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Background Paper

Bouncing Forward Sustainably: Pathways to a post-COVID-19 world

Strengthening Science Systems

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Abstract

This Background Paper was prepared to frame the discussion in the 1st Consultation on Strengthening Science Systems within the IIASA-ISC Consultative Science Platform "Bouncing Forward Sustainably: Pathways to a post-COVID-19 world". The paper briefly discusses the response of science and scientists to the COVID-19 crisis, the dissemination of research results and the input of the science community into public policy. While science responded fairly rapidly with appropriate research and the communication of research to the public and to policy makers, there is clear room for improvement. Drawing from the experience of the COVID-19 crisis, three axes of improvement are identified, namely *increased agility*, *enhanced reliability*, and *a more effective science-policy-society interface*. The paper identifies barriers that constrain and inhibit the effectiveness and efficiency of the science system in terms of these three axes. The barriers include misinformation and pseudoscience; the lack of access to data and to mathematical models; the slow pace of peer review; funding challenges both overall and in efficient allocation to critical issues; public trust in, and understanding of, science. Finally, in relation to science for policy, there are issues of transparency, contestation between scientists proffering advice, the need to widen the disciplinary base of science advice and the importance of adopting an interdisciplinary and systemic approach.

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Preamble

Science has been playing a highly visible role in the ongoing COVID-19 crisis. Policy makers and the general public expect medical sciences, including biomedicine, virology, and epidemiology, as well as economics, psychology, sociology, and international relations, among other disciplines, to provide clear insights, reliable solutions, and actionable advice in a timely manner. Policy makers all over the world report that they use scientific evidence to inform their decisions. Lay people routinely discuss the recent estimates of the reproduction number and what implications this has for everyday life. Researchers in a number of labs around the world are working tirelessly on the vaccine or other medical interventions. While perceptions as to how science has responded to the crisis may vary, there is a broad consensus that there is a room for improvement for the science system to serve the public interests in the context of rapidly evolving exogenous shocks.

The COVID-19 crisis will eventually come to an end. However, exogenous shocks propagating throughout global networks and leading to devastating impacts will certainly occur again. Despite warnings about a global pandemic of an infectious disease to be a likely cause of a "global catastrophe" (e.g., link), COVID-19 took the world by surprise. With the goal of enhancing our resilience to exogenous shocks in the future (link), the IIASA-ISC Consultative Science Platform on Strengthening Science Systems aims to analyze the experience of the COVID-19 crisis and formulate strategic recommendations as to how science can be better prepared to deal with similar shocks in a situation when many critical determinants and indirect effects are not well understood. This paper provides some background information and proposes three axes of improvement for science systems in the future.

COVID-19 take-off

On 31 December 2019 the Wuhan Municipal Health Committee informed WHO of "27 cases of pneumonia of unknown etiology (unknown cause)" detected in Wuhan City, Hubei Province of China (link). The source of disease and how it reached humans was unclear. On 20 January 2020 China's National Health Commission confirmed for the first time that the infection could have been transmitted from human-to-human (link). That same day the WHO stated that it was "now very clear" that human-to-human transmission of the coronavirus had occurred (link). On 30 January 2020 WHO declared the ongoing outbreak a Public Health Emergency of International Concern (PHEIC), and on 11 March 2020 they announced that WHO "made the assessment that COVID-19 can be characterized as a pandemic", adding that "this is the first pandemic caused by a coronavirus" (link).

In response to the outbreak, many countries around the world implemented mass quarantine measures including the declaration of a state of emergency, travel restrictions, recommendations to stay at home, bans on holding events, and the suspension of some economic activities. Schools, universities and colleges closed either on a nationwide or local basis in 190 countries, affecting over 70% of the world's student population (link and link). As of April, about half of the world population was in some form of lockdown with billions of people affected (link and link). From mid-May, a number of countries around the globe started to relax the lockdown measures (link).

Science's response to COVID-19

As early as January 2020, renowned medical experts started to comment on the new coronavirus outbreak including the statements that its spread was "clearly very concerning" and calls "to take the outbreak seriously and monitor the situation carefully" (link). Many influential business figures and experts across various fields also began to share opinions, analyses and advice (e.g., link and link).

Academic research, notably, medical science, reacted to the situation within less than a month. For example, already on 20 January 2020, an editorial in *Nature* emphasized that researchers had played a crucial role in publishing and sharing genomic sequences, that researchers were to be commended for making sequence data available, and were urged to continue doing so (link). Moreover, according to *Nature*, by 30 January, at least 54 English-language papers on the coronavirus had already been made available – many of them via preprint servers, but a few had found their way into peer-reviewed journals. These papers included several studies presenting estimates of the incubation period and scenarios of the virus spread. Other studies focused on the virus's structure or genetic make-up – information needed to identify drug targets and develop a vaccine. In addition, researchers published genomic data on the virus on the online platforms such as GISAID or GenBank (link).

In an article published in *Science Translational Medicine* on 11 March 2020 (link), the authors discussed mathematical models aimed at forecasting COVID-19 cases over time horizons of a few weeks that already began to appear in published papers and online resources. They emphasized that the development of comprehensive models that would include complex pathogen and society-based variables would require considerable effort and time (months to years), but that existing models developed for previous pandemics and outbreaks could be utilised. Furthermore, the authors emphasized the fact that while many mathematical modeling groups in the United States, China, and Europe were working independently to predict the spread of COVID-19 infections, coordination among these groups would help increase efficiency.

As of 11 May 2020, with the use of the keyword "COVID", the Scopus database identified 43 papers published in March, 2184 papers published in April, and 3568 papers published in May 2020 – a rapid rate of increase that shows no signs of slowing (link). An overwhelming majority of these papers indicated "Medicine" as a subject area, followed by "Immunology and Microbiology", "Biochemistry, Genetics, and Molecular Biology", "Neuroscience", "Nursing", "Health Professions", "Psychology", "Pharmacology, Toxicology, and Pharmaceuticals", "Social Sciences", and "Environmental Sciences". It is encouraging to see a much higher fraction of COVID-19-related papers published open-access (80%) as compared to the general open-access publication rate in subject area "Medicine" (38%).

The science system is challenged to swiftly provide high-quality usable results while at the same time advancing our understanding of the fundamentals (link). Many experts are of the opinion that a great deal has been achieved within a short period of time (link, link, and link) and in particular that unprecedented data sharing has resulted in faster-than-ever research on a disease outbreak: "Never before … have so many of the world's researchers focused so urgently on a single topic" (link). One noted problem is that the focus on COVID-19 de-prioritizes all other research areas. In addition, researchers have expressed concern as to multiple overlapping research endeavours and a consequent wasting of resources (link). There is considerable scope for increased cooperation and collaboration in research.

COVID-19 seems to aggravate existing inequalities in science. With regard to gender, for example, while it is too early to make robust statements, early journal submissions to date seem to suggest that COVID-19 has seen a reduction in the research productivity of women (link, link, link, link).

As regards scientific advice to policy makers, cases of delayed communication have been discussed in the media. For example, *Reuters* reported that in the UK, "scientific advisors concluded early the virus could be devastating", but at the same time, "for more than two months, the scientists whose advice guided Downing Street did not clearly signal their worsening fears to the public or the government". *Reuters* also reported that "the scientific committees that advised Johnson didn't study, until mid-March, the option of the kind of stringent lockdown adopted early on in China" (link).

Apart from the dissemination of the latest scientific results, the science community provided input to policy decisions through the participation of selected scientists in the work of advisory boards to national governments. For example, on 17 March 2020, the European Commission launched an Advisory Panel composed of epidemiologists and virologists from different member states to formulate the EU guidelines on science-based and coordinated risk management measures (link). In the UK, Scientific Advisory Group of Emergencies (SAGE) is a standing body that provides ministers and officials with evidence-based scientific advice in emergencies. SAGE itself relies on external science advice; in the case of COVID-19, this includes the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG; link) that consists of medical scientists, virologists, epidemiologists, a sociologist, and a psychologist. In Austria, a task force was set up by the Ministry of Health. Apart from Ministry staff, it includes experts in medical science, virology, epidemiology, computer simulations and crisis management (in the Advisory Board; link). Just prior to initiating a lockdown, on 26 March, when infection in South Africa was at a very early stage, a non-statutory Ministerial Advisory Committee (MAC) on COVID-19 was appointed to provide high-level strategic advice to the Minister of Health and Welfare. The MAC consists of four committees: 1. Pathologists and Laboratory; 2. Clinicians; 3. Public Health; and 4. Research; each committee is chaired by a leading scientist in the area (link).

Infodemic, misinformation and pseudoscience

"We're not just fighting an epidemic; we're fighting an infodemic," said WHO Director-General Tedros Adhanom Ghebreyesus at the Munich Security Conference on 15 February 2020, referring to fake news that "spreads faster and more easily than this virus, and is just as dangerous" (link). The WHO expressed concern that misinformation, disinformation and rumors hamper an effective public health response and create confusion and distrust among people (link). According to some experts, "The best way to fight misinformation is to swamp the landscape with accurate information that is easy to digest, is engaging and easy to share on mobile. It should also answer people's questions and ultimately fears" (link).

Many unsound practices and therapies have been advanced – sometimes even by universities and health-care institutions. Many would argue that scientists have a special responsibility to speak out when scientifically unsound views are propagated and disseminated. Strengthening the system of scientific expertise and quality assurance is critical in combatting the practice and dissemination of pseudoscience. To counteract the spread of rumors and misinformation on COVID-19 in the digital media, the WHO is working with search and media companies, including Facebook, Google, Pinterest, Tencent, Twitter, and TikTok (link).

Open data and models, and dissemination of scientific results

Data is essential for research and decision making at all levels. Countries publish up-to-date statistics on the number of those testing positive, those hospitalized, those in intensive care, and the number of deaths (link) at different levels of spatial granularity and disaggregation. Some governments have been criticized for not providing detailed enough information. For example, the UK government was criticized in early April for not providing data on the national hospitalization rates and for no regional, age or gender breakdowns of daily deaths (link). China is traditionally criticized by western experts for hiding information from own citizens (link). By contrast, Singapore has been publishing detailed data about every infected person. However, this may harm the patients' right to privacy and incentivize respondents to lie to authorities, undermining the quality of data (link). Due to measurement and publication lags, data on the economic and other indirect impacts of COVID-19 on the society is generally less readily available.

The private sector holds data that can provide complementary and very important information. Mobility dynamics, purchases patterns, even internet searches can be used to derive valuable insights to inform science, public policy, and personal behavior and choices. Some companies do make some of this data available for public use. For example, Google shared so-called community mobility reports which reflect the percentage change in visits to places like grocery stores and parks within regions in countries (link). Russia's biggest IT company Yandex pulls together various kinds of data including traffic, taxi use, and route searches to derive and make available in real time what they call the self-isolation index, which shows the difference in people's mobility compared to normal times (link). However, these are exceptions. Much more data in the private sector remains inaccessible, and even in these exceptional examples, IT companies do not offer raw data, but high-level aggregative data. Since private companies benefit from public investment in human capital, R&D, and infrastructure, they can be expected to bear significant responsibility to the broader society by contributing to resolving crises like COVID-19.

It is important that scientific models used to estimate the dynamics of the outbreak and its consequence are transparent (link). This concerns both the possibility for other researchers to run the model, as well as to have sight of and to be able to examine the computer code and input data.

Pre-print servers and other ways to disseminate results swiftly are playing an ever larger role allowing for the often slow and sometimes biased peer-review procedure to be by-passed. Publishers of peer-reviewed journals have provided free access to publications relevant to COVID-19 (link). Moreover, leading scientific journals have announced fast-tracking of the submissions related to COVID-19 (e.g., *Elsevier* link, *PLOS* link). This however creates a great pressure on scientists and increases the risk for scientific integrity (link). An artificial intelligence (AI) tool is being made available by a Brooklyn-based startup company Scite.ai to check which research findings are supported and which are contradicted by subsequent studies (link) enabling a massive cross validation of scientific evidence. As AI is far from infallible, it is important to fully understand and endorse the logic of the algorithms by which AI operates in order to ensure that humans remain in control of AI-informed decisions.

Funding

In mid-February, WHO voiced concerns about "the lack of urgency in funding the COVID-19 response from the international community" (link). This includes also the funding of research.

Some private funding was made available very swiftly. Most notably, on 5 February the Bill & Melinda Gates Foundation announced the commitment of $100 million for the global response to the coronavirus. This funding was aimed to help strengthen detection, isolation and treatment efforts; protect at-risk populations; and develop vaccines, treatments and diagnostics. On 15 April, the foundation announced additional pledge of $150 million, which brings their total commitment so far to more than $250 million (link).

Public funding has also been provided on a large scale (link). The EU convened the (virtual) Coronavirus Global Response International Pledging Event on 4 May 2020, in which country leaders committed nearly €7.4 billion to research on the COVID-19 vaccines and therapies, as well as to the distribution of the vaccine to poor countries once it becomes available. The paramount importance of the multilateral cooperation to tackle the COVID-19 challenge was continuously emphasized (link and link). The suboptimal state of global cooperation is reflected in the fact that this event was not attended by, amongst others, India, Russia and the USA (link). Some experts argue that while SARS, H1N1 (swine flu), MERS and Ebola were contained through rapid multilateral action, however, the cross-border response to COVID-19 has been less inclusive (link). For example, most experts are of the view that a coordinated global vaccine development effort using a "big science" approach would be most efficient as it would harness global expertise and resources toward a common goal (link).

While having adequate funding is crucial, a further challenge is to allocate funding wisely. Complaints have been expressed by experts regarding the plethora of various papers and preprints appearing such that "you can read through 50 before you find something that's actually solid and interesting. A lot of research resources are being wasted" (link). An AI-based tool has been developed to facilitate the search for reviewers, which should ultimately accelerate and improve the decision process on research proposals; the users of this tool found it "helpful and crucial in recruiting experts for our COVID-19 Emergency Call" (link).

Science-to-society

While universal access to science is recognized in the Universal Declaration of Human Rights (Article 27; link), normally scientific progress provokes only a limited public interest. COVID-19 has brought science to the forefront of public attention and concern.

The issue of trust in science and its possible erosion has been long discussed and these discussions have significantly intensified with the advent of COVID-19. The COVID-19 crisis challenges trust in science "as never before" (link). Trust in science is critical in determining how people interpret scientific information. Contradictory opinions exist on whether science has been losing the public trust. For example, while some experts argue that the increasing political polarization of the society in the USA has led to the erosion of trust in science (link), several surveys reveal the contrary and demonstrate that the US public's trust in scientists has remained consistently high over decades. Americans are reported to trust scientists more than many other institutions and professions, including journalists, judges, business and officials (link and link). Likewise, many studies confirm high trust in science across Europe (link and link). Somewhat lower levels of trust in science have been observed in the developing world (link).

However, while public trust in science generally remains high, there is an observable lack of public understanding of how science functions and what science can and cannot do. When dealing with matters of public policy, questions of values and how to strike a balance between competing priorities come into play. Science cannot give a single definitive answer (link). Different views and contestation are integral to the scientific endeavor. However, it is difficult for individuals outside of the science community to distinguish healthy scientific debate as opposed to an ill-founded contestation. In order to support trust in science, a richer understanding is needed of the context in which science operates and some capacity to recognize situations when the pursuit of other objectives is camouflaged by the pretense of scientific scrutiny. Stakeholders should be more realistic regarding the limits of what science has to offer when it comes to policy making (link). For its part, science has a responsibility to maintain scientific integrity and to be clear as to the limitations of the advice it submits. Scientists exercising this responsibility is a pre-requisite for trust in science on the part of both the public and policy makers.

In fact, the science-society linkage can and should work in both directions. Not only should scientists communicate information and insights, but also the active participation of lay people in scientific advances needs to be enhanced, for example, through citizen science and other engagement tools (link).

Science-to-policy

While a lack of consultation with scientists in the early stages of the outbreak was observed (link), many countries soon formed advisory boards and task forces consisting of relevant experts to solicit scientific advice (link). However, the activity and membership of such bodies are sometimes not sufficiently transparent (link). Moreover, these advisory boards and task forces often lack experts in some relevant disciplines, such as economics and the behavioral sciences. This absence may have weakened the capacity of the scientists engaged to provide nuanced assessments of the alternative policy measures and to anticipate their possible multi-dimensional unintended consequences. A recent editorial in the *South African Medical Journal* noted that "The absence of a truly multidisciplinary input involving the humanities, social sciences and relevant civil society and private sector actors, including actuaries …, robs South African policymakers of valuable insights that could prove invaluable in the country's fight against the pandemic" (link).

Indeed, COVID-19 is a multi-faceted crisis. Dealing with the crisis requires a holistic systemic approach, "systems thinking can help policymakers understand and influence the spread of infection and its multifaceted consequences across the community since society is itself a complex adaptive system. It can provide a framework to look beyond the chain of infection and better understand the multiple implications of decisions and (in)actions in face of such a complex situation involving many interconnected factors" (link). However, a systems based approach is often insufficiently emphasized and prioritized (link).

As many aspects of the COVID-19 crisis have so clearly demonstrated, science does not speak with one voice. Sweden exemplifies a country whereby scientific advice is integral to policy but at the same time that advice is strongly contested by many in the Swedish science community and indeed in the wider scientific community (link).

The science-policy interface is further complicated because scientists are committed to precision and rigor whereas policy makers are required to achieve multiple often intangible objectives under conditions of considerable uncertainty. The need for 'translators' between science and policy has been raised before, but these discussions will intensify as the COVID-19 crisis propels scientists and science advice to the very center of policy.

Policy outcomes are the result not only of scientific advice but also of other factors – notably finance, state capacities to implement policy and political considerations. "Whatever knowledge the researchers may provide, they have to consider that this knowledge is always interpreted in a political context before it is implemented in political decision-making" (link). Science can reveal what are the different policy choices and what are the costs and benefits of these different possible choices. This makes the call for transparency of how scientific advice has been used to inform what are ultimately political decisions complex but desirable, especially in order to overcome political opposition to engaging with science and science advice.

Science, global collaboration and cooperation

All the scientific disciplines have seen a long-term trend to very significant increases in global collaboration and cooperation between scientists. This has substantially improved the quality of science output. Global cooperation and collaboration have also enhanced equity in science through providing entry points for young scientists, for women and for scientists in the South. The COVID-19 crisis has seen a marked acceleration in collaboration and cooperation between scientists. Comparative experiences and learning become essential as countries struggle to define an optimal path in managing the COVID-19 crisis. However, barriers to cooperation exist particularly as access to data and research become politicised. Scientists have an important role to play in pressing for maximal global cooperation in research and in access to data, in the interests of good science and in the interests of equity in science.

Axes of improvement for the science systems

Based on the lessons of the COVID-19 crisis, three axes of improvement emerge that are required to ensure that science can react more efficiently and effectively to global exogenous threats: increased agility, enhanced reliability and a more effective science-policy-society interface.

These three axes will frame our discussions.

Increased Agility. The ability of the science system to react swiftly to newly emerging and rapidly unfolding issues at national and international levels, as is appropriate, should be significantly enhanced. This includes mechanisms to allocate and reallocate financial resources, to mobilize diverse scientific experts in specific fields as well the scientific community in general, and to establish vital partnerships. Public finances should be used to fund research in the public interest. Foresight should be done periodically to anticipate the range of possible global threats, and scientific expertise to deal with these threats should be continuously strengthened. The value and power of science diplomacy should be recognized and exercised.

Enhanced Reliability. Increased agility must be accompanied by enhanced reliability. Systems thinking can be a useful tool to realise these twin objectives. The ability of the science system to ensure the quality of the more rapidly provided scientific findings should be significantly enhanced. The institution of voluntary and anonymous peer-review, which was already subject to questioning prior to COVID-19, should be seriously re-examined in light of the emerging system of preprints freely disseminated and commented on by the scientific community online. Correcting misrepresentations and fact-checking should be viewed as a professional responsibility. Rigorous standards of scientific quality should be promoted without compromise and the efficiency of quality assurance instruments should be enhanced. Open data and open models should be applied as widely as possible.

More effective science-policy-society interface. To promote the use of scientific evidence for policy and private decision making, strong linkages between science, policy and society should be established in order to ensure that decision-makers and citizens are empowered in using science. It should be generally understood that it is in the interests of all to support countries with insufficient science-to-policy capacity and institutions and help them apply evidence-based policies. At the same time, it must be recognized that scientific advice is only one ingredient in the making of political and personal choices. While science must be integral to policy, the independence of scientists from political forces and the critical importance of contestation to scientific progress must be recognized and safeguarded.