts to an interactive hub where 200 metrics and over 40 million individual figures were published daily.

The spread of false claims about COVID-19 during the pandemic response illustrated that it is necessary for policy and science actors to be able to identify and understand shifts in public sentiment in 'real time'. Such understanding is needed to address issues that transcend the normal boundaries of a public health crisis, such as the rise of hate crimes that resulted from 'Coronaracism' in some countries (OECD, 2020[112]). Initiatives and actions are required by multiple actors at multiple scales to actively address misleading or harmful narratives as they emerge. Partnerships have been key to actively addressing misinformation, while amplifying and accelerating the distribution of 'good' information. The COVID-19 response has seen governments and/or scientific institutions leverage established and novel partnerships with the news media communication professionals and technology companies, including social media platforms, civic organisations, and community leaders. The most successful national responses have tended to adhere to a whole-of-society approach, even engaging individual citizens as co-collaborators in the development and translation of scientific knowledge into policy decisions (OECD, 2022[101]).

Closer engagement with journalists can serve to ensure that diverse perspectives are considered, while conflicting scientific viewpoints or information are framed appropriately in public communications. Information on expert qualifications, conflicts of interest, and how viewpoints fit into the broader scientific context (i.e., mainstream vs. fringe perspectives) are critical for the public to determine the validity of what is being reported. Successful engagement of communication professionals during the COVID-19 response often benefitted from previous efforts to establish mutual trust and workable relationships with public officials and scientists. In Norway, for example, closed briefing meetings were held between science advisors, public officials, and journalists to ensure that scientific information was conveyed accurately and to identify and address misinformation (Box 23). The efforts of technology companies have also been important to address COVID-19 public communication challenges, as social media has been identified as the source of almost 90% of misinformation, which is amplified via content curation algorithms (OECD, 2020[111]). In March 2020, Facebook, Google, LinkedIn, Microsoft, Reddit, Twitter, and YouTube released a joint statement regarding their intentions to collaborate with public health agencies to fight fraud and misinformation (See Box 25 for additional examples). While social media platforms have acted swiftly during the pandemic response to invest in initiatives to support official communication campaigns and to identify and remove mis- and disinformation, governments can assist these efforts through the introduction of guidelines, standards, and appropriate regulation that can facilitate trusted partnerships with scientific organisations.

Civil society organisations have been important contributors to pandemic mitigation activities, such as fact-checking and contact tracing, for which transparency and accountability are critical to securing the public buy-in and trust. With regards to fact-checking, formal autonomy of third-party entities can help ensure the delivery of unbiased analyses, but success can also be highly capital intensive. Some organisations have had to allocate resources strategically to prioritise the most impactful narratives, while others have sacrificed the nuance often required by turning to automated monitoring systems (OECD, 2020[112]). In addition, partnerships with both civic organisations and community leaders have improved the visibility and representation of the needs and concerns of the public, especially vulnerable and hard to reach groups, in the development and communication of scientific knowledge and targeted science-based solutions.

Box 25. Partnering with communication intermediaries

Working with social media to promote vaccination

Actions of social media platforms, like Meta (previously Facebook) have been critical to the success of campaigns to amplify validated and science-based information and to mitigate misinformation. Meta was able to leverage learnings from established and new partnerships during the COVID-19 pandemic response.

In April 2021, Meta launched a COVID-19 vaccine profile frame developed in partnership with the United States Department of Health and Human Services and Centers for Disease Control and Prevention (CDC). The initiative leveraged learning from an earlier campaign to promote blood donation in India, harnessing the power of social networks to promote COVID-19 vaccinations by improving the visibility of people who have been vaccinated. Working with UNICEF, the use of the framework has been expanded to Bangladesh, Brazil, Chile, India, Indonesia, Nigeria, Philippines, and Ukraine.

UNICEF Indonesia and Gavi, the global vaccine alliance, partnered to develop a Facebook advertising campaigns to improve uptake of childhood vaccinations during the pandemic. A Facebook tool, Audience Insights, was leveraged to target adverts to specific populations and deliver content that would resonate and educate, through the use of illustrations, statistics, and scientific articles. Another Facebook tool, Brand Lift Testing, was used to quantify and understand the effectiveness of the campaign and to adapt it accordingly. The UNICEF chapter has since started to create guidelines to apply learnings from the activity to other health priorities, noting that an effective campaign requires strong co-ordination and collaboration, both internally and externally.

During the COVID-19 pandemic, Meta also partnered with the American chapter of the Co-operative for American Remittances to Europe (CARE, https://www.care.org/ **),** a non-governmental organisation dedicated to poverty and social justice. The organisation participated in a two month training series, applying learnings to launch 45 communication campaigns in 20 countries in 2021. While campaigns were locally led and adapted to address challenges that were unique to each country, several universal lessons were identified that were relevant to many. One of these universal learnings was that trusted messengers, including celebrities, doctors, and faith leaders, are key to driving citizen engagement. Content and messaging that was personalised by demographics, language, and culture was also more effective.

Social media partners have also been instrumental in activities to mitigate and address mis- and disinformation campaigns. Technology companies have introduced various activities, including funding and collaborating with independent fact-checking initiatives; highlighting, prioritising, or otherwise directing users to official COVID-19 information sources; introducing experimental tools, such as filters and stickers, to engage users in spreading information on public health guidelines; and subsidising advertisements placed by official government or public health agency accounts.

Using infographics in the news media to make COVID-19 statistics more accessible

In the United States, openly accessible data and analyses from the Health Department, CDC and a dedicated coronavirus resource centre at John Hopkins University (https://coronavirus.jhu.edu/) have been used by mainstream media to report on the status of the pandemic, including infections, hospitalisations, death and vaccination rates across different states. Mainstream media outlets, including the New York Times and Wall Street Journal, have used this data to develop their own interactive on-line Coronavirus trackers.

3.3 Engaging the public and enabling citizen-led science

"Civic groups can easily see the needs of the public and unique population groups requiring certain services, doing this better than governments"

"The response from scientists has been indicative of a profound discomfort to patient involvement in science"

"Many conventional researchers' hypotheses have had

"Diversity of opinions can be skewed in one direction when there is a tolerance to withstand attacks on credibility from particular demographics and not others. We lose important voices when people are not willing to speak up as a result"

"Governments should be careful in their use of rhetoric to evoke public participation."

epistemic contributions from patients, but there are still enormous challenges that make it difficult for their contributions to be taken seriously"

""Exclusion is a major ethical issue that impacts the ability of those with Long COVID to make epistemic contributions"

"There is a need to investigate assumptions being made about knowledge creation that comes from citizens. Bottom-up initiatives that go against vested interests are important, but this is often where support from policymakers stops"

"Governments should provide more opportunities for the engagement of the public and civil society"

"Science literacy needs to be improved so publics can better appreciate nuance, why decisions are revised, different perspectives and fringe views versus scientific consensus"

"Citizen science initiatives are a mixed blessing. Sometimes such initiatives are no more than mislabelled attempts to exploit free labour for data collection and crowd out professional scientists"

Note: A curated selection of significant quotations was taken primarily from the 'Public communication and engagement in science' workshop held in April 2022. A complete list of workshop participants is available in Annex 4.

While public engagement has become a priority for science policy in many countries, its adoption has varied across jurisdictions. For example, it is not yet a formalised concept in the European Union healthcare system or in health research (Denegri and Starling, 2021[118]). Analysts point to a lack of infrastructure, guidance, and support from policymakers as potential contributing factors. More thought must be put into determining how insights and knowledge from the public can be more systematically integrated into scientific research and advice. This includes consideration of capacity and funding requirements and the implications of greater citizen engagement for the roles of scientists. Where public participation in science has been adopted in response to the pandemic, it has highlighted the importance of tailoring engagement strategies to the national context. In some economies, a strong culture of trust and collectivism posed a barrier when engagement activities were perceived by the public as attempts by officials or scientists in positions of authority to defer their responsibilities. In other instances, rhetoric used to evoke participation, such as Chinese Taipei's use of a war mentality to frame the pandemic response, later created dissatisfaction and unease when strict mitigation measures were reduced in the absence of a clear-cut 'victory'.[12] At the same time, there is a pressing need to address a longstanding and deeply rooted culture in both scientific and political institutions, which promotes one-sided communication as the most legitimate way to interact with the public (OECD, 2021[93]). Capacity development and experimentation will be important to instil the reflexivity lacking in the scientific and political communities and improve openness to different perspectives and willingness to engage citizens in questioning individual assumptions and biases.

During the COVID-19 response, social scientists have raised concerns about the lack of citizen engagement in many countries. This concern has been echoed by international agencies, including the WHO, UNICEF, and the Red Cross (IFRC) (Gilmore et al., 2020[95]). The initial stages of the pandemic response illustrated how fragile public engagement with science can be.[13] Very few science policy initiatives introduced during the pandemic mentioned citizen engagement or citizen science, with those that did generally only aiming to raise awareness of established activities rather than providing tangible support to established or novel engagement initiatives (OECD, 2021[45]). Analysis also indicates that during the COVID-19 response, the majority of citizen engagement occurred in the form of data collection. Noticeably fewer initiatives targeted the integration of public insights to shape problem definition, data curation, modelling, interpretation, or communication (See Box 26).

The most significant example of civilian participation in data collection during the COVID-19 response has been contact tracing, where countries have utilised a variety of approaches. Perhaps most widespread was the adoption of involuntary mobility monitoring and social media surveillance, which are not only passive in nature, but in many national contexts have occurred without the knowledge or consent of subjects (Tan et al., 2022[94]). Comparatively, more active engagement mechanisms, such as the use of apps that require users to input information to generate symptom data, have been much less common. Beyond this, almost all examples of community engagement from high-income countries have been limited to consultation, and most of these have given little attention to critical issues around equity, inclusion, or representation (Gilmore et al., 2020[95]).[14]

Box 26. Citizen engagement

Leveraging a culture of collaboration between citizens, scientists, and policy-makers.

Germany has a long track record of using citizen engagement in the development of science and policy. Engagement of citizens in the development of STI strategy and STI funding programmes has been relatively common practice since the introduction of initiatives like the Citizens' Dialogue for Future Technologies in the mid-2010s (Hahn, Seitz and Weinberger, 2014[119]). As of 2021, there were more than 170 projects open on the national citizen science platform (Moczek, Hecker and Voigt-Heucke, 2021[120]). Building on this foundation and COVID-related citizen science initiatives occurring in other jurisdictions, including the Estonian-driven 'Hack the Crisis' movement (https://garage48.org/hack-the-crisis) the German government and a coalition of civil society organisations developed the country's first crisis hackathon. Civil society was invited to participate from inception, with problem statements openly solicited to develop the hackathon's 42 challenges. More than 25,000 people participated in the #WirVsVirus (in English, #WeVsVirus) hackathon over 48 hours, generating almost 1,500 project ideas. Several follow-on initiatives have ensured that the promising ideas generated during the event were provided with the resources for further development and scale-up. This included support for the acquisition of new skills, connections, feedback, and resources. In addition to generating valuable and relevant social innovations, the initiative also had a positive effect on public trust, with 56% of respondents confirmed that it strengthened their trust in the German government.

A systemic approach to citizen engagement in pandemic response

Chinese Taipei's response to the pandemic depended heavily on co-ordination and collaboration across government and civil society. Analysts attribute success of the collective response to several factors. The National Health Command Centre (NHCC) developed following the 2003 SARS outbreak to co-ordinate cross-agency response efforts also collects and shares information about epidemics with civilians via mobile applications and press conferences (Hsieh et al., 2021[121]). Instead of monitoring transmission through mass surveillance, Chinese Taipei has employed voluntary reporting through an online Communicable Disease Case Reporting and Management System and a 24-hour Communicable Disease Reporting and Consultation Hotline. Civilians have been treated as valued participants, with avenues of engagement institutionalised through mechanisms like conferences and participatory platforms. Instead of top-down directives, sharing of insights from all government, science, and civil society actors is encouraged. While Chinese Taipei's COVID-19 response has been impressive in its success, it is also important to understand that the contributing historical and sociocultural factors are context-dependent (LIN, WU and WU, 2020[122]). Replication will require further analysis to ensure effective translation and implementation.

Citizen engagement in specific aspects of the pandemic response

To varying degrees, engagement of civilians in science and science policy development was an element of the COVID-19 response strategy deployed in a number of countries. For example, Korea has engaged civilians and civil actors in a variety of initiatives throughout the COVID-19 response, including participation on committees or through open online communication forums (Jeong and Kim, 2021[123]). In the Netherlands, over 30,000 citizens were engaged by policy-makers to make decisions regarding the relaxation of lockdown measures (Mouter, Hernandez and Itten, 2021[124]).

On top of moving from passive to active engagement, ensuring equitable inclusion must be a consideration in the development of public engagement mechanisms. This issue has been noticeably absent from most COVID-19 response efforts. The engagement of people primarily through the use of digital technologies and/or as passive data generators – the predominant modes of public engagement in most countries - risks inadvertently exacerbating existing power imbalances, as well as excluding certain population groups. More work is necessary to develop principles and guidelines that promote good practices and prevent the use of citizen engagement or citizen science initiatives that simply exploit participants (or 'crowd-out' scientists) or pay scant regard to issues of equity, diversity and inclusion.

As with public communication, insights from the social sciences and connections with trusted intermediaries, such as community leaders can be critical for addressing social, economic, and political inequalities in engagement strategies. Governments and non-governmental organisations can provide further support through the development of guidelines and creation of physical and digital spaces to promote dialogue.[15] On the other hand, engaging stakeholders who are averse to conflict or who may hold unpopular or divergent perspectives requires the creation of environments that enable engagement and discussion, while minimising the risk of adverse consequences or retaliation. Novel digital tools and platforms, as well as physical forums can be used to create safe and open spaces for dialogue.

In its most active form, public engagement takes the shape of empowerment, where citizen-led initiatives are catalysed from the bottom-up (Arnstein, 1969[125]). In theory, this type of engagement has the potential to be the most valuable because related activities are likely to reflect the most pressing and underserved needs and concerns of the public and include the most authentic insights. Empowerment is difficult to realise in practice as the creation and success of such citizen-led, bottom-up initiatives requires an enabling environment, where cultural and financial support are readily available. As a result, there have been very few examples of true empowerment in the development of science or science policy (Gilmore et al., 2020[95]). The most prominent citizen-led science activities catalysed by the COVID-19 pandemic are those that relate to Long-COVID, which are also an anomaly in that they largely occurred in the absence of financial or political support (See Box 27). These Long-COVID studies, which were led by patient support groups and have met with resistance from some professional scientists, present an important learning opportunity to advance citizen engagement and empowerment in the development of science (McCorkell et al., 2020[126]). The Long-COVID movement has brought to light a debilitating condition that is affecting millions of people worldwide. From a science policy perspective, Long-COVID emphasises the importance of supporting citizen-led science activities that balance or counter vested interests or dominant perspectives.

Box 27. Long-COVID and citizen-led science

The recognition of Long COVID is perhaps the most significant and well-known case of citizen-led science activity to come out of the COVID-19 pandemic. Studies have been led primarily by the Patient-Led Research Collaborative, which is a group of Long COVID patients, many of whom are also researchers (McCorkell et al., 2020[126]). The Collaborative was developed through a bottom-up process to analyse and communicate the experience of a large subset of COVID-19 patients who continued to experience symptoms past the official recovery period of two weeks. Since inception, the group has published and co-authored several patient-led studies. It has also been engaged by leading medical associations and government agencies, including the CDC, WHO, NIH, and others. In its studies, the Collaborative pays homage to scientific establishments that advocate for patient involvement in scientific decision-making, such as the British Medical Journal, but distinguishes between this type of engagement and patient-led research. In the latter, patients lead the research, often in fields where there are longstanding discrepancies between the priorities of conventional research and patient needs.

Studies from the Collaborative have been directly influenced and informed by the experience of Long COVID patients and have filled an important gap in the COVID-19 research landscape (McCorkell et al., 2020[126]). The initiative's first patient survey received 640 responses and data was analysed by a multidisciplinary and multinational team. A second survey was developed as numerous respondents to the initial survey continued to experience changing symptoms and relapses beyond 40 days. To increase the diversity of respondents, the survey was also translated into 9 languages and was distributed by partners and community leaders in multiple countries. Over 3,700 self-identified or confirmed COVID-positive individuals completed the 2nd international online survey (Davis et al., 2021[127]). Analysis indicates that respondents experience a variety of symptoms that are not often represented in public information or discussion of COVID-19 or Long COVID.

Public Communication and Engagement Policy Recommendations

Recommendation[3]	Policy Options
1. Science agencies and institutions should leverage and build on established capacities and good communication practices to address the needs, questions, and concerns of different population groups.	1.1. Leverage existing capacity, relationships, resources, and good practices to communicate and engage with different publics during times of crisis. Effective science communication needs to be prioritised and supported over the long-term and in such a way that it can be mobilised to address different crises and the needs of different population groups. 1.2. Engage directly with the public using a variety of communication mediums and innovative approaches to address distinct aspects of crisis response. Different tools, such as social media or news media platforms, can better serve different purposes and audiences. 1.3. Engage the social sciences and humanities in crisis response communication efforts that integrate qualitative and quantitative data, including narratives, and social and behavioural insights. This is important to ensure that communications are sensitive to different cultural contexts. 1.4. During crises, ensure that scientific messages, the delivery mechanism, and the communicator match with the target audience. Spokespeople for science should ideally be trusted, free of perceived political or personal motivations, and able to communicate in an empathetic way.
2. Scientists and science policymakers must invest in long-term public communication initiatives, strategies, and protocols to promote citizen trust in science.	2.1. Science communication must be transparent about uncertainties in the evidence being used to inform policy decisions. Openness and engaging a diversity of scientific perspectives are particularly important in rapidly evolving crisis situations. 2.2. Establish frameworks and guidelines for responsible scientific communication that take into account the importance of scientific autonomy and freedom as well as scientific rigour and social responsibility. Such guidelines may differ depending on individual status, e.g. government scientists vs academic or private sector researchers. 2.3. Improve science, data, and digital literacy to ensure that the public is familiar with the scientific process and what constitutes scientific evidence, able to engage effectively with science, and able to identify mis- and disinformation. 2.4. Leverage established and novel partnerships with intermediaries, including social and news media platforms, to reinforce trust in science by: disseminating timely, targeted, and compelling information; responding to questions about science; and, addressing false or harmful scientific claims.
3. Science policymakers, agencies and institutions should promote citizen engagement, including citizen-led science, and prioritise equity, diversity and inclusion (EDI) in this context.	3.1. Invest in establishing the infrastructure, capacity, resources, and research culture required to advance and adapt public engagement mechanisms that align with specific contexts. 3.2. Strengthen the consideration and participation in science of under-represented and divergent perspectives, including through partnerships and forums that facilitate safe and open dialogue. 3.3. Encourage and support bottom-up citizen science activities, recognising that some of these are likely to generate new knowledge which may disrupt the established scientific status quo.

Concluding Remarks and Policy Implications

The COVID-19 pandemic has been a massively disruptive, cascading global crisis, the likes of which national and international science systems have not been challenged with for many decades. In many ways, the response has underscored that these systems and their interface with policymaking and society must continue to evolve to address novel challenges and meet new threats and mitigate long-standing structural issues that limit their effectiveness. In this regard national governments have had to navigate a number of common concerns and difficulties and there are a number of important lessons that need to be learned regarding these. At the same time, important contextual differences between countries will determine the specific policy options and science activities that should be prioritised and how these are best designed and implemented.

This report represents part of the learnings from an analysis of how national science systems were mobilised to respond to the pandemic. It is focused on activities at the interface between science, policy and society – priority setting and co-ordination, scientific advice, and public communication and engagement. Findings illustrate that there are clear interdependencies between these activities and the underlying elements of science systems – access to data, research infrastructures, and science-industry collaborations (considered further in report 1). Many of these interdependencies relate to themes that are common across recommendations and policy options. The most significant of these are digital innovation, inter- or transdisciplinary engagement, and inclusion. The functionality of different activities is connected and interdependent, as efforts associated with one often contribute to the others. Comparison of the factors that enabled and challenged efforts to mobilise science during the pandemic reveals common deficits that policymakers must address to respond to forthcoming crises. These can be considered in terms of the phases of crisis response as well as the five meta-themes presented in *'Mobilising Science in Crises: Report 3 – Cultivating resilience at the interface between science, policy and society*: 1) Agile and strategic mobilisation of capacity; 2) Managing conflicting priorities; 3) Co-ordination and collaboration across levels of governance; 4) Transdisciplinary and reflexive science; and 5) Dynamic governance (Figure 6).

The COVID-19 response demonstrated the necessity of long-term and sustained investment to enable the **agile and strategic mobilisation of capacity** during crises. All three of the activities covered in this report have required, and benefitted from, the ability to leverage established data and information assets, research infrastructures and science-industry collaborations. With regards to public communication and engagement, established partnerships with communication professionals and other intermediaries enabled science advisors and public officials to keep the public updated, while presenting uncertainty and conflicting viewpoints transparently. Pre-existing initiatives to improve the science and digital literacy of the public were also important, arming citizens with the skills to navigate, validate, and make sense of scientific evidence - as well as mis- and disinformation. For science advisory structures, it was important that robust data sources, human capacity, and technological and institutional infrastructures were in place and accessible to experts. Some jurisdictions also benefitted from processes that facilitated the agile adaptation of scientific research priorities to address policy questions as they arose.

As the pandemic has evolved it has become clear that effective interactions at the interfaces between science, policy and society call for more **transdisciplinary and reflexive science**. Engagement of different stakeholders across scientific disciplines, sectors, and jurisdictions has been required to effectively address the multiple and interconnected dimensions of the COVID-19 crisis. However, in the early days of the pandemic response, many countries adopted a relatively one-dimensional approach to the use of scientific evidence in priority setting, policy development, and public communication activities. Engagement of expertise from the social sciences and humanities has been belated in most national science advisory structures. This has sometimes been reflected in the establishment of ad hoc or alternative science advisory groups that lacked adequate integration and visibility. The delayed engagement of certain scientific disciplines has also exacerbated deep-rooted tensions regarding the implicit hierarchy of scientific evidence. More importantly, the absence of a complete scientific evidence base is likely to have resulted in flawed policies in some instances.

Insights from the social and behavioural sciences have been particularly important to tailor public communication and engagement to the local context and to address the needs and concerns of different demographics. Likewise, where it has been possible, communication efforts, as well as setting priorities and translating scientific evidence into policy decisions, have all benefited from the engagement of civil society. The patient-led, Long COVID movement continues to shed light on a condition that is both debilitating and widespread, but which was initially unable to capture the attention of the scientific community. However, genuine and active public engagement (as opposed to passive participation) has been rare. Data collection has been the dominant form of citizen participation in science throughout the pandemic in most countries. In many cases, this was in the form of involuntary surveillance and, in the few cases where active engagement was solicited, there was little focus placed on equity, diversity, and inclusion (EDI).

Many aspects of the COVID-19 pandemic have been context-dependent, requiring the reinterpretation of global priorities and agendas in relation to regional, national, and even territorial trends, needs, and challenges. The pandemic has highlighted the importance, and also the challenges, in ensuring that LMICs are represented in setting priorities at the global level and supported, where necessary, in adapting them to the local context. Where regional co-operative initiatives have come to the fore in Europe, and to a lesser extent Africa and South-East Asia, countries have benefitted; however, a lack of **co-ordination and collaboration across levels of governance** with respect to setting and acting on research priorities has been noted in other regions, such as South America. There has also been a relative lack of international co-ordination in terms of scientific advice and the implementation of PHSMs. As countries have introduced, reversed, and adapted mitigation measures, it has been difficult for researchers and the public, alike, to keep up with current guidelines. This has fed into the rising prevalence of fatigue and apathy among the public in many countries. In addition, a lack of consideration for how national measures fit into a globally connected system has meant that PHSMs instituted in one country sometimes conflicted with and undermined the efficacy of another country’s response.

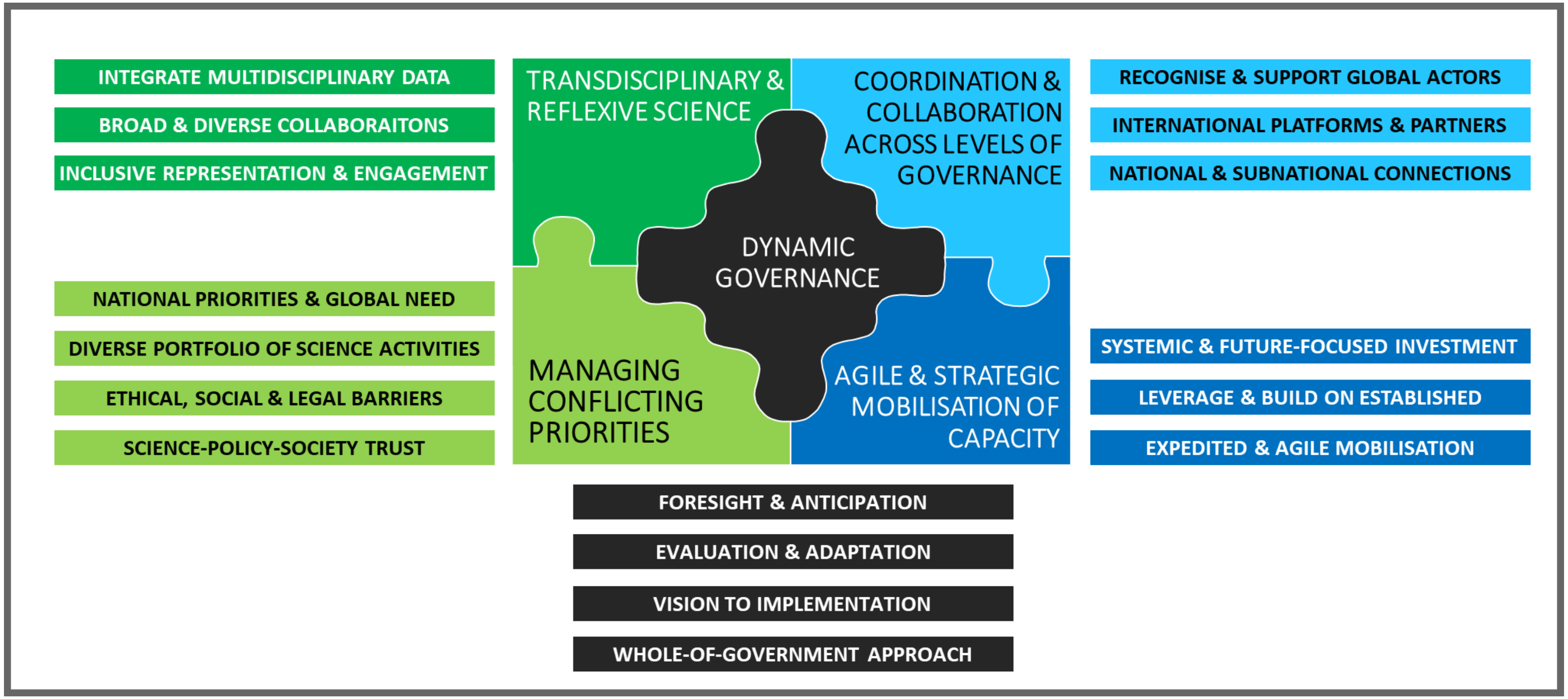
Efforts to strengthen the interface between science and policy, were reflected in the co-design of research agendas and helped to ensure the co-ordination and alignment of subsequent research with policy needs. Co-ordination and exchange was also required across policy sectors and levels of governance; however, in many jurisdictions, this level of collaboration was made complicated by the distribution of STI- and public health-related responsibilities across disparate ministries, agencies, and sub-national authorities. In many instances, complex governance - paired with the need for expedited action - resulted in the development of narrowly defined and unco-ordinated research funding calls, ultimately leading to duplication and fragmentation of research. With regards to the solicitation and curation of actionable scientific evidence, the clear designation of a central point of contact, whether an individual, structure, or institution, was used effectively in some jurisdictions to bridge policy and science domains. However, the ad hoc way in which many science advice structures were developed and augmented during the COVID-19 pandemic, tended to make science-policy interactions unnecessarily complicated.

The complexity of the pandemic and its pervasive impacts on virtually all aspects of society required scientists and policymakers to **manage conflicting priorities** in many aspects of the response. While rapid advances have been made in the development of medical countermeasures, many countries have been challenged by the lack of research undertaken in other areas, such as PHSMs. In a similar vein, compromise has also been required across levels of governance. International bodies, such as the WHO, have played a significant role in co-ordinating the development of global research priorities; however, international co-ordination has fallen short in several respects. With a few notable exceptions, international clinical trials have struggled to get off the ground. Little attention has been given to co-ordinating the use of PHSMs across countries or sharing related lessons, good practice, or scientific advice more broadly. While there has been general acknowledgment of the success of many South-East Asian countries in stemming transmission in the early days of the pandemic, there has been a lack of subsequent action to unpack how similar approaches might be applied elsewhere.

Some jurisdictions have successfully supported and empowered civil society organisations to manage activities with ethical or political undertones, such as contact tracing or fact checking. Engagement of these kinds of intermediaries can also help to improve the awareness of policy and science actors regarding the needs and concerns of the public. Maintaining public trust has been critical to successful pandemic responses. In this regard, transparency and consistency have been important in relation to a number of challenging areas, including: upholding academic freedom and associated scientific responsibilities; maintenance of scientific rigour despite accelerated timelines; and, in distinguishing the roles and responsibilities of experts and policy-makers. Uncertainty around many aspects of the pandemic has required public officials and scientists to communicate not only what is known but also to be open about the gaps in knowledge and the corresponding actions being taken to address them. Where transparency has been lacking, not only was trust eroded, but the ability of scientists and responsible authorities to address future misinformation was compromised.

Despite the significant need for public buy-in and trust and the challenges posed by the evolving and increasingly complex information landscape, very few initiatives appear to have been introduced with dedicated funding to scale-up public communication and education efforts. Limited financial and human resources and the general lack of onus on building resilience have also limited the use of **dynamic approaches to governance**, and proactive and strategic action from scientists and policymakers that would have improved crisis preparedness and response. The most successful national responses tended to adopt a whole-of-society approach, which included top-down guidance from experts and policymakers and bottom-up engagement from the public in the development and translation of scientific evidence into policy. A variety of intermediaries, from digital platforms to non-governmental organisations have played an important role here. However, these cases have been the exception. Likewise, efforts to co-ordinate the design and implementation of policy across sectors, actors and localities and to facilitate its evaluation and adaptation, have also been sporadic. Investing in developing scientific capacity, resources, and procedures to advance global preparedness and resilience will be key to ensuring that the response to future crises is more systematic, efficient, and agile and ultimately more effective.

Figure 6. Meta-themes and corresponding interventions to improve resilience in relation to complex crises and societal challenges



Note: This is a conceptual representation of the meta-themes and interventions raised in this report and discussed in detail in report 3. Meta-themes are depicted as the five central puzzle-pieces and interventions are shown as the corresponding color-coded rectangles. Dynamic Governance sits at the heart of the puzzle to represent the importance of structural change in this area as a key enabler of the interdependent transformations required in other meta-themes. Similarly, Managing Conflicting Priorities and Agile and Strategic Mobilisation of Capacity comprise the bottom layer of the puzzle to illustrate the foundation provided for the collaboration and co-operation denoted by Transdisciplinary and Reflexive Science and Co-ordination & Collaboration Across Levels of Governance. The graphic is intended as a general heuristic to guide policymakers. Efforts to prioritise and sequence various actions will depend on the national context and will likely require multiple iterations over the long-term.
Source: Authors' design.

Endnotes

[1] A curated selection of significant quotations was taken primarily from the 'Priority setting and co-ordination of research agendas' workshop held in October 2021 (https://www.oecd.org/sti/inno/priority-setting-and-coordination-of-research.htm). Note that as the workshop was unscripted, some quotations have been edited as necessary to ensure understandability. The selection was made to limit overlap or repetition among the quotations featured. The number of times a key issue is featured in the quotations is not indicative of its significance.[2] PHSMs are generally considered to include actions that can be taken by people, communities, institutions, domestic governments, and international bodies, aside from scientific countermeasures (vaccines, therapeutics), to limit the transmission of an infectious disease (WHO, 2020[128]). For the purposes of this document, the term, 'PHSMs' has been used in line with the terminology adopted by the WHO; however, over the course of the pandemic response, various other terms have been used, including non-pharmaceutical interventions (NPIs) (U.S. CDC, 2020[129]) and behavioural, environmental, social and systems interventions (BESSIs) ((n.a.), 2020[130]).

[3] Policy recommendations can be viewed as critical actions with universal relevance to the ability of science systems to prepare for and respond to crises. On the other hand, policy options represent potential measures which might be taken to achieve or progress towards the related recommendation. Stakeholder roles and responsibilities and how selected options are implemented will be dependent on the national context in which they are applied.

[4] For comparative national case studies, including detailed information and analysis of how scientific advice operated during the COVID-19 pandemic see the *Comparative COVID Response* (CompCoRe) project (https://compcore.cornell.edu) and the *Evaluation of Science Advice in a Pandemic Emergency (EScAPE) project (*https://escapecovid19.org/about/*)* both of which received United States NSF support from the early stages of the pandemic. (Publications from these studies can be accessed via their respective websites.)

[5] In large-scale crisis situations where multiple territories, countries, or regions are impacted, the capacity of policy and science actors to work across levels of government can be critical. Coverage of this issue can be found in several recent OECD publications, including: *The territorial impact of COVID-19: Managing the crisis and recovery across levels of governmen*t (OECD, 2021[54]) and the OECD *Recommendation on the governance of critical risks* (https://www.oecd.org/gov/risk/Critical-Risks-Recommendation.pdf) .

[6] National exceptionalism has been documented as a key factor in the COVID-19 responses of several developed countries. Scholars posit that these tendencies led to the denial of the severity of the situation and assumptions of invulnerability, which slowed the speed of domestic response efforts and justified the failure of individuals to adhere to public health guidelines (Bortolotti and Murphy-Hollies, 2022[131]).

[7] The scientific-political interface around hydroxychloroquine shows politicisation in relation to efforts both to promote the therapy in defence, or support, of current government leaders and to critique the drug and emerging findings with explicit reference to the political landscape (Marcon and Caulfield, 2021[132]).

[8] In a statement made during the United States hearing on "Misinformation, Conspiracy Theories, and Infodemics: Challenges and opportunities for stopping the spread online" in October 2020, the Research Director of Harvard Kennedy School's Shorenstein Center on Media, Politics and Public Policy covered various contributors to the spread of mis- and disinformation during the pandemic (Donovan, 2020[133]). She advocated that social media platforms must act against misinformation arising from anonymous sources, as well as harmful claims coming from celebrities, politicians, and other individuals with significant platforms.

[9] Several high-profile individuals, who had formerly held positions in science advice structures or the scientific community made public statements criticising CDC guidance at different stages of the pandemic response (Piller, 2020[90]). For example, a former National Institutes of Health Director and the president of the Rockefeller Foundation published an Opinion Piece in the New York Times (https://www.nytimes.com/2020/08/31/opinion/cdc-testing-

coronavirus.html) to counter CDC guidance that asymptomatic people did not require testing after being in contact with someone with COVID-19. The guidance from CDC was widely attributed to political pressure and was reversed several weeks later.

[10] A "ladder of citizen participation" was first conceptualised by Sherry Arnstein in 1969. It encompasses a spectrum of citizen involvement from non-participation (manipulation and therapy) to tokenism (informing, consultation, and placation) and citizen control (partnership, delegation, and citizen control) (Arnstein, 1969[125]).

[11] Misinformation can be defined as false or misleading information that is shared without the intention to do harm and potentially with the sharer unaware that the information is false. On the other hand, disinformation is defined as knowingly sharing false, manipulative, or misleading information with the intention of causing harm (OECD, 2022[101]).

[12] Chinese Taipei's initial public communication strategy rallied public support, in part, by framing COVID-19 as a national security threat (Yen, 2022[134]). Two years into the pandemic, the administration changed tact and adopted a 'living with the virus' mentality. Policy interventions shifted to shorten quarantines and keep businesses open; however, people continued to feel that the virus was a significant threat and, with the transition in the public health strategy, were potentially more likely to feel that government was incapable of protecting them. [see report from workshop on Public Communication and Engagement, https://one.oecd.org/official-document/DSTI/STP/GSF(2022)9/FINAL/en].

[13] A study undertaken by the United Kingdom Health Research Authority in March 2020 found that accelerating the development of research in response to the pandemic had reduced patient involvement in study design and implementation from 80 to 22% (Denegri and Starling, 2021[118]) (NHS Health Research Authority, 2021[135]). In response, the agency developed a national matchmaking service to facilitate connections between researchers, patients, and civilians to improve public engagement.

[14] While the majority of community engagement examples from high-income countries consist of consultation, there is an increasing number of initiatives and studies involving participation of patients and the public in research being undertaken in the Global South (Tembo et al., 2021[136]).

[15] Several suites of recommendations are already available to support science and policy actors in this area, including Humm and Schroegel's recommendations for engaging underserved groups (Humm and Schrögel, 2020[137]) and UNICEF's 16 minimum standards and indicators for community engagement (UNICEF, 2020[96]).

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Annex 1: Recommendations and options for Preparedness and Response

PREPAREDNESS

PRIORITY SETTING

Codesign research agendas to enable science systems to respond rapidly and holistically as crises evolve

- Ensure scientists have autonomy and strategic intelligence to set research agendas in the early stages of crisis response
- Facilitate agile agenda setting to foster preparedness and accelerate reallocation of resources
- Nurture long-term collaboration between policy-makers, scientists, and others to ensure coordination of national STI activities
- Integrate scientific evidence into policy development and social and policy imperatives into the scientific research agenda

Embrace an interdisciplinary and multi-dimensional approach when developing research priorities

- Adopt all-hazards methodology to surveillance and long-term agenda setting
- Support diverse suite of research between and during crises to balance short- and long-term returns
- Prioritise cross-disciplinary collaboration and mission-oriented research
- Proactively address knowledge gaps in development and implementation of PHSMs

Harmonise and standardize global research activities during crises and adopt learnings across borders

- Improve collaboration and communication between international and regional/domestic bodies
- Ensure global research agendas are inclusive of needs and challenges of disproportionately affected regions and populations
- Increase international coordination, collaboration, standardization of clinical and population research
- Leverage learnings and good practice from across countries, disciplines, sectors to improve PHSMs

SCIENTIFIC ADVICE

Take sustained action to develop structures, capacities, and good practices to generate science advice in crises

- Ensure sustained, long-term and strategic investment into science to provide the evidence-base required during crises
- Involve the scientific community in long-term emergency preparedness activities for rapid mobilization and alignment
- Proactively establish mechanisms and processes to ensure existing capacities can be rapidly leveraged and adapted during crises

Work together to ensure that science advice structures and processes can access broad expertise and are tailored to their operating context

- Include and prioritise a diversity of expertise in science advice structures. Test multidisciplinary structures in advance.
- Prioritise the development of culture, skills, and methods to synthesize insights across different disciplines, geographies, and sectors
- Ensure science advisory processes reflect the history, culture, regulatory, and administrative regimes where they operate

Improve coordination and exchange between local, national, and international science advice activities.

- Improve coordination and communication between subnational and national science advisory structures
- Leverage established international agencies and collaboration channels to develop universally relevant science advice
- Invest in long-term development of science capacities in LMICs and ensure global efforts are representative of all countries

Develop long-term strategies to increase and maintain the trust of civil society in scientific institutions

- Integrate formal, transparent governance mechanisms into science advice structures to ensure legitimacy and independence
- Embed quality assurance processes into science advice structures to ensure evidence is robust, reliable, and aligns with ethical standards
- Distinguish roles of scientific experts and policy-makers in development and use of science advice
- Clarify and codify legal liabilities of science advisors, while establishing mechanisms to mitigate the politicization of science and abuse of experts

PUBLIC COMMUNICATION & ENGAGEMENT

Tailor crisis communication to address needs, questions, and concerns of all citizens

- Leverage existing capacity, relationships, resources, good practice to communicate and engage citizens during crises
- Engage the social sciences and humanities in response efforts and leverage related data, narratives, and behavioral insights

Invest in long-term public communication efforts to rely on citizen trust in science during crises

- Improve science, data, and digital literacy to ensure the public is able to engage effectively with the scientific process and address mis/disinformation
- Leverage partnerships with intermediaries to reinforce trust in science, disseminate timely and targeted information and address harmful claims

Prioritise equity, diversity and inclusion in science and science policy by engaging the public

- Invest in establishing infrastructure, capacity, resources, and culture required to advance and adapt public engagement mechanisms
- Actively seek participation of underrepresented, disadvantaged and divergent perspectives through partnerships and forums targeted to open dialogue
- Encourage and support bottom-up citizen science activities, particularly those not aligned with the status quo or dominant political agendas

Legend

- Policy Recommendation
- Policy Option requiring action in identified stage of crisis response
- Policy Option requiring action in preparedness & response

Overlap

- Data access
- Research infrastructures
- Science-industry collaborations
- Priority setting & funding
- Scientific advice
- Public communication & engagement

Note: See following page for policy recommendations and options targeted to the response phase and a brief explanation to aid interpretation.

RESPONSE

PRIORITY SETTING

CODESIGN RESEARCH AGENDAS TO ENABLE SCIENCE SYSTEMS TO RESPOND RAPIDLY AND HOLISTICALLY AS CRISES EVOLVE

- Facilitate agile agenda setting to foster preparedness and accelerate reallocation of resources
- Integrate scientific evidence into policy development and social and policy imperatives into the scientific research agenda

EMBRACE AN INTERDISCIPLINARY AND MULTI-DIMENSIONAL APPROACH WHEN DEVELOPING RESEARCH PRIORITIES

- Support diverse suite of research between and during crises to balance short- and long-term returns
- Prioritise cross-disciplinary collaboration and mission-oriented research

HARMONISE AND STANDARDIZE GLOBAL RESEARCH ACTIVITIES DURING CRISES AND ADOPT LEARNINGS ACROSS BORDERS

- Improve collaboration and communication between international and regional/domestic bodies
- Ensure global research agendas are inclusive of needs and challenges of disproportionately affected regions and populations
- Increase international coordination, collaboration, standardization of clinical and population research
- Leverage learnings and good practice from across countries, disciplines, sectors to improve PHSMs

SCIENTIFIC ADVICE

TAKE SUSTAINED ACTION TO DEVELOP STRUCTURES, CAPACITIES, AND GOOD PRACTICES TO GENERATE SCIENCE ADVICE IN CRISES

- Proactively establish mechanisms and processes to ensure existing capacities can be rapidly leveraged and adapted during crises

WORK TOGETHER TO ENSURE THAT SCIENCE ADVICE STRUCTURES AND PROCESSES CAN ACCESS BROAD EXPERTISE AND ARE TAILORED TO THEIR OPERATING CONTEXT

- Include and prioritise a diversity of expertise in science advice structures. Test multidisciplinary structures in advance
- Prioritise the development of culture, skills, and methods to synthesize insights across different disciplines, geographies, and sectors
- Ensure science advisory processes reflect the history, culture, regulatory, and administrative regimes where they operate

IMPROVE COORDINATION AND EXCHANGE BETWEEN LOCAL, NATIONAL, AND INTERNATIONAL SCIENCE ADVICE ACTIVITIES.

- Improve coordination and communication between subnational and national science advisory structures
- Leverage established international agencies and collaboration channels to develop universally relevant science advice
- Invest in long-term development of science capacities in LMICs and ensure global efforts are representative of all countries

DEVELOP LONG-TERM STRATEGIES TO INCREASE AND MAINTAIN THE TRUST OF CIVIL SOCIETY IN SCIENTIFIC INSTITUTIONS

- Integrate formal, transparent governance mechanisms into science advice structures to ensure legitimacy and independence
- Embed quality assurance processes into science advice structures to ensure evidence is robust, reliable, and aligns with ethical standards
- Distinguish roles of scientific experts and policy-makers in development and use of science advice
- Clarify and codify legal liabilities of science advisors, while establishing mechanisms to mitigate the politicization of science and abuse of experts

PUBLIC COMMUNICATION & ENGAGEMENT

TAILOR CRISIS COMMUNICATION TO ADDRESS NEEDS, QUESTIONS, AND CONCERNS OF ALL CITIZENS

- Leverage existing capacity, relationships, resources, good practice to communicate and engage citizens during crises
- Engage directly with the public using a variety of communication mediums and experimental approaches
- Engage the social sciences and humanities in response efforts and leverage related data, narratives, and behavioral insights
- Ensure that messaging, delivery, communicator align with peoples' emotional needs and transparently answer urgent questions

INVEST IN LONG-TERM PUBLIC COMMUNICATION EFFORTS TO RELY ON CITIZEN TRUST IN SCIENCE DURING CRISES

- Be transparent about uncertainties in the evidence being used to inform policy decisions.
- Improve science, data, and digital literacy to ensure the public is able to engage effectively with the scientific process and address mis/disinformation
- Approach communication efforts with nuance and consider potential interpretation by different groups and in different contexts
- Leverage partnerships with intermediaries to reinforce trust in science, disseminate timely and targeted information and address harmful claims

PRIORITISE EQUITY, DIVERSITY AND INCLUSION IN SCIENCE AND SCIENCE POLICY BY ENGAGING THE PUBLIC

- Actively seek participation of underrepresented, disadvantaged and divergent perspectives through partnerships and forums targeted to open dialogue
- Encourage and support bottom-up citizen science activities, particularly those not aligned with the status quo or dominant political agendas

Overlap

- Data access
- Research infrastructures
- Science-industry collaborations
- Priority setting & funding
- Scientific advice
- Public communication & engagement

Legend:

- Policy Recommendation
- Policy Option requiring action in identified stage of crisis response
- Policy Option requiring action in preparedness & response

Note: The two tables show recommendations and policy options and in terms of relevance to the preparedness and response stages of the crisis management cycle. Policy options pertaining to both stages are shown in both tables. Overlaps and potential points of synergy between areas of science for policy and society (this report) and policy for science (report 1) are indicated with icons.

Annex 2: Expert Group Membership

Country	Name	Position	Organisation
AUS	Julian Thomas	Director, Professor of Media and Communications	Swinburen Institute for Social Research
BEL	Marie Delnord	Public Health Researcher, Epidemiologist	Sciensano, Belgian Public Health Institute
CAN	David Castle	Researcher in Residence	Office of the Chief Science Advisor, Government of Canada
CZE	Petr Bartůněk	Group Leader	Institute of Molecular Genetics,Czech Academy of Sciences
CZE	Tereza Stöckelová	Researcher, Associate Professor of General Anthropology	Institute of Sociology of the Czech Academy of Sciences
FRA	Yazdan Yazdanpanah	Director	ANRS Maladies Infectieuses Emergentes
JPN	ARIMOTO Tateo	Principal Fellow	Center for Research and Development Strategy (CRDS), Japan Science and Technology Agency (JST)
JPN	Mr. OYAMADA Kazuhito	Fellow	JST
JPN	Mr. KANO Hiroyuki	Fellow	JST
KOR	Dr. Inkyoung SUN	Head, Office of Development Co-operation Research	Science and Technology Policy Institute (STEPI)
KOR	Myong Hwa Lee, Ph.D	Head, Office of National R&D Research	Science and Technology Policy Institute (STEPI)
NLD	Prof. dr. F.W.A. (Frans) Brom	Professor, Normativity of Scientific Policy Advice	Ethics Institute, Utrecht University
NOR	Trygve Ottersen	Executive Director	Norwegian Institute of Public Health
PRT	Vanda Oliveira		FCT
PRT	Isabel Carvalho-Oliveira	Delegate and NCP for Health in the Horizon Europe Programme	Agency for Clinical Research and Biomedical Innovation
ZAF	Dr Ntsane Moleleki	Senior Specialist – Policy Investigation	National Advisory Council on Innovation (NACI)
ZAF	Dr Tozama Qwebani-Ogunleye	Project Manager	Institute of Traditional Knowledge, Vaal University of Technology (VUT)
UK	Randolph Kent	Director	Humanitarian Futures
UK	Mike Bright	Deputy Director, International	UK Research and Innovation

Annex 3: International Workshop Series Overview

	Workshop	Description
R2: POLICY FOR SCIENCE	I. **23 April 2021:** Enhancing access to research data during crises	**Completed in partnership with the RDA and co-located with RDA's 17th Plenary meeting.** Sessions focused on high-level policy frameworks and domain-specific issues. Biomedical and clinical data, omics and epidemiology, and social sciences and interdisciplinary research were covered in individual sessions.
	II. **11 May 2021:** Mobilising research infrastructures in response to COVID-19	**Completed in partnership with Science Europe and held as a satellite event of the 2021 International Conference on Research Infrastructures (ICRI).** Sessions explored key challenges and good practices for the emergency management and operation of research infrastructures across different research domains. Actions to enable preparedness for future crises were also considered.
	III. **16 September 2021:** Improving academia-private sector interactions	**Completed in partnership with the OECD working party on Technology and Innovation Policy (TIP).** Actors directly involved in participating and/or funding transdisciplinary research or co-designed policy presented learnings from specific case studies. GSF and TIP Bureau members also provided short interventions reflecting workshop learnings and their national contexts.
R3: SCIENCE FOR POLICY & SOCIETY	IV. **4-5 October 2021:** Priority setting and co-ordination of research agendas	Case study presentations and moderated discussion covered setting, steering, and co-ordinating research priorities during crises. Specific focus was placed on data collection, evidence for public health and social measures, and maintaining agility and flexibility. In a final panel discussion, participants reflected on the importance of international co-operation and global and national preparedness for future crises.
	V. **3-4 March 2022:** Scientific advice in crises	A diversity of scientific disciplines was represented by key experts in scientific advisory processes and policy development. Critical issues included interplays between science, policy, and politics; transdisciplinary knowledge; public communication and trust; co-ordination across governance levels; and implications for future crisis response.
	VI. **22 April 2022:** Public communication and engagement in science	The final event was added to expand on insights developed in earlier workshops regarding the role of civil society in a science-based response to crisis. Sessions were designed around the mitigation of mis- and disinformation; managing and communicating uncertainty; public engagement; and long-term trust. In a final panel discussion, participants reflected on the importance of advancing novel participatory approaches, while ensuring feasibility and buy-in from civilians, as well as policy and science actors.

Annex 4: Policy for Science Workshop Contributors

Workshop Session	Name and Title	Organisation	Country
Priority setting and co-ordination of research agendas			
Priority setting for research and data collection in the early crisis phase	Steven Hoffman, Scientific Director	Canadian Institutes of Health Research (CIHR)	CAN
	Virginia Murray, Head of Global Disaster Risk Reduction	UK Health Security Agency (UKHSA)	UK
	Charles Wiysonge, Director	Cochrane, South Africa and African Medical Research Council	ZAF
	Gregory Armstrong, Director of the Advanced Molecular Detection Programme	Centers for Disease Control and Prevention (CDC)	USA
Development of the evidence-base for social interventions	Atle Fretheim, Research Director	Norwegian Institute of Public Health (NIPH)	NOR
	Jan Brauner, Centre for Doctoral Training on Intelligent and Autonomous Machines and Systems	University of Oxford	UK
	Gideon Meyerowitz-Katz, Epidemiologist	University of Wollongong, School of Health and Society	AUS
	Susan Michie, Advisor to British Government	SAGE Advisory Group	UK
Priority setting and co-ordination as a crisis evolves	Balthazar Nunes,	Portugal National Institute of Public Health	PRT
	Camilla Stoltenberg, Director General	Norwegian Institute of Public Health (NIPH)	NOR
	Joseph Wu, Professor in public health	University of Hong Kong, China	HKG
	Byeongwon Park, Research Fellow	Science and Technology Policy Institute (STEPI)	KOR
International co-operation and priority setting: improving preparedness for the next crisis	Boitumelo Semete-Makokotlela, CEO	South African Health Product Regulatory Authority	ZAF
	Devi Sridhar, Professor of Global Public Health and Advisor to the Scottish Government on COVID-19	University of Edinburgh	UK
	Yazdan Yazdanpanah, Director	ANRS Maladies Infectieuses Emergentes	FRA
	Osamu Aruga, Director for International Affairs	Cabinet Office, Secretariat of STI Policy	JPN
	Ezekiel Emanuel, Vice-Provost and former government advisor on COVID-19	University of Pennsylvania	USA
Scientific advice in crises			
Science, policy and politics	Sheila Jasanoff, Pforzheimer Professor in science and technology studies	Harvard Kennedy School	USA
The operational challenges of making evidence-based policy	Sir Ian Diamond, Chief Executive	UK Statistics Authority	UK
	Jet Bussemaker, Chair and Professor	Council of Public Health and Society and Leiden University	NLD
	Bob Kolasky, Director of the National Risk Management Center *Chair of the OECD High-level Risk Forum*	United States Department of Homeland Security, Cyber and Infrastructure Security Agency	USA
Evolving advisory processes, roles and responsibilities of scientific advisors	So Young Kim, Director of the Korea Policy Center for the Fourth Industrial Revolution (KPC4IR)	Korea Advanced Institute of Science and Technology (KAIST)	KOR
	Marion Koopmans, Head of Viroscience	Erasmus University	NLD
	Petr Smejkal, Chief Epidemiologist	IKEM	CZE
	Dominique Costagliola, Senior Researcher and Deputy-Head	INSERM and Institut Pierre Louis d'Epidémiologie et de Santé Publique	FRA
	Patrick Fafard, Senior Investigator	University of Ottawa, Global Strategy Lab	CAN
Ensuring a holistic/ multidisciplinary evidence base	Muto Kaori, Professor of public policy	University of Tokyo, Institute of Medical Science	JPN
	Marijn de Bruin, Head of Research for Behavioural medicine	National Institute of Public Health and Environment	NLD
	Geoff Mulgan, Professor in social innovation and public policy	University College London	UK

	Rémi Quirion, President and Chief Science Advisor of Québec	President, International Network for Government Science Advice (INGSA); Chief Science Advisor, Quebec	CAN
	Bob Kolasky, Director of the National Risk Management Center *Chair of the OECD High-level Risk Forum*	United States Department of Homeland Security, Cyber and Infrastructure Security Agency	USA
Communication of scientific advice, building trust	Mikihito Tanaka, Professor in political science and economics	Waseda University	JPN
	Michael Bang Petersen, Professor in political science	Aarhus University	DNK
	Camilla Stoltenberg, Director General	Norwegian Institute of Public Health (NIPH)	NOR
	Dr. Henrique Barros, President	University of Porto, Institute of Public Health	PRT
Scientific advice at different scales: co-ordination and contextualisation	Melanie Davern, Associate Professor and Director	RMIT University and Australian Urban Observatory	AUS
	Christian Léonard, Strategic Director of Sciensano	Belgian Public Health Institute	BEL
	David Nabarro, Strategic Director; *former WHO Director and former UN special envoy on pandemics*	4SD	UK
	Nicole Grobert, Chair	European Commission Scientific Advisory Mechanism	EC
	Sir Ian Diamond, Chief Executive	UK Statistics Authority	UK
Implications for science advice in future crises	John-Arne Røttingen, Ambassador for global health	Ministry of Foreign Affairs	NOR
	Kiyoshi Kurokawa, emeritus Professor	University of Tokyo	JPN
	Helena Pereira, President of the Board of Directors	Fundação para a Ciência e a Tecnologia (FCT)	PRT
	Daan Du Toit, Deputy Director-General of International Cco-operation and Resources	Department of Science and Technology	ZAF
	Rebecca Bunnell, Chief Science Officer and Director	Centre for Disease Control and Prevention (CDC), Office of Science	USA
Public communication and engagement in science			
Scientific information, disinformation, and misinformation	Lu'chen Foster, Head of health partnerships	Facebook	USA
	Takahiro Kinoshita, Deputy-Chair	Covid-19 Navigator Cov-Navi	JPN
	Dr. Gabriela Capurro, Professor of Journalism and Communication	Carleton University	CAN
Managing diverse scientific opinions and uncertainties	Dr, Anat Gesser-Edelsburg, Head of the Health Promotion Program	University of Haifa, School of Public Health	ISR
	Jean-Gabriel Ganascia, Chairman and Professor of computer science	CNRS ethics committee and Sorbonne University	FRA
	Tracy Vaillancourt, Chair of the taskforce on COVID-19	Royal Society of Canada	CAN
Public engagement and mobilisation in science and science advice during crises	Li-Yin Liu, Visting assistant professor in Public Administration	University of Dayton	USA/TPE
	Felicity Callard, Professor in human geography	University of Glasgow	UK
	Dr. Barbara Prainsack, Professor in political science	University of Vienna	AUT
Building confidence and long-term trust	Takahiro Kinoshita, Deputy-Chair	Covid-19 Navigator Cov-Navi	JPN
	Li-Yin Liu, Visting assistant professor in Public Administration	University of Dayton	USA/TPE
	Felicity Callard, Professor in human geography	University of Glasgow	UK