Global Systems Resilience and Pandemic Disease—A Challenge for S&T Governance

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1 Introduction

The twenty-first century has been referred to as a time of emerging systemic risks (OECD, 2003). Many such risks relate to biological agents: emerging infectious diseases (EIDs) such as SARS, Ebola and Zika have become global threats. Because of its specific characteristics, COVID-19 has posed novel and unanticipated challenges to all social systems on a simultaneous, global scale, something not seen in recent human history. At the same time, it has laid bare pre-existing fragilities in health, economics and politics all over the globe. Such fragilities will be accentuated or make recovery from the pandemic more challenging in all countries (Baral, 2021).

Historically, the largest share of health risks has been assumed by people in the Global South. Fighting infectious diseases has rarely been a top priority for global politics. COVID-19, however, has become a uniquely relevant threat, not only for least developed countries (LDC), but also for global health systems in affluent societies. Just as the effects of COVID-19 are interconnected, emerging responses to the pandemic have become interdependent. Billions of dollars were invested in the

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global scientific response to address the pandemic, and researchers from many countries were mobilized to undertake unprecedented efforts and start new international collaborations in finding solutions to the crisis. In this way, COVID-19 has not only exemplified the global nature of risks in a hyper-connected world, but also that resilience needs to be conceptualized and fostered on a global scale.

In this chapter, we argue that COVID-19 has posed significant challenges, but also offers a valuable opportunity to rethink and improve how to effectively govern global health risks in ways that consider the potential unintended consequences of risk mitigation measures. We focus on fostering innovation capacities as a key feature of adaptive and transformative resilience in any complex system (Folke, 2006). In the context of health crises, technological innovations play a particularly important role. For instance, powerful algorithms can support local and national governments in managing large amounts of data and maintaining situational awareness; new surveillance tools can facilitate the tracking of those who are infected and mitigate the spread of the virus; and innovative medical research methods can provide treatments and vaccines to the population, offering hopes for a return to normality. But in many ways, the full potential of these innovations was not fully realized as imagined; tracing apps, for instance, are mistrusted by many people and often do not function across national borders. A lack of international solidarity slowed down the development, production and distribution of vaccines (Dosi & Soete, 2022). At the same time, vaccine hesitancy and low scientific and public health literacy sometimes propelled by the spread of misinformation and conspiracy theories have hampered the effectiveness of mass vaccination campaigns.

To make the best use of available and emerging technologies, we, therefore, need transparent and trustworthy innovation governance structures that attend to potential risks for the wellbeing of society. Studies in the field of technology assessment (TA) have shown that the cost of inaction may sometimes be greater than the need to make decisions quickly in response to emerging threats (van Baalen et al., 2021), but the accelerated development of technology may also create unintended and undesired consequences (Monteiro et al., 2017). In the case of COVID-19, there is a massive demand for rapid innovations (Lorgelly & Adler, 2020), and many challenges with respect to the proper conduct of detailed assessments. Technology assessment must consider the potential benefits, costs and risks of new medical treatments (Alkhaldi et al., 2021), but how can this be achieved in a global crisis?

This chapter suggests an answer to this question through outlining the elements which we believe should guide TA initiatives related to COVID-19. Such efforts should, as an a priori, engage global publics and involve institutions from different countries and regions. Assessing potential unintended effects of technologies adopted during a fast-moving crisis, including vaccines and apps, involves the incorporation of reflection on how vaccinations may interact with social cohesion, or how perceived risks to civil liberties in the context of new surveillance regimes affects uptake of tracing apps. Yet current governance structures and assessment protocols insufficiently consider both the immediacy of global health challenges, and the increasingly international nature of innovation processes.

To better understand the governance challenges of global technological innovation processes under the pressures of a global health crisis, this chapter looks at two technologies that have played a key role in public health strategies used to mitigate the COVID-19 pandemic: vaccines and tracing apps. We argue that these technologies and their governance have faced three interrelated challenges: problems of scale, trust and politics. These challenges, as they played out in the emergent use of these technologies, help us to identify some of the failures of governance and indicate potential ways to improve resilience for the future. We hope to provide inspiration for local, national or even international TA exercises to incorporate these principles into the way technologies with a global reach are developed and incorporated into responses during emergencies and beyond. The chapter argues that these three elements need to be considered when imagining and implementing such frameworks.

2 Technological Innovations for the Management of Global Health Crises

Governance of technologies during a pandemic involves various interrelated challenges; TA that is tailored for and reflexive to such challenges is needed to achieve flexible, effective and inclusive responses in a fast-moving crisis without losing sight of potential risks (Eckhard et al., 2021). In the context of COVID-19, advances in the fast-growing domains of information and data sciences as well as biotechnologies have received broad attention as key areas in the response against the virus. Governing these powerful, but potentially also risky technologies, involves stakeholders such as public and private health actors, alongside research and policy approaches.

Past examples are useful for reflection on the role of governance during emerging pandemics: the Zika outbreak in the Americas (2015–2016) is an example of how such biological risks can emerge and spread with high speed, challenging global response mechanisms. In these scenarios, inadequate policy choices can lead to public distrust in science or expertise, and can fail to adequately protect the population, save lives and prevent future risks. In the case of Zika, the different responses implemented in various countries and the expertise produced by multilateral organizations were the object of intense and widespread controversy. This included the way in which women's rights and poverty in LDC countries were framed (Roa, 2016), and how the use of untested technologies such as transgenic mosquitoes (Ribeiro et al., 2018) was decided and implemented, especially in Global South countries. These cases contributed to undermining trust in multilateral organizations and the manner in which they offered advice to respond to the pandemic, and raised issues related to the disparities in how countries were affected by and were able to respond to a global outbreak. These challenges would come up again with COVID-19, but on a much larger scale, involving the whole world.

The COVID-19 pandemic is also wrought with controversy and disputes around science, technology and expertise. The use of big data tools, including tracing apps

and other technologies to track and isolate individuals with COVID-19, in an attempt to slow the spread of the virus, was widely debated throughout 2020, the first year of the pandemic (Gasser et al., 2020). While in some countries, contact tracing apps quickly gained broad public acceptance and became a cornerstone of efforts to mitigate the spread of COVID-19, elsewhere they failed to achieve the necessary public penetration to become effective (Altmann et al., 2020). As will be discussed in detail below, the success or failure of tracing apps strongly depends on the availability of governance structures to introduce these health innovations in a transparent, trustworthy and risk-aware fashion.

Controversies around how surveillance should be used to manage pandemics, or the introduction of new technologies, have, therefore, been widespread during the COVID-19 pandemic. Comparative studies have shown, however, that controversies were not uniform across societies (Jasanoff et al., 2021). In many countries, misinformation and political polarization were major obstacles in getting innovations to the population. This was most visible perhaps in the US and Brazil, countries among those with the highest numbers of infections and deaths, in contexts where widespread extremist and denialist groups forced public debate to deal with anti-science, and anti-vaccine positions, which even questioned the existence of the pandemic.

In both the US and Brazil, anti-China positions have been significant elements in political responses to the crisis. This has shown the importance not only of taking stock of the available knowledge to support decisions, but the importance of understanding how political disputes can undermine a public health response, or even wholly impede the development of mitigation strategies. Vaccine hesitancy, for example, has been recognized as a challenge to public health policies, and it has been potentialized by organized misinformation in many countries (Tokojima Machado et al., 2020).

Each of these scenarios was a factor in explaining the number of deaths in specific contexts, and thus are crucial in understanding where specific countries failed or succeeded in curbing deaths from COVID-19. But building global resilience to pandemics requires reflection on the measures and principles which can be applied across different contexts, and in country-specific policy regimes. Therefore, understanding policy and governance failures on a global scale (like those related to COVID-19) requires reflection on broader patterns, and poses challenges to building one-size-fits-all solutions (Jasanoff et al., 2021).

3 Facing the Challenges of a Global Crisis Response: Scale, Trust and Politics

To face the governance challenges posed by global crises, we need to broaden how we imagine and practice governance of technologies to include social, cultural and political issues. To achieve this, we need to acknowledge a threefold challenge present in the COVID-19 pandemic, which can help us better understand the gaps which

need to be addressed. These challenges include issues of scale, trust and politics. Each of these elements is inevitably interrelated with the others, but can be separated analytically to provide insights regarding the enduring difficulties involved in building resilience to future crises. Calls for reimagining governance are not new: Global institutions have already called for responses and governance of technologies to become more dialogical, responsive and globally interconnected if we are to build longer-term resilience to future pandemics (UN, 2020). Our discussion builds on this emerging debate and outlines three elements which should inform global governance frameworks and assessment practices.

3.1 Scale: Dealing with Global Risks

A central issue in mitigating a pandemic is the sheer scale of the crisis: The speed of transmission and adaptation of the virus; the interconnected nature of global commerce and supply chains (Hobbs, 2020); the need to develop simultaneous responses at global, national and local levels, etc. Without a global approach, linked to other levels of governance, resilience alone will never be robust enough for similar situations. (see Ladikas and Stamm; Hennen and van Est, this volume).

There is thus broad debate about global pandemics needing concurrent global solutions (UN, 2020). In these discussions, countries are discouraged from seeking exclusively national or regional solutions. In the early spread of COVID-19, and in the challenge posed by emerging variants, tracking infections across national borders has been a continuous challenge. In the first half of 2020, when global production chains of health supplies were pressured to the limit, and a China-centered global division of labor also became a global problem (as most medical supplies in demand, including masks and ventilators are mass-produced in China), global interconnectivity became starkly apparent: Global circulation of people helped spread the virus, and global interdependencies in the economy were put to the test.

Even though the importance of tracking infections across national borders for containing COVID-19 was recognized early on by public health experts and authorities alike, most tracing apps were developed and implemented in the first half of 2020 at the national level (in countries like China and Germany) but often remained non-interoperational, mainly for technical or legal reasons (Jacob & Lawarée, 2021; Russo et al., 2021). This limitation particularly hampered the ability to contain infections in border regions with many international commuters, for example, at the German–French and German-Swiss borders. This has changed only slowly in 2021–2022, as the compatibility of several European tracing apps was improved (Blasimme et al., 2021).

Vaccines are also an example of how scale matters in TA: Vaccines were quickly developed due to a massive influx of resources (public and private), yet this has not meant that all people have had access to the resulting immunization opportunities. Treating vaccines as a market commodity (rather than a public good) has effectively concentrated the availability of vaccines in a few countries, leaving most of the

world with restricted or no access (Katz et al., 2021). This concentration of buying power relates to global supply chains, also concentrated in some countries (such as India and China). But it is also connected to the global disparities in science and R&D infrastructure, which restricts capabilities of vaccine development and enables vaccine nationalism and vaccine diplomacy, which subsume vaccination efforts to global power plays between nations (Dosi & Soete, 2022). The regulatory approval processes were also indicative of the challenge of scale: As vaccination started in early 2021, the diversity of national, regional and global approval processes created confusion around which vaccines were more effective and how to organize global vaccination efforts. In regions like the EU, where parallel national and regional (EMA) processes exist, this added a layer of complexity which added to controversy around specific vaccines (e.g., Sputnik V) and affected public trust.

Some initiatives attempted to mitigate this problem, with COVAX[1] being the most important (Eccleston-Turner & Upton, 2021). While it appears to have had success in ensuring more investment in vaccine development and accelerating the roll-out of technology, the multilateral initiative appears not to have addressed problems such as vaccine nationalism, whereby countries prioritize their own citizens' needs to the detriment of more effective global vaccination efforts. This is a huge challenge for any governance effort that attempts to have significant global reach: Can we build effective global public health strategies at all, if nation-states are still at the center of decision-making, funding and distribution?

The emergence and diffusion of several variants of the COV-SARS2 virus in different world regions has put to the test the effectiveness of even the most comprehensive national vaccination campaigns in countries such as Israel. In a dramatic way, this demonstrates that no country is safe, as long as the virus is able to spread and mutate easily elsewhere. As UN Secretary-General António Guterres warned in March 2020: "The magnitude of the response must match the scale of the crisis. (…) We are only as strong as the weakest health system in our interconnected world".[2] Imagining a more effective "global TA" can become an important step in the right direction in the case of addressing problems of scale: By providing fora, concepts, and arenas of debate that enable global conversations, and enabling better articulation of local, national and global forms of action, a truly global TA can make a positive policy contribution. Will nations continue to resist broader interference from organizations such as the WHO, especially in times of crisis where those with political and economic power push their way to the front of the line for vaccines? Combining trust in global solutions with the need for local situatedness is a major scientific

[1] "COVAX is one of three pillars of the Access to COVID-19 Tools (ACT) Accelerator, which was launched in April 2020 in response to this pandemic. Bringing together governments, global health organizations, manufacturers, scientists, private sector, civil society and philanthropy, with the aim of providing innovative and equitable access to COVID-19 diagnostics, treatments and vaccines. The COVAX pillar is focused on the latter. It is the only truly global solution to this pandemic because it is the only effort to ensure that people in all corners of the world will get access to COVID-19 vaccines once they are available, regardless of their wealth." (source: https://www.gavi.org/vaccineswork/covax-explained).

[2] https://www.un.org/press/en/2020/sgsm20029.doc.htm.

and policy dilemma. How to build trust and increase the adherence of countries and publics to measures that contribute to systemic resilience on a global scale, while many of them demand collective action and impact (including vaccination), remains an open question.

Producing assessments of technologies for use in global crises presents unique challenges: The need for global and interconnected responses has been defined, but how can TA be performed when countries diverge so greatly in their histories, cultures, values and political systems? The production of global surveillance mechanisms through apps may face resistance from countries where individual freedom and privacy are relevant, but not from countries where collectivity is cherished. But governments may resist such broad surveillance without proper guarantees to each country's sovereignty as regards data, for example. Vaccination on a global scale also presents overwhelming challenges: Convincing global publics of the need to adhere to vaccination schemes seems daunting when anti-vaccination movements are so effective in developed nations, and when access to health is so unequal across the globe. Trust in expertise produced globally is also problematic, as the example of the IPCC[3]—Intergovernmental Panel on Climate Change—shows (Beck, 2012; Hulme & Mahony, 2010). So how can global institutions and publics be engaged during a crisis of trust?

3.2 Trust: Improving Adherence and Participation

The issue of trust can be positioned with respect to longstanding debates within STS (Science, Technology and Society[4]) and social sciences concerning the place of science in modern liberal democracies, and the shifts this relationship has undergone since the second half of the twentieth century (Miller, 2008). While science is a central

[3] Created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports are also a key input into international climate change negotiations. The IPCC is an organization of governments that are members of the United Nations or WMO. The IPCC currently has 195 members. (source: https://www.ipcc.ch/about/).

[4] STS, as practiced in academia today, merges two broad streams of scholarship. The first consists of research on the nature and practices of science and technology (S&T). Studies in this genre approach S&T as social institutions possessing distinctive structures, commitments, practices, and discourses that vary across cultures and change over time. This line of work addresses questions like the following: is there a scientific method; what makes scientific facts credible; how do new disciplines emerge; and how does science relate to religion? The second stream concerns itself more with the impacts and control of science and technology, with particular focus on the risks, benefits and opportunities that S&T may pose to peace, security, community, democracy, environmental sustainability and human values. Driving this body of research is questions like the following: how should states set priorities for research funding; who should participate, and how, in technological decision-making; should life forms be patented; how should societies measure risks and set safety standards; and how should experts communicate the reasons for their judgments to the public? (source: https://sts.hks.harvard.edu/about/whatissts.html).

feature of how modern democracies are imagined, its authority has been under serious question for decades (Ezrahi, 1980). The way this issue has resurfaced in the twenty-first century will undoubtedly be the subject of intense scrutiny for a long time. Here, we discuss how this was made visible in the specific technological controversies in focus in this chapter, namely how innovations used in response to the COVID-19 pandemic have been received by publics in different countries. This is important if we are to reimagine governance, preserving a place for science in democracy while respecting skepticism and resistance to expert-centered decision-making.

The issue of trust (in direct relation to politics and values) has had an impact on the way TA is theorized and practiced during the pandemic, as recognized in the European context (van Baalen et al., 2021):

> However, political decisions cannot be based on scientific evidence alone; other political, social, economic, legal and moral considerations also play a role. This has also been the case during the COVID-19 pandemic. Anti-COVID-19 measures, such as lockdowns, social distancing or the introduction of tracing apps generally had broader impacts than mitigating the spread of the virus, such as social isolation and an increased demand of health services. To decide on such measures, policymakers must also weigh different values and interests. In most cases, however, this was not communicated clearly and transparently to the broader public. Policymakers often referred to scientific evidence or experts to substantiate their decisions, without acknowledging the role of other considerations in the choices made. (van Baalen et al., 2021, 11)

Controversies about technologies and COVID-19 have a direct relationship to the issues of governance we want to raise here, inasmuch as they relate to how publics accept or reject expert advice coming from national and/or global institutions; how they trust governments with their personal data, and how they accept surveillance (e.g., in the case of tracing apps); how publics accept and trust vaccines and vaccination campaigns, which is a longstanding issue in public health; and how they respond to other measures which impinge on their freedom and their health. Over many years, risk communication research has shown that trust is a central precondition for successful political communication related to risk, but also that public trust in official risk communication messages is dependent on perceptions of the communicating individuals and institutions, as well as the specific socio-political climate (Renn & Levine, 1991). COVID-19 has sparked many such controversies in different countries and has shown the degree to which issues of trust are central to establishing longer-term resilience to global health crises.

Vaccine hesitancy, for example, has been debated and recognized as a central concern to public health in many countries (Verger & Dubé, 2020), and sentiments of mistrust directed at vaccines have emerged strongly with COVID-19. While more common in industrialized Global North countries, hesitancy has also affected other areas of the world. This can be traced back to many possible factors, such as mistrust in the speed of vaccine development, organized strategies, and well-funded efforts to spread misinformation (Jaiswal et al., 2020).

In the case of COVID-19, the pandemic has been accompanied by a veritable "infodemic" (Cuan-Baltazar et al., 2020). Misinformation (be it organized or unintended) has proven to be a prominent feature of how the pandemic evolved in many

countries, affecting trust in public health authorities, technical decisions and technologies (especially vaccines). The Internet has become the main source of news and information, as well as a dangerous source of misinformation. Studies have shown that the speed and broad reach of misinformation on COVID-19 undermines trust in policies and vaccines, and is considered thus a public health concern in itself (Roozenbeek et al., 2020) in countries with disparate and distinct socioeconomic profiles. Indeed, the erosion of trust in science and institutions was a prominent trait in countries such as the US, Brazil and Italy (Battiston et al., 2020; Kreps & Kriner, 2020).

Ensuring adequate governance of the development and deployment of vaccines has already been recognized as the surest way out of the pandemic, but how can governance bodies deal with the increasing politicization of this technology? The controversies which emerge, sometimes fueled by specific political groups, or weaponized by extremists, have concrete effects on efforts to vaccinate globally, and may prolong the pandemic or even contribute to the emergence of increasingly dangerous virus variants. Addressing issues of trust is a *conditio sine qua non* for building both an effective short-term response (Islam et al., 2021) (improving adherence to vaccination, for example), but also for building resilience in terms of stronger relationships of trust between institutions and citizens (at the national level), and global trust in international governance bodies (at the international level).

The case of tracing apps shows that the importance of trust for a successful diffusion of technological innovations in the context of public health is not exclusive to vaccines. Similar to vaccination programs aiming for herd immunity, tracing apps strongly rely on broad use across society. Only if a considerable share of the population uses the apps in their everyday life are these tools able to fulfill their purpose and help to track and break infection chains. When introduced in many countries in the first half of 2020, there were high hopes that the apps could effectively slow down the spread of the COVID-19 virus, gaining time until vaccines would be broadly available. However, the usefulness of the tracing apps turned out to be much lower than expected by many policymakers and experts, mainly because too few people were willing to install and actively use the tracing apps.

Studies in various countries have shown that besides technical difficulties and fears of false positive alerts, a lack of trust in the apps was a main reason as to why these technologies were not used more broadly and today are often considered as failures (Bano et al., 2020; Beierle et al., 2021; Horstmann et al., 2021). Yet this research also shows that the issue of trust played out quite differently depending on the specific political and cultural context in which they were implemented. In countries like the US and Germany, disputes occurred around the privacy of sensitive health data (Mello & Wang, 2020; Simon & Rieder, 2021). In other countries, such as Australia, fears were more general regarding governmental surveillance, while elsewhere public discourses focused more on the possible positive potential of these technologies (Greenleaf & Kemp, 2020).

Importantly, several studies indicate that while general trust in political authorities is an important factor, it is not the only factor that influences public trust in tracing apps. Other factors that determine public acceptance of these technologies

include the transparency of the technical architecture, and the societal inclusiveness of the development process, as well as the public communication measures to explain the purpose and function of the apps (Hobson et al., 2020; Oldeweme et al., 2021). In general, decentralized approaches, building on open-source technologies and backed by trusted partner institutions are found to generate high trust rates (Simon & Rieder, 2021). Since most apps were developed on behalf of governmental actors and financed with taxpayer money, this directly relates to the questions of innovation governance. As (Ranisch et al., 2020) emphasize, "(…) to minimize the risk of adverse outcomes, ethical standards should guide and complement the process of development (ethics by design), implementation, use, and evaluation of CT apps." Policymakers can actively influence the level of public trust by setting these ethical standards to ensure an innovation process that pays close attention to the concerns of societal stakeholders and citizens over potential unintended side effects, such as misuse of software for public surveillance or theft of sensitive personal data.

Building better governance and resilience, therefore, must include facing matters of trust as they relate to the science-policy interface, as this has to do with the shape of democracy itself and the role of science within modern democratic regimes. Mistrust in science, albeit often perceived as a problem, is not necessarily a symptom of anti-science, but can also reflect specific civic epistemologies, a dilemma already identified in STS (Ezrahi, 2008):

> The gap between scientific and civil presuppositions about the relations of science and politics in the contemporary democratic state poses a very difficult challenge to STS scholars who must often switch back and forth between public policy contexts where expert definitions of causality are expected to have the authority to set the boundaries of possible value choices and strategies of action, and contexts where these are the social norms and conventions that set the limits to what are acceptable conceptions of causality. This often leads to confusions between an attitude of disrespect for scientific facts as a form of intellectual opportunistic relativism and as a considered critical response to the dogmatic advance of scientific facts as a means of defying working political or normative compromises. (Ezrahi, 2008, 181).

This presents a great challenge also to assessment practices, as they try to balance expert knowledge, public engagement and their own validity as a tool for policy- and decision-making in general. How should we construct TA at different scales in contexts where there is deep mistrust of vaccines? Or when experts are mistrusted, and misinformation is rampant? Governance frameworks have to be responsive to and reflective of situated civic epistemologies (Jasanoff, 2011b), and the ways in which policies are able to relate to science in situated ways in different national and cultural contexts. Because science and society can be seen as coproduced (Jasanoff, 2004), governance and resilience must also pay attention to how these relationships are established and sustain themselves in specific contexts. TA organized on a global scale would be supportive in strengthening awareness of this interconnectedness, as well as inducing mutual learning about different national contexts that need to be taken into account when designing technologies and policies which are appropriate to existing civic epistemologies, along with the perceived needs and demands of the respective publics.

3.3 Politics: Social Justice and Global Inequalities

As discussed above, issues of trust are crucial for understanding some of the challenges posed by global governance of technologies to build resilience. Issues of trust in science and technology, however, lead us into another broad challenge: how to reflect on and integrate politics into how we build resilience. Politicization of technologies such as vaccines became a problem in several nations during the pandemic (Bolsen & Palm, 2021). Another issue was how polarizing politics mediated how people adhered to "stay at home" policies and other measures which severely affected people's lives. To begin addressing this challenge, we should reframe governance away from using a linear idea of science/policy relationships, and take into account the myriad other variables at play in such contexts (van Baalen et al., 2021), which include the core of people's personal and **collective values, and their ideas** of desirable futures and politics, as discussed in concepts such as civic epistemologies (Jasanoff, 2011a; Miller, 2008). In addition, politics pertains to how power is distributed, and how inequalities make a difference, both locally and globally.

Politics in our argument refers to the disputes around desired goals, and differing **perceptions of what is at stake** in a crisis. As in other controversies involving science and technology, the disputes at play in this pandemic are never just about the better solution (vaccines, masks, apps, etc.), but also concern a common appreciation of what the problem is, which in turn has implications for the framing of possible and desirable solutions (Venturini, 2010). Technical expertise does not by itself lower the temperature of controversy or mitigate political disputes (Nelkin, 1975), and controversies often also involve the legitimacy of who is able to provide reliable expertise or be present at the table to make decisions (Nelkin & Hilgartner, 1986). Disputes around trust and values tend to become highly visible in controversies, as STS literature has extensively shown (Collins & Pinch, 1998; Lynch & Cole, 2005).

We understand the challenge of politics to be central to any effective attempt at building longer-term resilience to COVID-19 and future pandemics, and this may be the hardest challenge that countries and governance institutions have to face. Politics here also includes issues of **how power is distributed** in a given society, how decisions get made, and who gets to sit at the table in decision-making concerning pandemics. Of course, politics permeates every aspect of the discussion in this chapter, from vaccine nationalism to disparities in health. But political contestation of specific technologies used for COVID-19, and measures imposed by governments pose some specific challenges to both the imagination and implementation of governance frameworks, which deserve to be considered here.

Politics can be a way to analyze and understand the way governance mechanisms play a role in pandemics, and how that role needs to be the object of further reflection in building resilience. Making choices about policies or the adoption of technologies is never just a matter of assessing cost and clinical effectiveness, but always an issue of politics. Acceptance of expertise; vaccine hesitancy, denialist groups and governments, etc., demonstrate how politics is not peripheral, but central to any attempt to build resilience to pandemics. It is common to see debates around the

role of scientific uncertainty in political contestation (Kreps & Kriner, 2020), yet uncertainty in itself does not explain or help mitigate the political aspect of such choices, or contestation as part of responding to a pandemic.

TA can itself be seen as a political arena, in which all of these issues are made explicit in specific ways. From the choices of who gets invited to an assessment exercise, to how assessment is conducted, politics is an important element of how TA is used as a way to make choices about technologies. Aside from the internal workings of assessment, one can also look at how assessment practices interact with broader policy dynamics: How much does assessment actually affect or inform policy in specific contexts? How would a global assessment body or exercise be able to have impact in different cultures, given the various ways technology is perceived? TA, whether global or not, should be reflexive and aware of its political embeddedness, and not invest in a purist or linear understanding of science-policy relationships. This is also a point made about the IPCC (Beck, 2012), and debates about global TA can find inspiration in the critique of technocratic solutions made by studies of climate governance.

This has never been so explicit or so urgent an issue as during the COVID-19 pandemic. Politics relates inextricably to the elements discussed above. Adherence to solutions such as vaccines, or to longer-term measures which may be deemed inevitable for resilience, depend on people trusting institutions and feeling they are represented as part of the solutions being proposed. Becoming part of the decision-making process also presupposes constructing common ground for deliberations around potential solutions. Going back to scale: When we talk of global pandemics, resilience involves engaging not only publics with similar cultural and historical backgrounds, shared values and aspirations, but also global publics with widely different histories, forms of government, values and ways of organizing technical decisions. Ignoring politics on the global scale will also hamper resilience, when for example we fail to achieve a global level of mass vaccination to control a pandemic; or when we fail to address health disparities, or disparities in access to science and technology.

This problem of how science and technology relate to politics has led both the academic and policy communities to develop critical and applied reflections on how to build responsibility into governance frameworks and institutional practices (Jacob et al., 2013; Stilgoe et al., 2013), especially in the European context. TA is a practical outcome of such reflections with a long tradition of developing institutional formats and methodologies of policy advice in many European countries. Global governance to foster resilience to pandemics at a global level could benefit from this experience (Ladikas et al., 2019; Van Est, 2017). However, the COVID-19 pandemic has again emphasized questions of how to perceive responsibility as part of the response: When urgency demands incisive and speedy actions, how are countries to improve responsibility, responsiveness and reflexivity in their actions? Is the requirement for effective and fast decision-making, which characterizes any crisis, at odds with attempts to ensure inclusive political processes, or can participatory processes improve crisis responses by activating broad societal resources (Eckhard et al., 2021)? In the absence of global frameworks to distribute and make vaccines available in an

affordable manner, how are countries which have been excluded from the vaccination effort to respond to calls for more "global cooperation," or even trust in global institutions, which may involve external advice relating to hygiene, changes in economic policies or limits to movements inside and outside their national borders?

Global and local-level **disparities** have played a huge role in this pandemic, as they have in other historical and recent outbreaks (Mamelund et al., 2021). These include disparate access to health, racial disparities and deep inequality in terms of available infrastructure to manage and respond to health emergencies. (Bibbins-Domingo, 2020; Brooks, 2016; Quinn et al., 2011). Importantly, the vulnerability of different social groups is dependent on their specific material coping capacities, but also by social and psychological attributes (Eriksen et al., 2020). This means that governance frameworks and responses at all levels should take this into account if they intend to be effective. This has been acknowledged in international calls for action by organizations like the United Nations to prestigious research institutions (Martinez-Juarez et al., 2020), but it remains to be seen how this will be tackled in practice.

Addressing disparities again throws us back into the need to include political choices and political disputes when discussing governance of technologies and technical advice. Building reliable international cooperation involves addressing immense disparities in access to research funding, health technology development, and the deployment and distribution of accessible and reliable information and treatments. Current vaccine nationalism in the acquisition and distribution of vaccines, and the leveraging of vaccines in geopolitical strategies by countries such as China, India and the US erode trust in multilateral or global institutions and frameworks and lay bare the absence of material cooperation between unequal partners. Likewise, extreme disparities within national borders have shown to be detrimental to national social cohesion, opening countries to chaotic responses to COVID-19, with catastrophic consequences in terms of lives lost, increases in poverty and institutional disarray (Jasanoff et al., 2021).

4 Conclusions

We have argued that building better global governance for the future involves matters of scale, trust and politics. Each element helps us to see different aspects of dilemmas posed and illuminated by the COVID-19 pandemic, as well as dilemmas for the governance of science and technology in general. Scale matters, because if risks have a global aspect, then institutions and policies need to have global reach. This demands international cooperation, trust and solidarity to overcome disparities within and between countries and regions. The production and distribution of vaccines has impacted on international relations and highlighted gaps relating to unequal distribution of R&D capacity (and how this is a risk for future resilience), as well as difficulties in producing and making vaccines available. Overcoming the pandemic means immunizing billions of people on a global scale, therefore, we have yet to establish

new institutions and policies to make these risks more manageable. The COVAX facility offers some hope, but truly global solutions are still both underdeveloped and undertheorized.

Trust is important both in terms of strengthening social cohesion within countries, and enabling greater acceptance of policies, therefore, ensuring the effectiveness of responses to crises like a global pandemic. The infodemic associated with COVID-19 (but not restricted to it) has global ramifications, and needs to be addressed internationally. Trust among countries and between countries and global institutions is crucial to enable any kind of successful global governance to take effect. A gap in trust became clear during the Trump presidency in the US, for example, but mistrust between China and other countries, and between countries and the WHO or the UN also illustrate how this is relevant to global policies and resilience.

Politics are never absent and can never be ignored. From the contestations of policies and expertise within countries, to the disparities that mark the pandemic (racial, gender, economic, etc.), politics is present in all aspects of the issue. Social disparities are central to understanding who suffers most during pandemics: Poor countries, and the poorest people within countries; minorities (ethnic, racial, sexual, cultural, religious, etc.), women, and those with limited access to health in general. Ignoring disparities makes trust unreachable and undermines how expertise helps to orient policy. It undermines both science and democracy if we do not remain vigilant of their interconnectedness. Assessing risks and governing technology needs to include and reflect on its political aspects as a central part of the expertise which is mobilized to understand the risks and benefits of different innovations. The disparate capacity which countries have to produce, access and assess innovations can also become a global risk, especially during a global crisis, and is also an issue for global governance.

This leads to the question regarding how to develop governance approaches that solve, or at least moderate, the challenges involving scale, trust and politics. While some efforts aim to improve global collaboration, but often fail to secure trust across diverse social and cultural contexts, others appear stronger in building trust, but in turn struggle to achieve internationally coordinated and unified progress against global health risks. To overcome this, new modes of governance are needed, based on principles of resilience thinking, inspired by research traditions in ecology, organizational studies and other disciplines (Folke, 2006; Ruiz-Martin et al., 2018; Walker, 2020). These approaches would focus on capabilities at the local level to develop innovative strategies to adapt to new trends and risks. However, such a decentralized approach does not mean that actors work in isolation. On the contrary, a resilience approach to global governance would put a strong emphasis on networks to exchange experiences and foster transboundary learning. This could provide the basis for new forms of governance that meet the global nature of the grand challenges of our time, while paying close attention to local cultural and political contexts.

Attempts at governing globally through robust science-policy interfaces are still rare, and under construction (and dispute). The example of the IPCC as a mechanism for providing reliable knowledge for governing climate change is interesting to examine, both for its successes and its failures. One important failure relates to the issue of politics mentioned here: When the science used for global governance is produced mainly in specific institutions in the Global North, by authors from this region (Ford et al., 2012), this poses a problem for building trust and engaging nations from other parts of the world. And although science is an example of a global network of practices and institutions with some embedded aspects of global governance, it is also a structurally unequal system. Therefore, to expect trust to emerge purely from the availability of reliable scientific knowledge is to ignore other aspects important to assessing the risks and potentials of science and technology.

Global forms of governance need to address a series of issues, which are not on the agendas of the WHO or other governance schemes, but which can be mobilized to rethink global frameworks: The unequal geographies of science (Hulme, 2010) and technology which still mark the production of knowledge and the capacity to build technologies and innovations to address crises like the pandemics of the present and the future. This of course relates to the trust and politics discussed above: Governance of technologies at a global level cannot ignore issues of social justice, without which resilience will not be possible. Just as policies govern science and technologies conditioned by local perceptions, practices and histories, the knowledge that drives governance needs to also be reflected upon as emerging from unequal geographies, and therefore, needs to be governed with an aim to increase the participation of and attention to excluded and marginalized groups.

This in turn relates closely to the issue of scale: The globalizing drive in the governance of climate change, for example, runs the risk of collapsing all scales into a generic and universalized "global," which erases the local and other scales at which events and practices take shape. This view from everywhere, as discussed by Hulme (2010), needs to be critically assessed as the only possible governance scheme for global problems. As discussed above, local experiments, values and specificities have to be taken into account as another path to build resilience and global forms of governance which will be more legitimate, and therefore, engage broader global publics and institutions. TA as a practice at the interface of politics, science and the public provides appropriate structures and methodologies to enable democratic, inclusive and scientifically well-informed interactive processes of knowledge-sharing and deliberation. How to transform and apply this at a global level to foster resilience to pandemic disease is a challenge that needs to be considered from a long-term perspective.

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