







Research

## Resilience in the times of COVID: what the response to the COVID pandemic teaches us about resilience principles

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**ABSTRACT.** Times of crisis offer a rare opportunity to understand the mechanisms underpinning the resilience of complex adaptive systems. The coronavirus pandemic that started in 2020 overwhelmed health systems worldwide and forced governments, businesses, and individuals to deploy a range of coping and adaptation strategies. Through an online survey targeting members of the Resilience Alliance and their collaborators, we examined 61 distinct strategies deployed in the initial months of the pandemic to assess empirically which resilience-building mechanisms were actually implemented to navigate the crisis. Our results show that managing connectivity, feedbacks, and learning were essential during the initial part of the pandemic. Other principles such as building diversity, redundancy, polycentricity, and inviting participation become important in rebuilding during the aftermath of a crisis, whereas keeping a systems view, monitoring slow variables, and practicing adaptive management are practices that should be incorporated during regular times.

**Key Words:** *crisis management; governance; health; resilience thinking; social-ecological systems; theory*

### INTRODUCTION

Moments of crisis offer an opportunity to learn about the resilience of social-ecological systems. That is, although we can theorize about what grants resilience in a well-functioning system, it is when things break down that we realize valuable lessons about the mechanisms that build and maintain resilience. Thus, there is much to be learned from observing society's response to a crisis in terms of gaining a grounded perspective on what works and what does not when navigating turbulence. This is particularly important for resilience thinking, which as a field has developed sophisticated heuristics and principles on how to manage social-ecological systems (see Gunderson and Holling 2002, Walker and Salt 2006, Biggs et al. 2012), but rests on an uneven empirical foundation. The coronavirus pandemic that started in 2020 constitutes a rare chance to observe which resilience principles have been enacted on the ground, thus providing empirical backing to advance theory.

In March 2020, the World Health Organization officially declared the coronavirus crisis a global pandemic. COVID-19 belongs to the large family of coronaviruses that cause respiratory tract diseases, similar to SARS and MERS, and its symptoms are often mild but, for the elderly and those with underlying conditions, it can be fatal. At the time of writing, over 6.2 million people worldwide have died from coronavirus and more than 515 million have contracted the virus (WHO 2022). A vaccine was developed at the end of 2020 and over 11 billion doses have been administered throughout the world, although its deployment remains uneven (WHO 2022). The coronavirus pandemic quickly overwhelmed the capacity of health systems, disrupted supply chains, and prompted emergency lockdowns in most parts of the world. Although the management of the outbreak has varied widely over the course of the pandemic and among countries, no region has been spared, and some countries, such as the United States or India have been thrown into political turmoil as a result.

Beyond its medical dimensions, the coronavirus pandemic has exposed the vulnerability of highly interconnected, complex systems (Walker et al. 2020). In particular, the tightly coupled supply chains along which the economic system is globally organized, increased the susceptibility to shocks that spread quickly across scales and sectors, producing cascading failures (Bryce et al. 2020, Collins et al. 2020, Hynes et al. 2020, Kontogiannis 2021). We have witnessed a doubling of the risk of hunger (FSIN 2020) and disruptions throughout all sectors of the economy (Nicola et al. 2020). As countries navigate their way through the crisis, it has become evident that the multitude of overlapping actors, interests, and administrative boundaries make it difficult to coordinate an effective response and that impacts have and will continue to exacerbate existing inequalities. At a local scale, households and communities have been dealing not only with the burden of disease and grief, but also with a broad variety of shocks from recurrent lockdowns including loss of income, social isolation, and homeschooling.

Given its reach and severity, the COVID-19 pandemic presents an unusual opportunity to document individual and societal responses to a crisis event. We examined COVID coping strategies deployed within the first six months of the coronavirus pandemic to assess which resilience principles previously identified in the literature were actually employed in initial stages of the crisis with the following goals: (1) adding empirical evidence to the resilience principles identified in the literature; (2) offering lessons that can serve in preparation for the next crisis; and (3) exploring the temporal dimensions of navigating crisis and their implication for managing resilience. A growing number of studies have focused on assessing the effectiveness of the strategies initiated by governments and other organizations in their efforts to contain the pandemic by establishing the relationship between mitigation strategies and changes in the rate of transmission (see for example, Li et al. 2019, Haug et al. 2020), others have focused on early

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lessons from the experience of practitioners (see Linkov et al. 2021). We abstract from concrete strategies and experiences to consider the principles, or mechanisms, behind the strategies that have been commonly deployed. That is, whether a government imposes a school lockdown, or a curfew, or limits social gatherings above a certain number of people, all of these strategies boil down to one resilience principle, namely, managing connectivity. Similarly, whether a hotel is turned into a temporary hospital or a brewery starts producing hand-sanitizer, both strategies are examples that take advantage of existing redundancies. By focusing on the principles of resilience that were deployed, we can draw broader lessons that are generally applicable to social-ecological systems independent of context, thus solidifying the empirical basis for managing resilience.

Resilience remains difficult to define and implement. The term resilience as we use it here was introduced by Holling (1973) as an approach to understanding change and permanence in complex adaptive systems, which was initially applied to the management of natural systems but increasingly used to understand broadly defined social-ecological interactions. The evolution of resilience thinking as an approach has been outlined by others (see Walker and Salt 2006, Quinlan et al. 2015) but here we focus on the principles, or mechanisms, of resilience that are intended to guide implementation and monitoring.

Based on Biggs et al. (2012), we identified 10 resilience-building principles (Table 1), which we subdivided into principles pertaining to the structure of the system, principles that promote systems thinking, and principles relevant to the management of the social-ecological systems (after Quinlan et al. 2015). In terms of structuring a system, the following principles are understood to increase resilience:

- Increasing diversity, this is because having diverse elements in a system implies having alternatives for responding to a crisis, as well, increasing the chances that some parts of the system will be unaffected, or affected differently, by a shock;
- Building redundancy, refers to having elements of the system that are different but fulfill similar or overlapping functions, so that if one fails, other elements can still perform that function;
- Managing connectivity has to do with managing the links between the different parts of the system. Sometimes connecting parts of the system increases its resilience, as in when resources are needed, other times, such as during a health pandemic, isolating parts of the system is the best course of action.

The second set of principles pertains to adopting a systems lens in the framing of a situation. This translates more concretely into the following principles:

- Managing slow variables, which means identifying and tracking variables whose change is more gradual, often goes unnoticed, and yet is connected to thresholds that could lead to the reorganization of the system;
- Managing feedbacks, which has to do with understanding immediate as well as long-range reactions to an intervention in the system and can be amplifying or dampening;

- Framing issues in terms of complex adaptive systems, that is, considering the interactions between the social and ecological elements of the system and across scales, as well as its emergent properties.

Finally, the third set of principles pertains to the management of complex adaptive systems and includes:

- Inviting participation in decision-making processes so as to have a more complete picture and diversity of perspectives that will lead to a better understanding of the issue and trust-building among stakeholders;
- Providing opportunities for learning and experimentation, especially if these can reduce the inherent uncertainty of social-ecological systems;
- Implementing adaptive management, that formalizes an iterative learning-by-doing approach to decision making in which policies are understood as hypotheses; and
- Fostering polycentric governance, which involves having multiple decision-making centers that function in a semi-autonomous manner.

Although we recognize that resilience is above all an approach to a problem rather than a checklist of principles, we have chosen to focus on the principles as a necessary simplification that furthers the implementation and adoption of resilience thinking.

## METHODS

Using snowball sampling, we administered an online survey to members of the Resilience Alliance and collaborators. The Resilience Alliance is an international, multidisciplinary research organization, established in 1999, that explores the dynamics of social-ecological systems and a referent of resilience thinking. We deployed a survey between May and July 2020 that asked participants to identify and characterize strategies used for dealing with the coronavirus pandemic with which they were familiar. Participants did not need to have first-hand experience implementing the strategies, just enough familiarity with the strategy to be able to characterize it in terms of: where the strategy was deployed, the scale at which it was deployed (individual, city, region, national), how quickly the strategy was deployed (it was pre-existing, within days, within weeks), and by whom (individuals, cities, national or state governments, businesses, grassroots, organizations, or partnerships). Last, participants were asked to identify which resilience principles were embodied in the strategy (see Fig. 1). For example, a participant may point out how turning an art gallery into a temporary emergency health shelter is an example of functional redundancy, or that lockdowns were a way of managing connectivity. At the end of the survey participants had the chance to suggest additional people to include in the survey. This study was approved by Arizona State University's institutional review board (STUDY00011979) and all participants provided informed consent to take part in the study.

The data collected were reviewed by the authors although no effort was made to correct the participants' characterization of their responses with regard to the resilience principles that participants assigned to the individual strategies (see supplemental materials). The first part of the results up to the correlation table uses descriptive statistics and relies on this data. A second analysis was

**Table 1.** Resilience principles based on Biggs et al. (2012) with examples on how they manifested during the coronavirus pandemic.

	Principle	Example(s) during the pandemic
Configuration of the systems	Diversity. Having a range of different elements in the system that respond differently to stressors.	Having a diversity of food producers allowed some grocery stores to maintain a steady supply of goods;
	Redundancy. Having elements in the system that perform similar or overlapping functions.	Transforming hotel beds and university dorms into hospital beds; Retooling industry to manufacture essential health products;
Using a systems approach	Connectivity. Either increasing or decreasing connections between parts of the system.	Maintaining six feet of distance while in public; Free online webinars and activities for school age children;
	Systems lens. Considering the dynamic interplay between social and ecological variables across scales, as well as emergent properties and non-linear behavior.	Removing patent barriers to ensure broad and quick roll out of vaccines;
	Feedbacks. Consider action and reaction within a system.	Panic buying (amplifying feedback);
Managing the systems	Understand that reactions to an initial intervention could either amplify or balance it.	Fines and warnings for going outside during lockdowns (balancing feedback);
	Slow variables. Tracking variables that control internal dynamics of the system and change at a gradual pace.	Using available savings to compensate for loss of income; Growing acceptance of alternative work arrangement such as telework;
	Adaptive management. Iterative approach to management that emphasizes learning-by-doing.	Phased easement, or enforcement, of social distancing directives depending on infection rates;
	Learning. All and any of the processes that lead to a better understanding of the system and reduce its uncertainty.	Small businesses trying out alternative arrangements; Governmental dissemination of best practices to stay safe;
	Participation. Inviting the views and involvement of a variety of stakeholders to improve understanding and come up with better solutions.	People collectively participating in activities such as sewing masks for hospitals;
	Polycentric. Having multiple decision-making nodes that behave semi-independently from one another.	Different levels of government setting rules for their jurisdiction (e.g., mask-wearing mandates).

done to identify and group strategies that formed a pathway out of the crisis. The pathways were derived by thematically coding the following open-ended questions from the survey “describe an intervention in response to the COVID-19 crisis that builds resilience (e.g., social distancing)” and “what are the strengths and limitations of this response?” Each response was inductively coded to derive insights directly from the data. Inductive coding is particularly relevant for exploratory studies seeking to derive new insights, as is the case here (Linneberg and Korsgaard 2019). Coding here refers to identifying segments of meaning in one’s data and summarizing those with a word or sentence (Saldaña 2013). A first order coding, which we called tags, identified a host of themes related to the interventions in response to COVID-19 (for e.g., new supply chains; going local). These themes were then aggregated into a higher-level set of coding to synthesize codes that were related to one another (Gioia et al. 2013, Linneberg and Korsgaard 2019). For example, the tags “government financial aid,” and “providing free healthcare” were related under a higher-level theme called “welfare state.” These higher-level themes represented the different pathways identified.

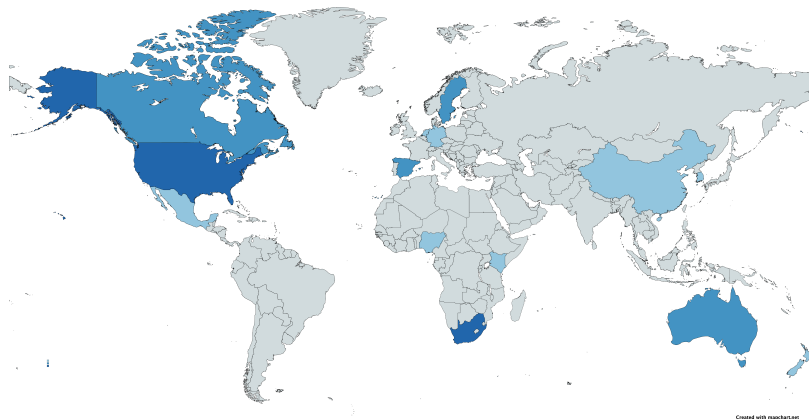
**Limitations of the methods**

Snowball sampling tends to exaggerate consensus because participants refer to people in their networks with whom they tend to share common values. This factor likely plays in our data because we chose to survey members of the Resilience Alliance, which form a somewhat cohesive group already. However, given that the survey required people to assign resilience principles to each strategy, it was important that the sample population would have enough knowledge and background on resilience thinking, and with the Biggs et al. (2012) paper, to be able to make this determination.

**Fig. 1.** Survey questions.

1 Describe an intervention in response to the COVID-19 crisis that builds resilience (e.g., social distancing)
2 Add any sources and/or links that are relevant to understand this response.
3 The response that you identified above is building the resilience of what and to what?
4 What are the strengths and limitations of this response?
5 Where is this response taking place geographically (e.g., Barcelona)?
6 Where was this response deployed? Check all that apply. <ul style="list-style-type: none"> <li>• Individuals or households</li> <li>• Neighborhood</li> <li>• City</li> <li>• Region (e.g., county)</li> <li>• State or province</li> <li>• Country</li> <li>• International</li> <li>• Don't know</li> </ul>
7 Who implemented this response? <ul style="list-style-type: none"> <li>• Individuals</li> <li>• Small and medium-sized businesses</li> <li>• Large businesses</li> <li>• Grassroots efforts</li> <li>• Formal organization (e.g., Medecins Sans Frontieres)</li> <li>• Municipal government</li> <li>• Provincial/state government</li> <li>• National/federal government</li> <li>• Government agency (specify)</li> <li>• Collaboration</li> <li>• Don't know.</li> <li>• Other:</li> </ul>
8 How quickly was this mechanism implemented? <ul style="list-style-type: none"> <li>• Pre-existing</li> <li>• Within days</li> <li>• Within weeks</li> <li>• Within months</li> <li>• Don't know</li> <li>• Other:</li> </ul>
9 What resilience principle(s) do you think this response exemplifies? Check all that apply. <ul style="list-style-type: none"> <li>• Increasing diversity</li> <li>• Increasing redundancy</li> <li>• Managing connectivity</li> <li>• Systems thinking</li> <li>• Managing feedbacks</li> <li>• Managing slow variables</li> <li>• Participation</li> <li>• Adaptive management</li> <li>• Learning</li> <li>• Polycentric governance</li> <li>• Other, please describe:</li> </ul>

**Fig. 2.** Geographical distribution of strategies in the database. The degree of shading corresponds to the number of strategies.



In addition, because the survey was deployed between May and July 2020, some of the respondents had already undergone the first wave of the pandemic, such as those in Asia, Africa, and Europe, whereas those in the Americas were in the thick of the first wave. Therefore, the responses capture different degrees of uncertainty and hindsight.

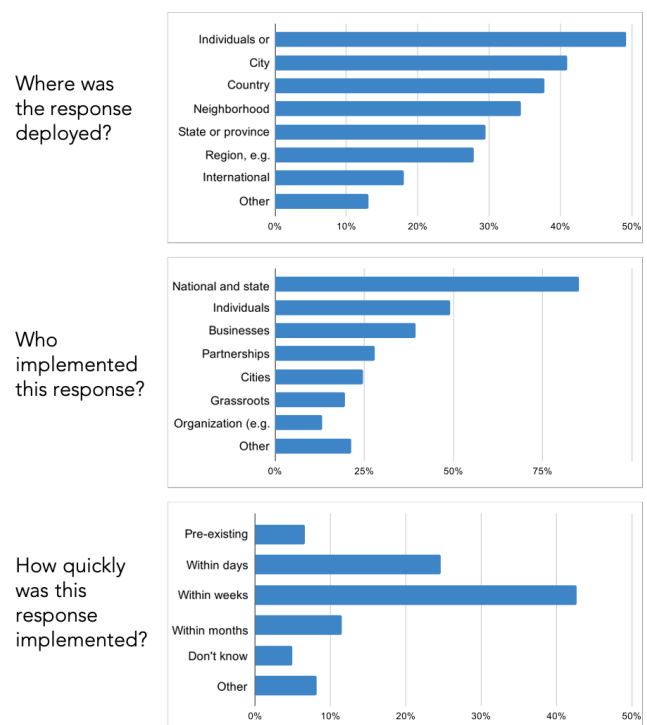
## RESULTS

The survey was distributed to 124 resilience researchers and practitioners around the world and our response rate was 40%. The results contained 61 distinct strategies from 49 respondents (participants were given the option of submitting several strategies). Respondents were asked to submit a strategy with which they were familiar but there was no requirement for the strategy to have been implemented in the place where they lived, although this was the case for many of the submitted strategies. Overall, 17% of the submitted strategies were either global or regional in scope, e.g., European Union, pan-African, and 2% were online strategies. The United States and South Africa were the countries that had the most strategies identified (17% each), followed by Canada, Sweden, Spain (8% each), and Australia (6%). Other countries represented in the database included China, Singapore, Mexico, Germany, the Netherlands, New Zealand, Kenya, and Nigeria (see Fig. 2).

The database contains responses that were deployed at a variety of spatial scales and often at multiple scales simultaneously. Almost half of the strategies (49%) were implemented at the household or individual level, 41% were actions implemented at the city level, and 38% at the national level. About one-third of strategies were implemented at intermediate administrative scales, with 30% being implemented by states or provinces, and 28% being regional in scope, such as counties or Indigenous communities. International strategies accounted for 18% of the actions contained in the database; this meant strategies that were implemented in more than one country simultaneously. When it comes to who implemented the strategies identified, the majority originated from national and state governments (85%), although almost half of them were implemented by individuals and households (49%). Businesses were the implementers of 39% of the strategies in our database, the majority of which refers to strategies adopted by small businesses. City governments,

grassroots, and large organizations implemented less than one-third of the strategies identified. Finally, strategies were deployed relatively quickly. Most of the strategies identified in our database were implemented within weeks (43%) or days (25%), with a small percentage of them having adaptations on something that was pre-existing (7%). There were only 11% of strategies that were implemented within months, but this reflects the fact that our survey was deployed in May and July 2020, so within months of the first coronavirus wave. Please refer to Figure 3.

**Fig. 3.** Summary of the characteristics of strategies deployed between May and July 2020 to deal with the coronavirus pandemic.



### Resilience principles

The principles of resilience ranked in order of frequency are shown in Figure 4 below. The principle that was most frequently cited in the set of strategies was managing connectivity, followed by managing feedbacks, and establishing processes for learning. Strategies that increased redundancy, participation, diversity, and the practice of adaptive management were also important. Last, and this may be a reflection of the timing of our survey, there were fewer strategies that demonstrated a systems understanding of the issues, such as those that tackle slow variables or promote polycentric governance.

#### *Connectivity*

Connectivity was the resilience principle most often identified in the strategies, which is not surprising given the nature of the crisis as a health pandemic. That is, viral illnesses spread through being in close proximity to an infected person, so it is sensible that early in the pandemic, strategies for reducing contact at all levels, from travel bans to sheltering-in-place to school closures, were broadly implemented as key to reducing contagion. Countering the broad move to isolate to reduce viral spread, participants also identified a number of ways that people devised to maintain, replace, or create new ties, presumably to satisfy the gap in our networks of relationships caused by the sudden removal of physical interaction.

In general, there were two tendencies with regard to the new forms of connectivity that emerged during the pandemic. One was to create virtual ties. For example, there were a multitude of authors that offered free online readings for children, and most white-collar work was adapted for teleworking from home. The second way in which connectivity changed during the pandemic was a renewed emphasis on local ties. Bottom-up solidarity networks that organized the delivery of essentials to populations at risk emerged, or were reinvigorated, in many communities around the world. For example, SOLIVID is an online platform that emerged in Barcelona (Spain) to map and connect grassroots solidarity efforts related to COVID-19, such as offerings of child care for working parents, sharing of classroom resources among teachers, or general mental health support. In Cuenca (Ecuador), people in need of food or supplies during lockdowns would hang a white flag on their door and neighbors responded by bringing what was needed.

#### *Learning*

Respondents identified two modes of learning taking place simultaneously during the pandemic: the first type of learning can be characterized as unidirectional transmission of information. Respondents identified a variety of ways and platforms that helped people be informed, for example, by listening to government bulletins to obtain updates on policy changes or by consulting a web dashboard on COVID cases. Resilience theory does not consider this form of passive learning as enhancing resilience because it is limited to the consumption of data, however others have indicated that appropriate management of information is important during health crises to “reduce illness, save lives, and maintain societal structures” (Reynolds and Quinn 2008:16S). Information for crisis and emergency risk communication needs to be prompt, accurate, credible, empathetic, respectful, and geared toward action (CDC 2018), although this is far from what we witnessed during the

coronavirus pandemic, which was characterized by the constant spread of misinformation (Motta et al. 2020).

The second form of learning that participants pointed out was associated with activities that were experimental in nature and that captured immediate adaptive responses to changing conditions, such as updates of official guidelines as new information became available. That is, respondents recognized that there is a degree of learning in the initial experimentation that follows a crisis. For example, small businesses and restaurants had to quickly come up with creative ways of staying viable, which led to the development of delivery and pick-up services for most products, as well as ways of experimenting with the use of outdoor spaces, e.g., extending restaurant seating into sidewalks. Similarly, the elementary educational system used a variety of ways to continue teaching school children that included experimenting with online instruction platforms, hybrid models of learning, and revamped spaces and rules for in-person instruction. The latter form of learning has elements of adaptive management and, indeed, the two appear together in the co-occurrence matrix (Fig. 4). Although adaptive management is more structured, in both cases, learning occurs as an iterative process in response to a changing environment for the purpose of gaining new knowledge on how things work and improve future responses.

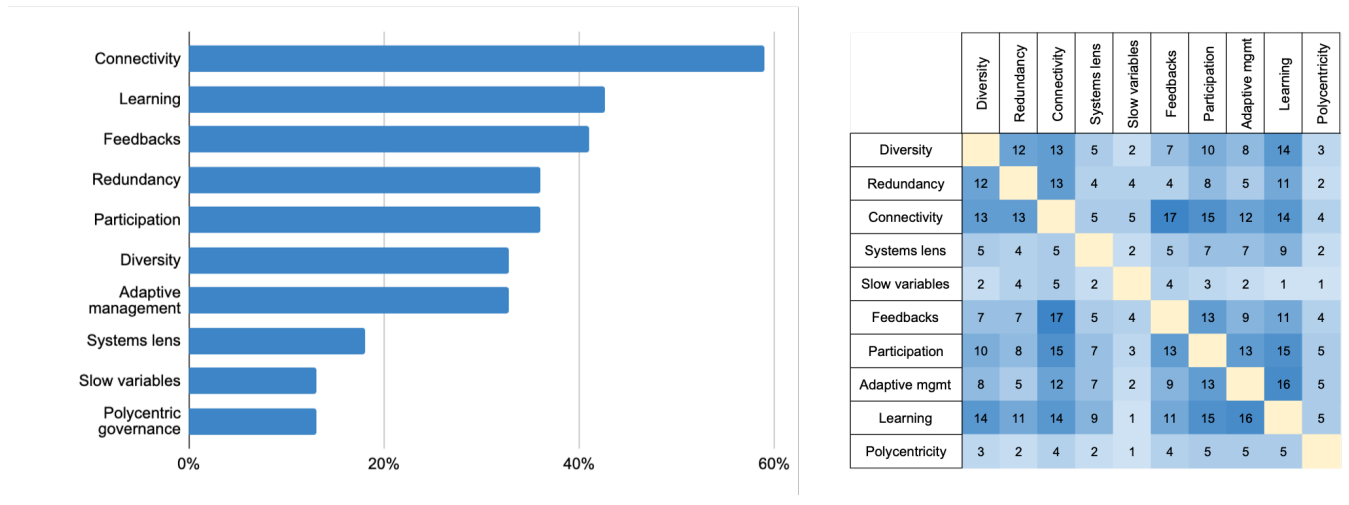
#### *Feedbacks*

Feedbacks are mechanisms to control the internal dynamics of the social-ecological systems by designing an intervention that either amplifies or dampens an initial response. The majority of feedbacks that participants identified in the response to the pandemic were dampening feedback loops, which are most useful for maintaining a system within bounds. In this case, dampening feedback loops were usually connected to reducing connectivity as noted in the co-occurrence table. Thus, the examples are similar to the ones cited earlier in relation to managing connectivity, such as the way in which bans on air travel, city-wide lockdown mandates, or school closures, which helped to reduce the numbers of in-person interactions where potential transmission could happen, which ultimately reduced the rate of contagion.

There were fewer examples of amplifying feedback loops. One worth noting was the way in which engaging in small solidarity efforts boosted morale. Mental health impacts due to grief, isolation, exhaustion, and anxiety soon became a concern paralleling the concern for contagion (Cullen et al. 2020). Participants identified that being engaged in actions that helped others, even in small ways, such as by delivering food to those in need or sending emails to check-in, were important ways of building positive energy that helped sustain them and allowed them to continue doing more voluntary actions. Indeed, others have pointed out how traumatic events create conditions for bonding and how the solidarity and social ties that emerge in the aftermath of a crisis play a key role in getting out of it (Elcheroth and Drury 2020).

Last, although feedbacks are considered mechanisms for managing the system and we have focused on those that were intentionally set up, they can also occur spontaneously, particularly amplifying feedbacks. For example, the panic buying that was observed at the beginning of the crisis emerged spontaneously, that is, people perceived a potential interruption in supply and began stocking up on essential items, causing store

**Fig. 4.** (Left) Principles of resilience identified in the strategies by participants ranked in order of frequency (n = 61). (Right) Co-occurrence matrix highlighting interactions between principles.



supplies to dwindle, which in turn increased the perception of scarcity and further induced more panic buying. Amplifying feedback loops can be problematic for maintaining resilience because they can cause a system to spiral out of control.

*Redundancy*

The types of measures that participants identified as increasing redundancy were associated with repurposing physical spaces and processes in which there was sufficient overlap in form or purpose. For example, open-air spaces such as parking lots and sidewalks in front of restaurants were converted into patios, large indoor spaces such as art galleries and hotels were used to house COVID patients temporarily as hospitals reached capacity. Examples of repurposing include the adaptation of manufacturing processes to supply health products in high demand, e.g., some distilleries began manufacturing hand sanitizer, large industrial manufacturers such as Honeywell in the United States began producing disposable facemasks.

Redundancy was also understood in a social sense as providing additional social safety nets to address the loss of income and purchasing power, which was one of the main challenges for households during periods of strict lockdown. Respondents highlighted aid programs sponsored by governments, for example, how Canada provided monthly relief cheques to a large swath of its population during the initial months of the crisis. As well, respondents identified bottom-up organizing efforts to create safety nets that had local reach and aimed to protect local businesses. For example, in Sweden as farmers lost revenues due to restaurant closures, REKO-rings (a scheme similar to community-sponsored agriculture) sprung up to ensure that these farmers were able to connect with buyers and sell their produce.

*Participation*

Within our data set, participation encompasses two forms of engagement. One understanding of participation was made up of strategies that facilitated people coming or acting together. That is, respondents identified strategies in which people partook in a collective activity, such as the opening of streets for pedestrian

use or webinars for kids by children’s authors and illustrators, as examples of participation. Although in both cases participants were passive recipients, these strategies were perceived as participatory because they embodied a sense of collectivity and indeed, the matrix shows co-occurrence between the participation and connectivity principles.

By contrast, more academic understandings of participation presume some degree of power sharing in processes of decision making (sensu Arnstein 2019). The strategies that fall under this category demonstrate a higher degree of agency. In an example from South Africa, the nature-based tourism sector that was greatly affected during the pandemic reached out to donors to find ways of supporting their sector by switching to payments for ecosystem services as a means of financing conservation. In this case, it is clear that those involved in the tourism sector worked together to come up with solutions that benefited their group and that in doing so they claimed power to decide how best to organize their sources of financing. We also note in the co-occurrence matrix how participation appears together with learning and adaptive management and hypothesize that the pandemic created the conditions, or the necessity, for groups to self-organize and experiment together, for example, how bubble family arrangements organized to provide for childcare

*Diversity*

Roughly one-third of responses included taking advantage of diversity in some form. These ranged from a diversity of transportation methods to replace public transport during lockdown (e.g., bike and walk-friendly zones) to a diversity of food supplies and sources, (e.g., restaurants offering delivery, selling through farmers’ markets) to a diversity of governmental responses. Diversity builds resilience because it provides a repertoire of alternatives. Importantly, diverse elements will respond differently to the same shock, so even if some parts of the system are affected, others can still carry on. Thus, the critical characteristic that increases the resilience of a system is response diversity.

In the co-occurrence matrix, diversity coincides with learning, which reinforces the idea that the initial months of the pandemic created the conditions for quick experimentation and having, or creating, diverse options provided opportunities for comparison, whether it was governmental agencies trying different approaches at different scales (see polycentricity below), different approaches to teaching (in-person pods, online, or other), or different types of socialization (zoom happy hours, driveway gatherings, and zoom dating).

#### *Adaptive management*

The initial months of the coronavirus pandemic were characterized by both high uncertainty and a sense of urgency. Thus, many of the strategies identified by our survey respondents had the purpose of learning while managing, which is the essence of adaptive management. All sectors of society had to adapt quickly, from businesses to households to governments, while new information about the disease was still emerging. Because of the degree of uncertainty, most adaptations done in this context had a degree of experimentation and learning-by-doing, which has been mentioned before, e.g., restaurants modifying their business model from lockdown, to pick-up and delivery, to outdoor dining, to comply with changing regulations. One important aspect of adaptive management has to do with monitoring the impact of policies. This was clear in the strategies of governments and health agencies that continuously updated their directives based on new information, as well as in the phased responses according to levels of transmission, health dashboards, and contact tracing apps.

The following three principles appeared less frequently in the set of strategies that participants identified: Adopting a systems lens, which means approaching a situation considering its dynamic nature, inherent complexity, emergent properties, and nonlinear behavior. Among the few responses that suggested a systems lens was the way in which some federal governments chose to invest in Indigenous remote communities as a means of building general resilience in the face of COVID. Another highlighted direct financial help to citizens for the same reason. A third example was how contact tracing was digitized. Although what constituted taking a systems lens depended more on the framing of the respondents than perhaps other variables. All of these strategies seem to speak to interventions that considered larger temporal or spatial scales and second order effects.

Slow variables were generally poorly identified, i.e., most examples that identified slow variables as a feature of building resilience did not articulate what aspect of the intervention constituted the slow variable. One example is of traveling less and consuming less. Here, we can infer potential slow variables of behavioral shifts and lifestyle changes that reduce exposure (reducing detrimental types of connectivity). Another more direct example is from South Africa where mental health support has been provided for healthcare workers on the frontlines of combatting the virus. The idea being that the deterioration of mental health may be gradual and go unnoticed for a prolonged period of time before the person is at the point where they need help.

Finally, there were few examples of polycentricity in the response to COVID. Perhaps the most consistent way in which polycentricity shows up in the response to the coronavirus pandemic was in the way in which different levels of government

were able to adapt their mandates to their jurisdictions as they saw fit. However, there is a thin line between polycentricity and simply an uncoordinated, politicized response. More productive examples of polycentricity at the grassroots scale include linking community action networks in Cape Town to each other horizontally and vertically to learn and share in a polycentric manner.

#### **Pathways out of the crisis**

Last, we also considered constellations of strategies that converged to create possible pathways out of the pandemic. All of the responses were categorized into broader pathways based on the similarities of strategies adopted across cases. Four main pathways were identified (see Table 2):

1. The securitization pathway emphasized top-down measures to control and restrict the movement of people to stop the contagion. Although physical distancing is warranted for reducing viral transmission, this pathway has undertones of authoritarianism that potentially impinges on broader civil liberties and grants undue power to authorities beyond the pandemic. Furthermore, prioritizing strict adherence to social distancing measures does not consider other important aspects of people's livelihoods, such as the loss of income or the mental health impacts.
2. The grassroots pathway recognized the importance of bottom-up leadership. This pathway featured a strong mobilization of grassroots efforts, and in particular a restructuring of food supply chains and the delivery of essential goods to vulnerable people. COVID-19 responses also bring a restructuring of public spaces that support new collaborations to reimagine commons (urban green spaces, transportation systems) to provide safe social spaces and contribute to mental and physical health.
3. The online pathway illustrated the emergence of new ways of living and working online that allowed flexibility and social distancing but are also contributing to isolation and mental health issues. Some people pointed to a new emerging common that was global, rather than local, in nature which was the emergence of greater collaboration to solve the global pandemic, for example, by enhancing data sharing and international collaborations in dealing with the health crisis.
4. The welfare state pathway summed the idea that the way out of the pandemic required ramping up systems of social safety nets that extended care to the most vulnerable. Similar to the securitization pathway, this remains top-down but sees the role of government as a provider rather than enforcer.

These different pathways represent broad courses of action that emerged immediately after the pandemic that are not, however, mutually exclusive nor all-encompassing. Other pathways may emerge in the upcoming months and pathways often coexist simultaneously, especially because these are often driven by different sets of actors at different scales that focus on managing different aspects of the pandemic. Nonetheless, there are tensions between some of the pathways, for instance between increased securitization which limits the agency of individuals to increase safety and grassroots actions that often aim to activate people's capacity to act.

**Table 2.** Four pathways out of the crisis. A pathway is a constellation of strategies and principles that emerged as distinct courses of action.

Pathways	Description	Examples	Main resilience mechanisms	Benefits	Potential issues	Frequency
Securitization	COVID-19 leads to the adoption of restrictive measures that center around the control of movement, creating tensions between security and personal freedoms	Social distance rules, mask mandates, lockdowns	Connectivity, feedbacks	Eases the burden on healthcare system	Police state, potential for power abuses that deepen inequalities, unemployment	30%
Grassroots	COVID-19 activates grassroots efforts that aim to help the most vulnerable, often linked to a turn to the local	Reorganization of food supply to favor local food producers, pedestrian streets	Connectivity, participation, diversity, learning	Boost to local business and local food systems, creates community, hope, safe social spaces	Ad hoc approach, possibly short-lived	30%
Online living	COVID-19 changes the ways that people connect and work leading to new forms of public space and online commons	Shift to online ways of working and living, rise of online support systems, restructuring of businesses, enhanced data sharing	Learning, connectivity, participation	Flexibility, co-production of knowledge	Issues of mental health and isolation, online access is unequally distributed, slow	23%
Welfare State	COVID-19 reinforces the role of the state which is forced to step up to provide support to its most vulnerable	Financial aid, investment into the health-care system, top-down leadership informing what will be done next	Redundancy, systems lens	Provides safety nets	Costly, difficult to maintain in the long run	17%

Each of the pathways identified above is associated with activating a different set of resilience mechanisms (Fig. 5). The securitization pathway emphasized the two resilience mechanisms that are most prominent in the data overall, that is, the management of connectivity and feedbacks. The grassroots pathway also relied on the management of connectivity followed by diversity. The online living pathway focused on learning followed by connectivity. The welfare state pathway highlighted managing feedbacks and redundancy as its main resilience mechanisms. Thus, although all the pathways emphasize addressing system configurations (i.e., managing diversity, redundancy, and connectivity), the pathways also relied on managing the system (i.e., most frequent resilience strategy adopted in online living is learning) and adopting a system's approach (i.e., primarily focus on feedbacks in the welfare state pathway) to increase resilience in light of the pandemic.

## DISCUSSION

The purpose of our analysis was to understand the principles of resilience underpinning the initial responses to the COVID-19 pandemic, noting that although a pandemic constitutes a specific public health challenge, it can also be taken as a proxy for other large societal shocks including future pandemics, the impacts of climate change, and beyond. In doing so, we seek to provide empirical evidence for the principles of resilience that have been identified in the literature and also consider what lessons might be applicable for an upcoming crisis. Out of the resilience principles identified in the literature (Biggs et al. 2012), our survey identified three principles that shaped the initial response to the crisis, which were managing connectivity, enhancing learning, and the management of feedbacks. The principles of increasing diversity and redundancy, inviting participation, and practicing adaptive management were next in order of frequency. Finally,

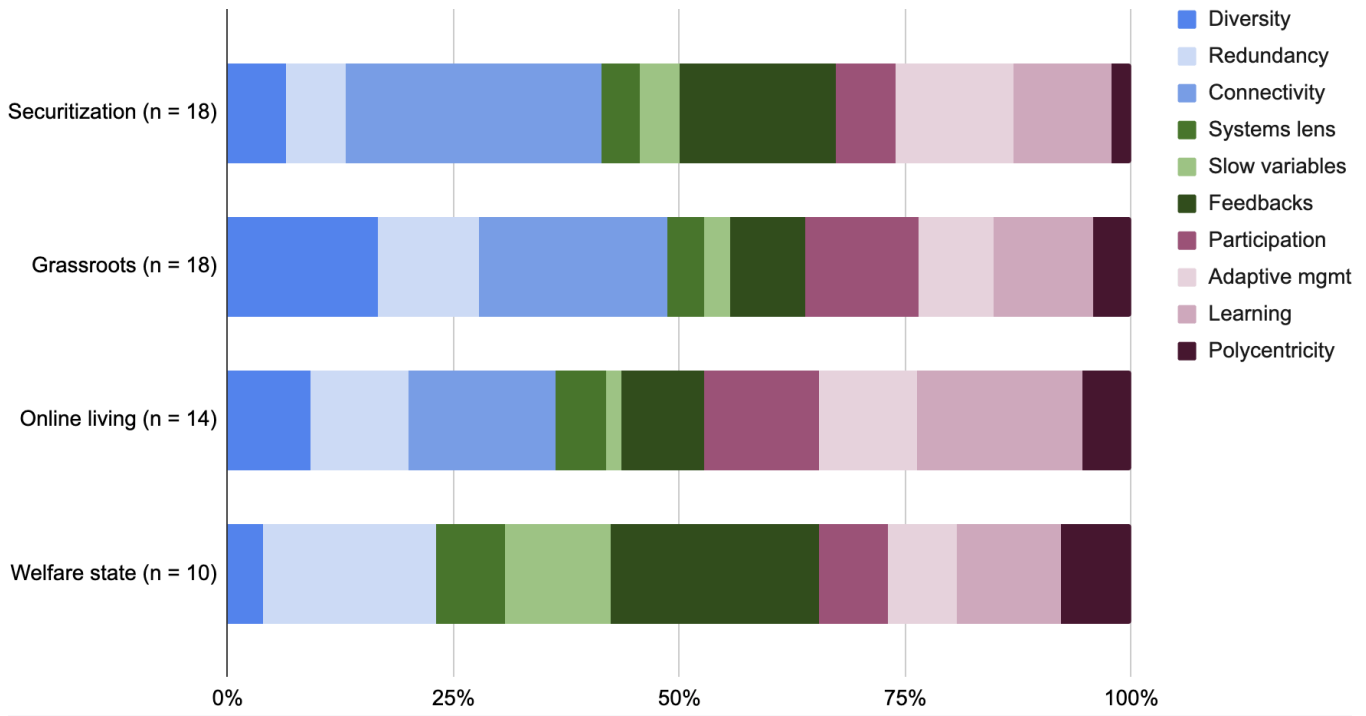
the principles related to adopting a systems lens, managing slow variables, and polycentricity were less prominent in our responses. We also note the formation of two predominant pathways out of the crisis that occurred simultaneously but are guided by opposite drivers: one relies on state-enforced mandates to stop transmission and the other relies on local, bottom-up approaches that look out for vulnerable groups. These two pathways were not mutually exclusive but coexisted highlighting the diversity of responses of different actors and at different scales.

The variation in the degree of implementation of the different resilience principles during the initial stages of the coronavirus pandemic suggests that some principles are more useful in a crisis situation than others. Namely, the most important resilience principle at the onset of the coronavirus crisis was the management of connectivity. Although the importance of connectivity can be readily ascribed to this being a health crisis, this principle likely applies more broadly because most crisis situations require both isolating the part of the system that has become dysfunctional while connecting it to resources that can help fix it. For example, when flooding occurs, it makes sense to cut traffic to the flooded area while also sending rescue helicopters to airlift survivors. The lesson here is that managing the connectivity between the elements of a system is critically important to maintaining its resilience while navigating a crisis, and that resilient systems need to have both shutoff mechanisms and alternative connection routes that can be activated quickly.

The other two principles of resilience that were implemented with higher frequency during the initial months of the coronavirus pandemic had to do with learning and managing feedbacks. Both of these speak to the need to navigate a highly uncertain and variable environment, which requires continuously reassessing what is known and then setting the proper incentives to guide



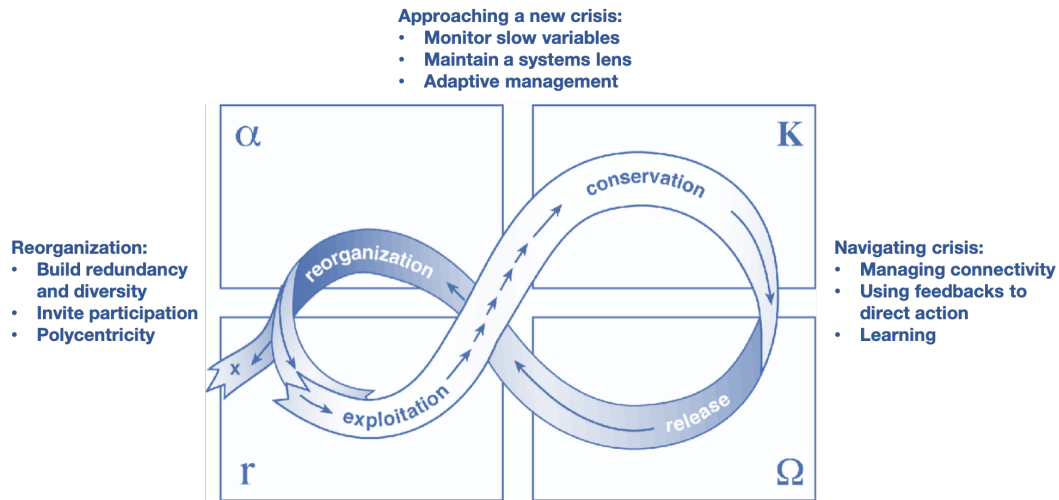
Fig. 5. Four pathways and associated resilience mechanisms.



action. In terms of learning, we remark that respondents included passive forms of learning as well as active, experiment-driven lessons. However, only the latter is usually considered relevant for building resilience. That is, traditional learning mechanisms and institutions are likely too slow during an evolving crisis. For example, during the early years of the AIDS/HIV crisis, gay men's knowledge was more sophisticated in understanding what constituted safe sex practices than the medical establishment (Escoffier 1998). Part of this knowledge would have been learned through experimentation and channels that were not accessible to formal institutions. Thus, systems that are able to connect with vernacular and local knowledge sources can get key insights that will help them navigate uncertainty. This could also include setting up infrastructure to obtain signals from large, unofficial, and decentralized sources of information, for example, the Eyes on the Rise app developed in South Florida (US) that encourages citizens to report flooding events, or the HarrassMap app developed in Egypt for women to report incidents of sexual harassment. Both apps tackle very different crises but they capture crowdsourced knowledge that is anonymous and spatially explicit. Finally, to use learning mechanisms effectively to build resilience, it is necessary to understand the power dynamics associated with managing knowledge and information during a crisis. The coronavirus epidemic may have presented an extreme case of misinformation, particularly in countries like the United States where the crisis and its solutions have been highly politicized from the outset (Motta et al. 2020, Ratzan et al. 2020), however, in all cases it is important to recognize that the narratives spun by governments, health agencies, and media are responding to specific pressures and interests.

Focusing on feedbacks is important for two reasons: first, feedback mechanisms set up the incentive structure necessary for a coordinated response, which starts to get to the crux of the governance of crises. Here, there are important considerations not only on what prompts people to act collectively in an uncertain environment (see Elcheroth and Drury 2020) but also on how to balance speed with analysis, centralization with decentralization (Janssen and van der Voort 2020) and the underlying ethical considerations. The COVID-19 crisis revealed a variety of governance approaches across countries and cultures; from China to Sweden, we see variations in terms of the use of incentives or punishment as mechanisms for enforcement as well as the value placed on individual freedoms or collective actions (Yan et al. 2020). The second aspect of feedback mechanisms that is important for the management of crises is that, if set correctly, feedbacks provide an opportunity to understand the underlying workings of the system by observing the response to an intervention. This is the essence of adaptive management, where policies are understood to be testing hypotheses about the working of a complex system. The pandemic created conditions for rapid adaptation as people were actively experimenting, taking advantage of pre-existing diverse conditions, or setting up small experiments to understand what might work and why. There are a number of reasons why people are more willing to experiment during a crisis, for one, they are often faced with novel conditions for which they were not prepared. For example, working families had to think of alternative arrangements to provide childcare and education once schools were closed. At this point families were likely willing to consider a variety of arrangements, such as bubble families, because maintaining the status quo was not a viable option. As well, crises are moments of shifting baselines, of

**Fig. 6.** Temporal dimensions of resilience principles.



questioning and challenging core beliefs and assumptions that might no longer hold, thus opening the solutions space to experimental ideas (Smith and Elliott 2007).

At the other end of the spectrum were the principles that were implemented less frequently, namely, managing slow variables, adopting a systems lens, and polycentric decision making. This may be the case because all of these mechanisms require long lead times and need to be implemented before the actual crisis. That is, slow variables can be drawn upon during times of crises but they cannot be set up during one. For example, households that had savings were able to use these to shelter in place for longer and purchase supplies more easily. Critical slow variables need not be economic; Lugo (2020) identified social, ecological, and technological variables that played a role in the impact and subsequent recovery from hurricane Maria in Puerto Rico that ranged from government corruption to vegetation to the dependence of the island on fossil fuels. All of these factors were set up for success, or failure, prior to the actual hurricane. The takeaway is that because slow variables are tied to the overall resilience of the system, they can provide buffering capacity and options during turbulent times, but they need to have been in place well in advance.

Similar to the slow variables, a systems approach requires that it be present before the crisis strikes for it to be useful, which is not often the case. In particular, the pandemic revealed the fragility of living in a highly interconnected and complex world that also values maximizing efficiency. This is perhaps best exemplified by several sectoral analyses of supply chains during the crisis, e.g., food (Béné 2020, Love et al. 2021) or medical materials (e.g., Gereffi 2020). These analyses showed how the globalized economy that we live in relies on lean production, just-in-time delivery, vertical integration, and long-distance trading, which is the economic equivalent of the pathology of command-and-control (sensu Holling and Meffe 1996). That is, we have created a highly profitable (although unfair) economic system that performs efficiently, under a set of narrowly defined conditions. For example, to reduce inventory and storage costs, just-in-time

delivery uses a set of logistics arrangements that require careful orchestration to ensure that all of the connections from manufacturing to delivery occur in a timely fashion. If one part of this system of logistics experiences a delay, the entire operation will be affected because there is little redundancy in this arrangement that can help cope with disturbances. Last, polycentric governance arrangements also need to be set up in advance but they are inherently difficult to implement, and it often emerges and self-organizes when conditions allow and institutional arrangements facilitate it. As well, polycentricity often serves as an enabler for other resilience-building principles including increasing participation, improving connectivity and diversity, and creating opportunities for learning and experimentation (Schoon et al. 2015).

What emerges from our analysis is that there is a strong sense of temporality that determines when each of the resilience principles is most useful. If we think of complex systems as having periods of stability punctuated by moments of rapid change as in Holling's adaptive cycle (Gunderson and Holling 2002), then we can assign the principles of resilience identified in the literature as follows: first, navigating an evolving crisis ( $\kappa$  to  $\Omega$ ), as we have documented, requires managing connectivity in a way that isolates the issue but provides alternative routes to address the situation; activating learning mechanisms that emphasize the gathering and disseminating of information; and setting up appropriate feedbacks to direct action, resources, and people. Second, in the aftermath of the crisis as the society moves toward reorganization ( $\Omega$  to  $r$  and eventually to  $\kappa$ ), there are key principles that need to be considered to enhance resilience for a future event. These include choosing pathways that build redundancy and diversity across a polycentric governance structure and that invite broader participation in the design process. Finally, as the new system consolidates ( $r$  to  $\kappa$ ), it is important to resist simplification and maintain a systems lens (Abreu Saurin 2020, Hynes et al. 2020, Walker et al. 2020, Kontogiannis 2021), practice adaptive management, and monitor slow variables that are tied to the resilience of the overall system (see Fig. 6).

### Future research

Our analysis of strategies deployed in the aftermath of the coronavirus crisis adds empirical evidence to the usefulness of resilience principles identified in the literature. However, by its very design, our work is the beginning of a larger conversation. We consider additional elements that impacted the first months of the initial wave of the coronavirus pandemic to identify possible areas of future study.

First, many of the responses were colored by a sense of solidarity and expressed a normative orientation that is usually mute in resilience thinking. For example, some answers spoke about prioritizing the needs of the most vulnerable. Also, answers tended to favor the local scale, highlighting horizontal linkages, e.g., checking on neighbors, rather than nestedness across scales. We are probably seeing the confluence of resilience and vulnerability ideas, which are often thought to be the inverse of one another but in fact have distinct lineages (Eakin and Luers 2006, Miller et al. 2010). Whereas resilience is rooted in systems science, vulnerability is rooted in disaster studies and has a stronger normative base. It seems that a clearer articulation between the two fields is necessary to explore both the systemic and the human implications of crises.

Second, our work identified key principles to navigating the pandemic in general, however, it would be interesting to compare different communities and their responses based on preexisting levels of resilience and adaptive capacity. For example, how did diversity factor in? That is, were some communities more resilient because they were more diverse and what type of diversity was most important? What were the conditions that allowed for quick learning and experimentation? Associated with that, as societies start to move toward recovery, how are decision makers planning for their desired resilience pathway? What are the key slow variables that need to be put in place so that communities build resilience for the known unknowns, i.e., whether pandemics, natural disasters, or political instabilities? And what are trajectories for recovery and how do they set things up for the next one? Finally, the role of polycentricity in governance remains difficult to assess. Can polycentric governance systems be planned or are they emergent properties of the social-ecological systems in which they are a part? Thus, important comparative work is still missing. Going forward, we can envision ways in which coordinated responses across municipalities and multiple scales of governance emerge, provide mechanisms to learn from successes and failures, and improve the overall system resilience to the shock of an epidemic.

### CONCLUSION

We have examined initial responses to the coronavirus pandemic from a resilience perspective to understand the mechanisms that became activated as coping responses on the ground. We invited members of the Resilience Alliance and collaborators to identify the resilience principles behind these initial strategies. Although the sample is small, this was necessary to ensure that they could identify resilience principles because our study used deductive logic to interpret what was happening on the ground as the crisis unfolded. We found that the most important, or frequent, resilience principles enacted during the pandemic had to do with managing connectivity, which included isolating measures to reduce transmission while creating alternative ways of staying in

touch. Similarly, learning was key in the early stages of the pandemic. Some of the learning was simply about gathering information. However, participants pointed to learning through experimentation, particularly as a way of figuring out how to proceed, as an important element to navigating the developing crisis. The third principle that was present in the early stages of the pandemic was the establishment of feedback mechanisms that helped guide the behavior and provide the infrastructure for governance. Our research also suggested two broad pathways out of the crisis that emphasized opposite qualities. Both occurred simultaneously but emphasized alternative routes, one being top down, the other grassroots. Our research suggests that there is an important temporal component that makes some principles of resilience more applicable than others, specifically during times of crisis. However, we say this knowing that our research reports the results of a small sample and that there is still critical comparative work that is missing.

*Responses to this article can be read online at:*

<https://www.ecologyandsociety.org/issues/responses.php/13223>

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### Data Availability:

*The data that support the findings of this study are available as supplementary material. Ethical approval for this research study was granted by Arizona State University STUDY00011979.*

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## Appendix 1. Responses

Description of interventions in response to the COVID-19 crisis that builds resilience (e.g., social distancing)	The response that you identified above, is building the resilience of what and to what?	Strengths and limitations of this response	Geographical location of response
Immediate financial help was offered to full-time workers and students by the Federal government in the form of a monthly benefit cheque. This has allowed many people who lost work because of the pandemic to continue to cover basic expenses. It has also opened a conversation about the possibility of establishing a basic income for all.	The financial benefits build resilience of households to economic shocks associated with the pandemic.	Immediate financial aid to people who need it (\$2000/month; \$1250/month for students); limitations - costly to federal budget, amount might be enough for some people but not others, restrictions to who can apply	Canada
Modularizing - social distance, face masks, hand washing, isolating in 'covipods'	It builds resilience of the individuals, and also builds resilience of society by isolating infected individuals. The idea is to reduce spread of infection and avoid overloading the medical system.	The virus is still out there. Modularization might slow down the crisis until a vaccine is developed. But there is a cost of modularization. An alternative is to rely on the immune systems of individuals and let the virus spread. This avoids cost of modularization and does not wait for a vaccine. However, there could be a lot of deaths especially of older age classes. Sweden is an example to see the age distribution of deaths.	Modularization is happening almost everywhere in the U.S., to varying degrees.
Sensemaking - online platforms for interpreting what is going on; Building New Routines - individuals finding ways to structure their interactions with others in a way that makes them feel in control; Value Orientation- finding ways to connect one's behavioral choices to the concerns of others in a meaningful way	The individual's resilience to the shock and dislocation of the pandemic	It has less to do with a general guideline and more to do with how an individual makes a novel and stressful situation comprehensible, meaningful and manageable (strength). Weakness: generalizability of any particular response	Everywhere
Increased social grants to most vulnerable people who cannot access money or food during lockdowns	Building resilience of people vulnerable to livelihood shocks, e.g., those with piece jobs and lack of formal employment or who are laid off/unable to work due to a crisis.	Strength- provides a safety net so that in nobody should be unable to afford their basic needs like food; Weakness- often not well implemented, people fall through the cracks and often governments don't have the funds to do it adequately. Testing for who qualifies is also problematic.	South Africa
Parking spaces become pedestrian/terrace; summer schools; social distancing labs, local food coops, 'holiday streets'	Greening local neighborhoods, creating social networks, accelerating shared mobility	Very local, no policy instruments readily available, temporary nature	Rotterdam, NL
Rebuilding a big exhibition hall into an emergency hospital with 600 hospital beds for COVID-19 patients in about 2,5 weeks in the Stockholm region. The exhibition hall collaborated with the property manager, the Stockholm regional office (responsible for health care) and the national defense. In the end, it never had to be used and they decided to dismantle it.	Building resilience of the health care system in the face of a pandemic	It builds up a buffer for the health care system, but it also depends on that there is competent staff and adequate materials etc. It makes use of a resource - a venue, that didn't get used since all the exhibitions were cancelled. Like with any buffer, it is very difficult to know if what is enough.	Stockholm, Sweden
There has been a drastic increase in both producers and consumers signed up for and buying from my local "farmer's market" initiative (REKO-ring in Swedish). Several of the producers were impacted by the	It builds resilience of the food system to global shocks that influence the trade of food from beyond the local region. Indirectly, it builds local resilience of the local, as many	It has happened without any coordinated efforts or official support. That means it is unclear how long-lasting this change will be. However, since many have been made	Stockholm

decrease in restaurant sales and discovered the farmer's market as an alternative source of income during the crisis. There was also a lot of coverage on the vulnerability of the very globalized food system that we depend on in Stockholm, which I believe increased the consumers' awareness and willingness to support local food producers.	of these producers have sustainability certifications and are high in biodiversity and ecosystem services. This builds resilience to e.g., extreme weather, climate change, etc.	aware of this initiative, they might want to continue buying some of their groceries there even after the crisis has subsided. The "self-organized" character of this initiative makes it very flexible, which is both a strength and a limitation - it adjusts to changing conditions, but also requires voluntary efforts.	
Shelter in place, especially for elderly	To stop the spread, lower the contagion of the disease	Limitations- all or nothing approach, that doesn't account for other strategy such as creating larger networks or bubbles to allow for people to work.	State of Georgia
Contact tracing	Resilience of communities to COVID	Strengths: helps to identify and isolate potential carriers before they spread it to others. If done effectively early on it can eliminate spread (i.e., New Zealand). Weaknesses: relies on people to accurately report (or if done through e.g. cellphones raises privacy issues) and relies on those exposed to quarantine. Takes resources to do it effectively.	Many places, effectively in South Korea, Germany
Sustainable transport (e.g., walking and cycling)	Building resilience towards more sustainable forms of transportation	cheap (strength), improves physical health (strength), only an option for short distance commuting (limitation)	Montreal
Digital technologies (e.g., apps) for contract tracing	Of the community to the risk of community spread	You need a society willing to have their government track them using their smart phones and give up their personal information. It's a draconian measure that can work in top-down, centralized governments but in countries like the US there is a lot of resistance to this because of infringement to individual rights.	China, Singapore, Korea, I think....
Mandatory wearing of reusable (cloth) masks in public in South Africa, Kenya, Nigeria and other countries (regulations are gazetted in government gazette)	This is tricky to define, but by limiting the spread of droplets, the intervention is slowing the spread of the virus, and therefore could be buying nations time to build resilience of health care systems before the peak infections.	Strengths: fairly easy to implement and to enforce through social pressure (e.g., grocery stores in South Africa do not allow one to enter the store without a mask). Limitations: improper wearing of masks may mean that individuals feel a false sense of security and no longer prioritize other interventions such as handwashing.	South Africa, Kenya, Nigeria, and other countries
Increase in people participating in Community Supported Agriculture or other forms of direct sales from farms	The resilience of household food security to supply chain disturbance	Strengths for HHs: shortens supply chain, fewer links that can be affected negatively so more consistent supply of fresh fruit/veg; increased knowledge of food system. Limitations for HH: price higher and CSA require upfront investment - limits who can participate (excludes low-income households). Strengths for farms: increase income; if CSA, clearer picture of finances for season because all participants invest	US. Maybe EU/UK too?

		at the beginning of the season. Limitations: farms using more single use plastic	
We have been fostering food security in a locality in Oaxaca	Resilience of social ecological food systems to shocks by fostering sovereignty	This is carried out at a local scale. Implementation and follow up is hard given the COVID associated restrictions for gathering people	Santo Domingo Tomaltepec Oaxaca
Monitoring Cases of Covid19	Building resilience of global public health to one where outbreaks can be suppressed quickly	Strength: Highly spatially explicit Limitation: Lag time between contraction and showing symptoms	All over the world, headquartered in public health centers
In the Western Cape Province, South Africa's current Covid-19 epicenter, many hospitals focused more strongly on mental health support for health workers. They increased psychological services at hospitals, and at a provincial level rolled out strategies for mental health support to hospitals.	Building the resilience of the health care system to increase pressure of hospitalizations. Increasing capacity in mental health support for health care workers is focused on managing the feedback of increased hospitalizations leading to increased stress on health works leading to worsening health care mental health --> diminished health care working capacity --> even more pressure on remaining staff -	Positives: seems to be at least partially successful in managing the feedback described above (see Daily Maverick article shared in the link section). Negative: Requires increased government resources to support extra mental health capacity and increasing pressure on mental health professionals. Implementing a mental health strategy may require resources that are not widely available during times of crises.	Western Cape, South Africa (mostly Cape Town)
Daily press briefings by the state governor, usually with other officials such as the state chief medical officer or experts from the University of Nebraska Medical Center, to inform the public about the pandemic, safety measures, and the state's ongoing response.	I would frame it as building the resilience of the public confidence in the state's coronavirus response through transparency and continues updates as things change. The idea is to avoid surprises, resentment, and loss of public confidence that could lead to citizens ignoring health recommendations.	The approach relies on citizens staying informed, and the government to trust the public to follow health guidelines that are not mandatory. Too much information can confuse people or incite panic but there has been no panic and little confusion so far, though as time has gone on the number of people following some of the voluntary health recommendations seems to be dropping. One strength the state government has worked with University of Nebraska Medical Center (UNMC) for health guidance on safety procedures and communication. There is a high degree of public trust and pride in UNMC since they treated Ebola patients brought to the U.S. during the 2014 outbreak. Nebraskans listen to UNMC health experts.	Nebraska (statewide)
On the 27th of March 2020, South Africa entered into a "level 5" national "lockdown", a period of strict restriction of movement and interaction. Only essential services were allowed to operate, including health services, food production/distribution and retail, utility services, and security services. Alcohol sales, cigarette sales and all events were prohibited. The homeless were gathered up and housed in temporary shelters. A driving permit was required for driving and that could be checked by police at roadblocks. The national defense force (army) was deployed to help the police enforce these regulations. All borders to neighboring countries were closed, and all	The national lockdown's main purpose, as I understand it, was to build resilience within the health care system to the inevitable increases in COVID-19 patients. South Africa, and especially the Western Cape (which has been a hotspot since the beginning as international tourists brought the virus mainly to Cape Town and surrounding areas), spent the time that was "bought" by the lockdown to build field hospitals, increase treatment capacity at existing hospitals, source ventilators and	At least in the Western Cape, the primary aim to increase the resilience of the health care system seems to have been achieved. The strength of this response is the ability to focus all attention and resources on one aim, which is deemed the priority at the time. However, as you may imagine, the limitation of this laser-focused response is the wide-ranging fall-out in other areas of society. Huge numbers of people suddenly unemployed led to sharp and devastating increases in food insecurity and poverty, as	South Africa



<p>flights into South Africa were prohibited, except repatriation flights for tourists stuck in South Africa. A national "solidarity fund" was created to accept donations to be used in the fight against the virus. After 5 weeks of level 5 lockdown, on 01 May, we entered into level 4, which saw the easing of some restrictions. People were allowed to go outside between 6-9am to exercise or walk your dogs, within a 5km radius of your home. Group activities were still restricted, as was the sale of alcohol and cigarettes. The government introduced a curfew between 8pm and 5am. Public transport in mini-bus taxis was restricted to a small number of passengers. The government started to roll-out additional grants and increases to existing grants (e.g., child grants) for the poor and vulnerable to access additional funds. On 01 June, we entered level 3. All South Africans are required to wear masks at all times while out among other people, and practice social distancing. Most people could now return to work, and exercise times were extended from 6am to 6pm. Alcohol sales are allowed, but cigarette sales are still prohibited. Restaurants, shops, and cinemas can operate, providing they adhere to social distancing and hygiene guidelines. In Cape Town, beaches and national parks (e.g., Table Mountain National Park) are still closed. Non-contact sports are allowed. Travel between provinces within South Africa is still prohibited for leisure but is allowed for business. Social gatherings are still not allowed, except for work purposes and for funerals. A general point: The national government, and our president specifically, has put an emphasis on deliberative stakeholder engagement throughout this process. He has continually engaged with business, unions, industry, and other stakeholders to understand the implications of lockdown for the economy and society. He has also surrounded himself with a scientific advisory committee and has taken on board the advice of medical experts. There has been a continued process of learning and adjusting, as new information has become available, and the government has received feedback from the people.</p>	<p>oxygen, and increase the morgue capacity at hospitals. It was understood from the very beginning that South Africa's context (e.g., high density informal housing, high percentage of co-morbidities like HIV and TB) would not allow for a complete eradication of the disease as was attempted in other countries. Instead, we played for time, and hoped to avoid the devastating spikes in cases that have overwhelmed health care systems in other places.</p>	<p>well as increased rates of domestic and gender-based violence. Existing inequalities were thrown into even sharper relief. In addition, the use of the army to enforce lockdown rules was highly problematic, and there have been instances of police/army brutality and even deaths of South Africans at the hands of the armed forces. The authoritarian response has caused citizen groups and human rights advocates to issue dire warnings about state overreach and totalitarian power grabs that will be difficult to reverse. In general, the government has attempted to deal with issues as they emerge (e.g., they started distributing new grants for the poor and unemployed and set up domestic violence support centers), but it seemed like they were often surprised by consequences that emerged. In other words, the response initially seemed very proactive (implementing a strict lockdown before South Africa had its first COVID-19 casualty), but then it seems like the government still ended up playing catch-up with all the developments that were hard to foresee.</p>	
<p>Investments to support Indigenous remote communities in going through the crisis; part of this funding, hopefully, goes into improving basic services and health facilities.</p>	<p>Resilience of Indigenous communities to COVID19 and other future crises.</p>	<p>Strengths: Can improve basic services that were lacking and severely affecting many communities' capacity to cope with COVID19 if some community members were to get infected. Massive investments are needed to improve basic services in several Indigenous and remote communities (e.g., clean running water, basic health services, accessibility to good</p>	<p>Canada</p>

		and affordable food). Limitations: Massive funding is required, and that announced by the government is not, according to many experts, sufficient to meet the needs of these communities. Also, it's important to keep track of how the funds are used, and if they are really building long-term resilience or rather used for short term solutions	
Social distancing, wearing a face mask, avoiding crowds and indoor public places	Resilience to avoid catching the virus	-	Lincoln, Nebraska
Global data sharing and open access of academic work related to the pandemic	One could argue it's coming a bit late (in this specific case), but it's helping the global community move faster and be more responsive by sharing data and findings almost real time. It's building resilience of our knowledge base in the face of unknowns.	The strength is to increase our knowledge as fast as possible, building on a truly global and collaborative expertise. The open access allows anyone to access this information, independently of their financial resources. The limitation is that this happened in reaction rather than in anticipation, and that knowledge building takes time and will not necessarily solve anything in the short term.	Global with some nodes (e.g., scientific journals, institutions) concentrating the information and acting as disseminating platforms (e.g., John Hopkins University, USA)
Solidarity networks	Communities to socio-economic vulnerability	Strengths: bottom-up; limitations: not institutionalized enough	Barcelona
Support for getting food and essential to elderly and vulnerable people in our island	Protecting the vulnerable, by building the resilience of Stockholm region's healthcare to deal COVID-19	Haphazardly organized, perhaps not everyone who need it is reaching out for help. Small scale.	Tranholmen island, Stockholm, Sweden
Sweden bans on visits to elderly care homes, considered the most "at risk".	Supposedly building the resilience of elderly care homes to the pandemic by limiting the risk of contagion and pro-actively isolating them (increasing modularity in the network).	The main limitation is that this isolation was neither followed with massive testing nor personal protective equipment for health care staff operating in these elderly homes. As a result, the disease spread unnoticed and ravaged the elderly care homes.	Sweden
Liberate public space for people and not motorized vehicles	Of the city's public management to coronavirus	Strengths: it was timely, there was an opportunity: the traffic reduced significantly, and physical space at the same hours of the day was required (due to Spanish COVID special restrictions, walking and practitioners sports was allowed only from 6 to 10 am or from 8 to 11 pm). Temporality is good but... Limitations: temporality of these measures is also bad, given the positive benefits of this type of interventions on the environment and health.	Bilbao, Barcelona, Madrid.... I would say that most of the big cities in Spain have applied these measures.
Masks	Manufacturing masks independently	-	Igualada
In Ottawa, the National Capital Commission turned streets they were responsible for into bike lanes.	People were able to practice physical distancing and get outside into public spaces.	This got people out but kept people safe in dense downtown cores. This City of Ottawa was very slow to innovate, so it was great the NCC could do so.	Ottawa, but see other cities that have been innovative.

<p>Due to COVID-19, social distancing, and lockdown requirements currently in South Africa, our project has come up with different ways to stay connected. I have tried to send out an email with news snippets, my own personal reflections on the lockdown and the impacts on my work, my feelings about being at home and not in the office. This email helps to keep our team focused and reminded about the work we are doing together even though we are no longer able to meet in person. The responses I receive from colleagues is encouraging, it helps them feel like pushing through the difficult times of working alone at home.</p>	<p>It maintains the diversity in the team, it encourages learning new skills and sharing those with each other and also strengthens the participants relationships to each other.</p>	<p>By opening myself to engage with our team members I am building the trust already there and allowing a space for communication, sharing and learning. The limitation may only be felt when we return to our 'normal' office day to day lives and the interactions that are quite personal now may not continue.</p>	<p>Grahamstown, South Africa</p>
<p>Decision by researchers working on COVID-19 treatments and vaccines to engage in unprecedented sharing of data, samples, sequence information, etc.</p>	<p>Resilience of drug discovery pipeline to crisis</p>	<p>The unprecedented sharing of data, samples, etc has enabled work on over 200 vaccines within months of the start of the pandemic, among other things by the coronavirus being rapidly sequenced and the sequence data openly shared. Subsequent partnerships and collaborative efforts are unprecedented in their scale and in regard to the associated timelines (see JAMA reference above)</p>	<p>Globally - the WHO maintains a list of COVID19 vaccines that are in development, along with information about lab locations.</p>
<p>Helping people less fortunate than yourself - seeing THEIR resilience - how they cope with so little, and yet can smile and rejoice at any help given them gives you strength and makes you aware of your privilege, and makes you want to continue giving. Then there's no room for fear.</p>	<p>Resilience of the people working to provide sustenance, as well as the resilience of those who receive it. There is an exchange of resilience, of the human sharing of an unavoidable set of circumstances and a determination to continue - not to give up.</p>	<p>Strengths - it is boundless (although fatigue is real); it feeds on the strength of others. Limitations - not everyone experiences it, and in situations where there is a critical mass of despair, it is difficult to 'light a candle' sometimes.</p>	<p>Grahamstown/Makhand a, Eastern Cape, South Africa</p>
<p>Leadership that reinforces and builds trust in institutions seems to be key to effective response, if not an 'intervention' per se. This leadership has a number of characteristics but essential are: transparency in communications across diverse populations, multi-level (Federal-State-local) government coordination and collaboration; bipartisanship (ability to 'reach across the aisle'); and reframing/questioning the very fundamental structural origins of the pandemic and imagining alternatives to returning to 'normal.' This leadership does not need to be solely in government, it can also be (and sometimes more importantly) in civil society, private sector etc. And this isn't usually achieved with a single intervention because that trust must be sustained.</p>	<p>Social-ecological systems at all scales TO the full suite of disturbances (pandemics, disasters, etc)</p>	<p>Better (equitable) outcomes for people everywhere and the planet. Limitations: It could be very difficult and slow to implement or may only be partial. And it needs to be constantly revisited and adapted.</p>	<p>Conversations are happening (i.e the articles above) in various English media around the world (US, UK, Australia, India...)</p>
<p>Deliveries of food to people in lockdown in public housing estates</p>	<p>Community networks being used to enable individuals to cope with restrictions, I'm not quite sure how to frame that in relation to resilience of what to what? resilience of the community being built to withstand external shocks? maybe, but the community is rallying around individuals who have no</p>	<p>Strengths: community sector stepped in to provide services that were not being provided by government agencies; food provisions were culturally appropriate which the gov't ones apparently were not; gave food to those who needed it, gave an opportunity to help to those who felt helpless</p>	<p>Melbourne, Australia</p>

	capacity to respond to the shock themselves.	Limitations: volunteerism can provide excuse for continued gov't inaction	
Collaboration between local food producers to supply local food.	Resilience of local food system to guarantee the resilience of food supply in an agroecological way.	Strengths: Guarantee food supply, promote alternative food networks, promote short supply chains, fosters food sovereignty, fosters agroecological transitions. Weaknesses: Lack of previous collaboration, time to build trust, problems with the agro-industrial food system.	Catalonia
In order to lift the spirit of the population, John Krasinski started a YouTube show called 'Some good news' in order to bring good and hopeful news in a time which was dominated in the news by illness, economic loss, and death.	Resilience in the community and people to live through the time and create a hopeful feeling, see alternatives and options	It was very powerful and uplifting in the beginning, however it was not sustainable for the long run. Since it was successful, an economic interest took over and, the show was sold.	Internet
Investing in active transportation infrastructure (e.g. closing streets off to cars, subsidies for micro-EVs)	The resilience of communities to respond to the shock to public transportation in the short-term and to the coming shocks from climate change in the medium-to-long term.	Strengths: promotes health, social solidarity, relatively cheap. Limitations: must carefully consider the needs of persons with disabilities.	Many cities in Europe and Asia. Very few cities in North America.
Assisting others with food aide	Our community to the lockdown and concomitant loss of work, salaries, school feeding schemes and even soup kitchens	Strengths - unification of multiple cliques in our community, quick response to a crisis situation, made many aware of their privilege by contrast; Limitations - logistics were extremely challenging especially under lockdown, only a limited number (around 2000) homes received support; doesn't build the dignity of the recipient.	Makhanda a city in the Eastern Cape in South Africa
Social distancing - avoidance of crowded spaces maintaining at least six feet from the next person, maintaining contact only with people within your household	Resilience of the health care system / residents to COVID-19	Strengths: keeps the COVID curve down; makes taking care of patients manageable Weakness: slowdowns certain sectors of the economy	Puerto Rico
I don't think there are many interventions that increase resilience to COVID-19. By COVID-19, here I mean the corona virus, not its repercussions on the world economy or the food system. There have been some drug trials (for treating symptoms, not causes) and a vaccine is not on the sight. Institutions (rules of behavior) such as social distancing or mask wearing can and do reduce the transmission rate ( $R_{eff} > 1$ is the threshold above which you have a regime shift), making the crises more manageable from the medical system perspective -- not necessarily the economic or political systems as seen in the US--; but in itself it does not increase the resilience of patients exposed to the virus e.g. it does not reduce recovery time neither the net mortality rate. In other words, it delays the hit, but it does not avoid it. Another intervention but with contested results is plasma transfusion (blood) from recovered patients to sick ones.	My answer was "it does not build resilience" when formally speaking about COVID-19. If your question is about the ripples of the pandemic (COVID19) on other systems such as the economy or food systems, then there have been some interventions that can be mentioned. But they generally address symptoms of the crises (e.g., food shortages) not their causes (e.g., inequality).	I mentioned three interventions: i) drug (randomized control) trials, ii) behavioral norms, and iii) blood transfusions. In that order, the strengths are: i) allows to discard negative treatments and focus efforts on potential treatments for treating symptoms or deactivating the virus (vaccine route); ii) are cheap and produce fast results; iii) transfer the knowledge of one system (the immune system) to another. The disadvantages are: i) it seems to contradict the principle of polycentricity, many RCT have been stopped or delayed because the health system is not unified and centrally managed (US) or has problems to "speak across nations" (EU); ii) requires full compliance to be useful, opening up too early or a few people not following the rules can hamper the efforts of many (e.g. Florida); iii) I don't think the intervention has	RCTs all over the world, but the larger ones in UK, Europe, China, and USA. Behavioral norms, all countries in a way or another (there is also a database of rules and when they were put in place). Blood donations in the US as far as I know.

		been part of a RCT so it's hard to know if it really works + blood types distributions or who is able to donate or receive is asymmetrical across the world.	
Virtual social gatherings	People's mental health to periods of isolation	Connects people directly, but not everyone has access or ability, level of connection not as good as in-person contact.	Everywhere
<p>1) Rapid mobilization- very quickly a call went out through various networks in Cape Town asking people if they were willing to help during the unfolding covid-19. These people were then grouped into neighborhoods to develop "community action networks" CANs. Quickly these CANs then paired with other CANs- normally matching low income areas with high income areas to build networks of solidarity- activities were then developed to match the needs arising in the different neighborhoods</p> <p>2) Community mapping- rapidly working to identify vulnerabilities within the community- e.g. disabled, sick, food insecure households, and also identifying people and resources that could be used to help e.g. who is available to do shopping for others, who can take food to the homes of people that can't leave their houses etc.</p> <p>3) Food solidarity (rapid relief)- Based on the mapping we were able to identify people that were more food insecure than before- lockdown meant informal work stopped and therefore people had no income to buy food, we started with food vouchers for local stores through fundraising both locally and abroad, but the vouchers did not go that far, so we then started sourcing and buying food (fresh veg and dry goods) in bulk so the money could stretch further, and providing weekly boxes of food. Demand far outstripped supply and funds so we can to pivot and move to developing community kitchens which could serve daily meals</p> <p>4) Leveraging networks and knowledge- we formed working groups to build on particular skills of the volunteers- e.g. food security, health care support, communications, emotional well-being etc this was critical in making sure we could address the multiple needs surfacing. We also leveraged all our networks both in terms of fundraising- locally and internationally, and also building new relationships with existing grassroots and NGOs in order to support those groups who had been working in areas on issues for a while and could provide advice grounded in local realities e.g. U-Turn working with homeless communities, Amava Oluntu- working with youth etc</p> <p>5) Broadening participation- decision making in the beginning was rapid, decentralized and ad hoc, made by those people who put their hands up to get involved but we realized</p>	I think many of our activities tried to build resilience of communities to be able to respond to emerging challenges- diversifying networks and knowledge. We focused on a number of resilience building activities e.g., developing new food flows, community kitchens as nodes of activities, food gardens, healthcare support etc	The strengths of this response have been greater community cohesion for those people involved in activities, and obviously immediate support and relief. Many of the activities are more in response to the socio-economic impacts of the lockdown than the disease itself. The crises that have been emerging have not been brought about covid-19, they are existing challenges in a deeply unequal society- food insecurity, poverty, gender-based violence, poor education, homelessness have all been exacerbated by rolling lockdowns (we are still in a state of lockdown day 119). Some of the activities might be creating less resilience- e.g., reliance on single flows of food from community kitchens- what happens when donations run out? IT is also very hard to build and broaden participation when gathering is illegal and most people do not have internet access, so communication is hard and often impossible- but there has been innovative responses using WhatsApp. Add to these low levels of literacy and understanding of the virus, and also inability of people in informal settlements to isolate safely. While there have been phenomenal efforts from bottom-up initiatives- there have been less successful engagement at higher governance levels with a totally ineffective and paralyzed state to supply basic support (although we are much luckier in the Western Cape than other provinces with better health care facilities). The limitation is also staying power/fatigue- people need to work and earn money and so many volunteers have dropped away- too many people are doing the work of governments for free with no support.	Cape Town

that we needed to broaden participation both in terms of diversity in our neighborhood, and also the neighborhood we are supporting- We (Muizenberg) is relatively more resourced than our partner neighborhood Vrygrond which is a mix of low and informal settlements with high poverty and crime- the same decisions were not appropriate for both areas/ issues.			
Doing things for other people - it stops you worrying about yourself - things like packing and delivering food parcels.	Building psychological resilience; feeding people who are desperate, giving hope.	The strengths: delivering hope, respite, food; Limitations: reliance on local donations and not sure how long those will last. Govt response has been hopeless - and still is.	Eastern Cape
Staged responses by government, with the opportunity to learn	Resilience of the system to the uncertainty in both the virus (and how it affects people) and how people respond to the restrictions	Enables proportionate response and tailoring as more information becomes available. Enables learning and action at the same time. Limitations are that learning is lagged 14 -28 days and may not carry over from between waves.	Australia and New Zealand, but presumably everywhere where there is decent institutional capacity to learn. E.g., ie not USA and UK???
While tourism revenues have been helping to deliver biodiversity conservation and local livelihoods, the pandemic has dramatically altered many local economies. There are numerous initiatives to raise grants and loans for well-known wildlife areas and their associated safari tour operators, but there is much less focus on supporting marginalized rural community stakeholders. The Luc Hoffmann Institute aims to incubate a new Collaborative Platform that can address this shortcoming while helping to amplify existing fundraising efforts. An African community with one united voice stands a greater chance of pushing this issue globally, is currently competing with other impacts.	Is building the resilience of the biodiversity conservation and livelihoods who are dependent on nature-based tourism, which is a notoriously unreliable industry, and vulnerable to perceptions of risk linked to disease outbreaks (sometimes far away on the same continent), economic and political instability, as well as the potential for local saturation of the market	Strengths: Stakeholder engagement on a large scale that enables the co-design of the initiative, the buy-in and support Limitations: Many unknowns and the need to fill these gaps at a considerable speed to act timely	Africa
Entry restrictions into Australia, plus more recent caps on entry	Of the Australian population to the virus circulating abroad	Intends to reduce transmission of the virus into Australia. But impedes on the ability of Australians to return, plus makes the population vulnerable to the virus if it does come through	Australia
Adoption of/ seeking of the use of local butchers to process meat instead of relying on the few large meat processing plants	This builds the resilience of the food supply system to the consumer. This also shows how non-resilient our current food supply system is to large disturbances, but how it is trying to adapt.	Strengths are that it is allowing for food/ meat to be processed to help keep the supply up while large processing plants are closed due to illness and outbreak but is limited because the local butchers are not used to such demand and are not set up to process as many requests that are being submitted which is causing major losses to the local producers who are now faced with continuing to feed the animals and incur more expense or just cull (remove from	Rural America, especially in ranching and farming regions

		herd either by selling or eradication) them with a loss of profit. Also there is a big issue with restaurants being closed which drove the demand for a lot of products and now there isn't the demand so some producers are left trying to find new markets for their products.	
City closing stores and restaurants build resilience; Additional item stocking such as food, necessary household items like toilet paper. This will prevent you from interacting with people who may possibly carry the disease; Limit travel outside the country and states; Wearing facemask	By preventing the population reaching its threshold and changing to a different alternative stable state. This prevents any further spread and the spread of infection. The stable state we are	Strengths are preventing any further spread  Limitations: Not enough research for this specific strain of virus and that includes know edge gaps. We don't know if it prefers cold or warmer temperatures.	Lincoln, Nebraska USA
Delivery and takeout food availability	Resilience of the economic system and small businesses to the economic collapse and lack of customers (in-person) due to Covid-19. It also provides a degree of resilience in terms of human happiness; preserving some of the norms and culture of pre-social distancing.	Strengths: keeping people employed, options for those still working long hours as essential employees, general human happiness and normalcy. Weaknesses: poor social safety nets in the USA require people to keep working somehow or risk losing their homes, health insurance, security, etc. requiring the businesses remain open even if there is a risk to employees and the work is technically non-essential	Across the USA (presumably elsewhere); large and small restaurants/chains
Frequent, science-based communication from (some) political leaders	Building the emotional and social resilience of the Canadian population. This means they are more resilient to the economic and social challenges in the face of the uncertainty and anxiety associated with an evolving pandemic situation.	Strength - single source of information tied to economic action; limitation - potential for conflicting messages at sub-national geographic units.	Canada-wide
Travel less and buy less stuff	Of individuals and families to economic pressures	It is self-organized but is constrained by personal needs	everywhere
Temporary relief grant for economic distress in South Africa	Building resilience of impoverished households to food insecurity, lowered employment opportunities	Strengths: provides immediate hunger relief to unemployed and families and allows for them to also support local traders who can then continue to operate in communities. Limitations: temporary measure and small amount that does not facilitate the ability to save capital.	South Africa
Turning streets into pedestrian walkways	Society's ability to function normally outside the home to risk of infection	Provides multiple benefits, places to interact safely, allows access to businesses. Not in all places, many people still don't feel comfortable there (marginalized members of society, elderly people), only works in dense neighborhoods (not suburbs)	Montreal and elsewhere
Restaurants doing curbside	From going into complete chaotic state where more than half the human population decreases	Prevents any human contact	Lincoln Nebraska

Online scientific conferences	Resilience of the international scientific community to disease and therefore the world to the novel disease (scientists travel so frequently, and conferences are massive social events where individuals are in close proximity)	Strengths: the science continues, preserving the importance of conferences on resumes, etc. for students, still able to learn what others are doing, reduced cost for travel, more accessible, more equitable, quick response time. Limitations: lack of ability to network and begin collaborations, uncertainty	Globally, within scientific communities everywhere
Effective risk communication	Individuals have accurate and frequent information about the risks of the virus and what people can do to protect themselves and what they cannot control. Build institutional resilience as they need to maintain their legitimacy and credibility of their policies in order for people to cooperate. This is NOT happening in the US, and its eroding institutional resilience.	Related to the answer above, it's a mechanism that maintains the social contract between government and society for both to protect themselves	New Zealand, Iceland, Germany
Diversifying income for conservation areas in Africa. Across Africa, Covid-19 travel restrictions has decimated the tourism industry, which supports livelihoods and conservation initiatives across the country. African conservation's reliance on ecotourism has long been unsustainable, and the current crises has prompted many operators and agencies to look to diversifying their income streams. In Namibia, for example domestic tourism was widely promoted at discounted rates whilst international travel bans were still in place, and domestic and inter-regional tourism has also been promoted elsewhere. Other strategies include potential carbon credit trading, diversifying the kind of tourism experiences on offer, and more integration with sustainable agriculture approaches.	Building the resilience of wildlife conservation systems to the loss of biodiversity and livelihood benefits	Many of options for diversification still rely on tourism, albeit it is different types of tourism and tourism from local people. The benefit of focusing on domestic tourism is that it represents an investment in nature-people relations at a local level, which may prove important to of societal support, and for scale-appropriate protected area management in the future. However, even domestic tourism is prone to the impacts of local lockdowns and other stressors, so just diversifying to other tourism streams isn't enough. Other diversification approaches (e.g., carbon credits) are not feasible everywhere.	Several places in Africa (e.g., Namibia, Ol Pejeta (Kenya), South Africa, Gambia)
Retooling industry production for essential health products. In this case, the ethanol industry in Nebraska partnered up with UNL to produce hand sanitizer for hospitals, hand sanitizer, and other healthcare service providers.	Building the resilience of sanitizer supply for essential healthcare services to the shock of unprecedented demand of the product by the public at large.	It is a clever way to boost production and availability of hand sanitizer, but it is uncertain how long production will be able to continue. The project relies on donated supplies from companies and relaxed regulations by the FDA due to the crisis. These two factors, especially the supply uncertainty, may become an issue if we are in the same spot a year from now and still dealing with sanitizer shortages. On the other hand, sanitizer companies likely will have ramped up production by then.	Lincoln, Nebraska
Closing some communities, prohibiting outsiders from coming in (or if they do, obligation for a two weeks quarantine before)	Building resilience of remote communities to COVID19	Strength: provides a very strong protection to risks of the virus spreading in these remote communities that are not equipped to face the virus. Might foster capacity building at the local level. Limitation: Potentially not viable on the long	Northern Canada



		term, as these communities do depend on some level of connection to the outside, for example to receive some foods and goods by plane and ships, or to see some relatives, etc.	
Distributing stories, and literacy and numeracy activities to parents of young children through newspaper, WhatsApp and radio	Our community to a situation where normal education structures are unavailable	Strengths are that parents feel more empowered, literacy material usually unavailable in poor families is accessible, it's cheap compared to book distribution, newspapers and WhatsApp have different audiences. Catches parents when they WANT to know about participating in their child's education; not all families are reached, not sure how many families use the material, many families can't afford WhatsApp; cost involved in producing a Newspaper, radio failed; at some points the newspapers were unable to publish	Makhanda which is a small 'city' in the Eastern Cape, South Africa
use of online meeting platforms - provide a virtual space for meetings/gatherings/conferences that cannot take place in-person	resilience of K-12 schools /higher education / education NGOS / government/ some businesses to decreed shutdowns and mandated curfews and social distancing	does not allow for hands-on learning processes that need to occur, co-production of knowledge that results from in-person dynamics not as effective; virtual spaces are not equality accessible to all	Puerto Rico/most countries
Zoom (video call) social interactions/parties	Building the resilience of the community and the individual to psychological distress, mental illness, and loneliness more generally while maintaining social distancing and therefore building up the resilience of the community to disease	Strengths: inexpensive, equitable (where laptops and Wi-Fi are common and affordable, this is not universally true within the USA), maintains social distancing, maintain social ties, promotes creativity, increases mental health. Weaknesses: only replaces human interaction for so long; finite	Globally