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Top lesson from COVID for solar geoengineering: Anticipatory research is needed

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This perspective article argues that anticipatory research into possible "emergency" response measures such as solar geoengineering will increase knowledge, and thus confidence, in any future decisions to either deploy or reject these technologies. Similarities between COVID and climate can reveal some perspective on the benefits of anticipatory vaccine research for anticipatory for solar geoengineering research. Although we deeply hope governments will aggressively reduce emissions and scale up adaptation efforts in time to avoid the worst climate impacts, we argue that the benefits of anticipatory solar geoengineer research currently outweigh the risks of not moving research forward.

KEYWORDS

solar geoengineering, solar radiation management (SRM), COVID, anticipatory research, climate change, emerging technologies

Introduction

Doctors and scientists know with certainty that pandemics will strike. It is not a matter of if, it is a matter of when and how bad. So, scientists prepared. Two years into the COVID-19 pandemic, scientists developed an innovative and highly effective vaccine at record speed. Researchers had worked for decades developing all the needed pieces of an RNA vaccine. When, rather abruptly, humanity faced a global pandemic, it took months, not the usual years to test, produce, and begin distribution of this vaccine.

Like global pandemics, global climate change is not a matter of if, it's a matter of how fast and how bad. Both COVID and climate change present existential crises that disrupt society at a global scale, cause vast and unevenly distributed human suffering along lines of race, geography, and class, and demand innovative, interdisciplinary, and international action to address. Prior research enabled an "emergency" response to the COVID-19 pandemic. Like epidemiologists, climate scientists have a high degree of certainty that the globe will overshoot the ambitious target of keeping temperatures well below 1.5°C set by the UN's 2015 Paris Agreement.

Given the demonstrated inability of world governments to adequately reduce emissions through international cooperation and domestic action, it may become necessary to cool the Earth rapidly to avoid the worst climate impacts for humanity and ecosystems. Yet, unlike COVID vaccine research, which anticipated the global pandemic, we lack anticipatory research into "emergency" strategies for addressing the impacts of a temperature overshoot. We know little about the ways this might be done and the potential risks and benefits of any such intervention. One underexplored, but highly controversial, way to do this might be solar geoengineering. Yet, lack of political support has impeded the ability of anticipatory research to progress.

Our hope is that through all the misery associated with this pandemic, humanity might have learned something of use to inform responses to another existential global problem: climate change. We deeply hope governments will aggressively reduce emissions and scale up adaptation efforts in time to avoid the worst climate impacts. However, like other recent commentaries on this issue, we argue that the benefits of anticipatory solar geoengineering research currently outweigh the risks of not moving research forward (Buck et al., 2020). Like vaccine research that anticipated a global pandemic, we argue here that anticipatory research into possible "emergency" response measures such as solar geoengineering is needed to increase knowledge and thus confidence in any future decisions to either deploy or reject these technologies.

Why compare COVID and climate?

To determine if the COVID experience could inform our management of solar geoengineering, we should first examine the similarities of the two problems. Political scientists use problem structure variables to evaluate the types of institutional design responses that might suit specific types of problems (Jinnah et al., 2021; Mitchell, 2006; Morin et al., 2022). Some such variables include: geographic scope, issue salience, distribution of values, number of and asymmetries between actors, uncertainties about science or the preferences of other states, linkages to other issues, and whether a problem is benign or malignant in nature (Rittberger and Zürn, 1991; Koremenos et al., 2001; Miles et al., 2002; Biermann and Siebenhüner, 2009).

Although a comprehensive problem structure analysis is outside the scope of this short perspective, we examine here four commonly analyzed problem structure variables to determine if comparing these *problems* (i.e., climate change and COVID) and the *response measures* we are interested in (i.e., solar geoengineering research and vaccine research) makes sense. Specifically, we look at their: geographic scope, issue salience, asymmetries between actors, and scientific uncertainty.

The geographic scope of both problems (i.e., climate and COVID) and the response measures have global impacts and interest. Similarly, both have high issue salience across all variables, with both problems and response measures posing global existential crises for humanity and both response measures facing massive resistance from those skeptical of the safety (e.g., anti-vaxxers) and morality (e.g., anti-solar geoengineering activists) of these technologies. Both climate change and COVID have deeply uneven distribution of impacts with poorer communities and communities of color facing the worst such impacts in both cases. Similarly, vaccines and solar geoengineering also have potential for highly uneven impacts, with both vaccine access and solar geoengineering research highly concentrated in the developed world. Finally, scientists are relatively certain about the most severe impacts of both climate and COVID.

Despite these similarities, COVID does not represent a perfect analogy for climate. For example, we understand quite a bit more about the potential worst impacts of vaccines than the potential worst impacts of solar geoengineering. Vaccine development has benefited from extensive research and solar geoengineering has not. In fact we argue here that anticipatory research could decrease uncertainty about solar geoengineering outcomes. COVID lacks the "moral hazard" concerns generated by solar geoengineering research (i.e., mitigation deterrence). However, recent studies have actually demonstrated that "moral hazard" concerns for solar geoengineering may themselves be overstated (Cherry et al., 2022). Solar geoengineering demands particularly robust governance structures (see Smith, 2020). Never-the-less, the similarity of the *types* of issues across two problems will allow us to learn from a comparison. Therefore, although the problem structures see some variation they are sufficiently similar to warrant the preliminary comparison undertaken in this short perspective.

Anticipatory research saves lives

Because the elements of an RNA vaccine had been the subject of prior extensive research, anticipating a future but highly likely problem, companies were able to produce a completely innovative and effective vaccine in a matter of months. Much of the key research was done by individual researchers deeply interested in specific aspects that underlie vaccine development. Researchers like Jason McLellan, a structural biologist at UT Austin was inspired by the MERS outbreak to understand how the spike proteins on corona viruses could form the basis of a vaccine. His team found a modification to the spike proteins which stopped the protein from changing shape as it entered a cell and thus allowed the spike protein to induce the right antibodies. Katalin Kariko's focus on RNA allowed her to find a way to instruct cells to make the spike protein of choice, which in turn resulted in a protective immune response. Similarly, Özlem Türeci, the cofounder and chief medical officer of BioNTech led the clinical development of "Project Lightspeed," the company's successful effort to develop and distribute an mRNA-based vaccine against COVID-19 in <1 year. Without this coordinated and investigator driven research we could not have rapidly developed highly effective vaccines.[1]

1 See Zuckerman (2021) for a history of these scientists and their breakthroughs.

Government scientists conducted anticipatory research. For years before the pandemic, the US National Institutes of Health (NIH) conducted mission-oriented research to find a way to quickly produce a reliable and universal vaccine for generic coronaviruses, which could be customized to fight different coronaviruses. Although curiosity driven research culture currently dominates most scientific fields, designing a mission-oriented geoengineering research program around needed outcomes, as was done by NIH, would likely fill knowledge gaps more efficiently (Long et al., 2015; Sarewitz, 2016; Long, 2017). These research discoveries underlie the Moderna, J&J and Pfizer-bioNTech vaccines.

Imagine what the outcomes of the pandemic might have been if the biomedical research underlying the COVID vaccines had never been done. Like George Bailey in the movie, A Wonderful Life, exploring the world as it would have been if he had never been born, we can imagine a world without the science needed to produce vaccines. Many more people would have died and the economic and social consequences would have been even more horrendous. As terrible as this pandemic has been, the outcomes without a vaccine would have been orders of magnitude worse. The vaccine that saves millions of lives was produced by the many scientists who piece-by-piece created a body of knowledge that could be quickly deployed into a completely new class of highly effective vaccines. *This never would have happened without proactive anticipatory research.*

Now imagine a future where the climate has deteriorated dramatically compared to today. Imagine crops failing, famine, flooding and drought, massive ecosystem loss, and massive disruptive migrations. If in this future, suppose we had not conducted anticipatory research into "emergency" climate mitigation measures, the world, especially the most vulnerable among us, might well be locked into decades of suffering. Looking back from this imagined future, we see we had a choice to know more about what we could do by proactively researching solar geoengineering as an anticipatory strategy for addressing the worst climate impacts. In that dark future, we may regret having not made a research investment in solar geoengineering, even if just to know that we explored and rejected it as ineffective or too dangerous.

Geoengineering research, like biomedical research, invests in solving future probable problems. Some geoengineering research proceeds without federal funding. However, these projects are far too modest to make sufficient progress in understanding the potential and pitfalls of geoengineering methods. The topic deserves a focused research program that identifies key scientific questions and funds projects to explore the answers.

Successful management of climate change requires exploration of all possible tools. We need to know more about whether any geoengineering tools could reduce negative impacts and better understand the tradeoffs of deployment they would incur. We should look to COVID vaccine development as an imperfect—but instructive—example of how anticipatory research can help in preparing for worst case scenarios.

Discussion: Important considerations in moving research forward

The COVID vaccine experience also highlights several important (but non-exhaustive) considerations that must be kept front of mind in moving any solar geoengineering research program forward.

First, safety is paramount. Both COVID research and geoengineering research can present significant risks. In the case of COVID, "gain of function" research conducted at the Wuhan lab could prepare researchers to fight more lethal viruses. Reports indicate that the safety culture and procedures at Wuhan were likely relatively weak. Several reviewers have concluded this research likely had inadequate oversight, control and transparency (e.g., Rogin, 2020).

Similarly, solar geoengineering must be researched in a way that ensures public safety. This includes initially only moving forward with research that presents little or no environmental risks. Neither current climate conditions nor early research needs warrant immediate large-scale interventions, which might present safety concerns. Much may be learned through numerical modeling. Further, thoughtfully governed, low risk, small-scale outdoor experimentation that is deemed by peers to have scientific merit, may yield critical understandings and insights that could be useful in future scenarios of deeply climate impacted worlds. If and only if research suggests that these technologies may provide more benefit than risk, then larger scale experiments might be considered. Much remains to study before it makes sense to conduct experiments large enough to incur any climate perturbation, and perhaps this will never be warranted. Equally important, ensuring safety also means establishing thoughtful governance. Plenty of models are already in circulation for how to move from the current blank page to a fairly robust system of checks and controls (e.g., Chhetri et al., 2018; National Academies of Sciences, Engineering and Medicine, 2021).

Second, balancing scientific goals with social concerns is key. Largely due to advances in governance and local engagement mechanisms, COVID vaccine trials were possible without recreating the dark history of early stage vaccine testing in marginalized communities (Barry and Molyneux, 1992; Kruger et al., 2014; Bekker and Mizrahi, 2020; Makoni, 2020). So too must solar geoengineering researchers learn to balance scientific goals with social concerns -even if they don't fully understand or value them. It's a reality of doing business and the sooner scientists learn to engage with these concerns, especially by genuinely supporting the development of governance structures to ensure people feel adequately protected—the more likely they will be able to move their research goals forward. Again, plenty of governance models have laid the groundwork for governments and others to adapt and adopt.

Third, communication must be clear and transparent. The management of the COVID pandemic by US government agencies was confusing, disorganized, conflicting and politically influenced. Given the complexity, controversy, and potentially the urgency, surrounding solar geoengineering, these same communication and transparency pitfalls could easily affect geoengineering research, not to mention any possible future deployment. Governments must start thinking early about communication plans for this issue. In parallel, scientists must take seriously public interest in this issue and clearly communicate about ongoing research, its goals, the state of knowledge, expected outcomes of experiments, and potential risks and benefits.

Fourth, privately funded research can present future problems. Privately funded solar geoengineering researchers can develop vested interests, and these subsequently might try to influence research and/or deployment choices that could have vast global impacts. Federally funded solar geoengineering research could avoid some of these issues and arguably should be the major research modality. The US government's Operation Warp Speed succeeded in producing vaccines quickly, but private control of vaccine technology has created serious distribution and distribution*al* issues with vaccines not getting into arms quickly enough and with historically marginalized groups being most severely impacted by those shortages. Pharma vaccine profits have reached many tens of billions of dollars, but companies have refused to license the technology or use profits to vaccinate in developing countries (Abramson, 2022). Private control of solar geoengineering IP could result in industries who might try to influence deployment choices to their benefit rather than the benefit of the world's population. We might protect against this by limiting or prohibiting patent rights on solar geoengineering technologies.

Conclusion

The COVID pandemic has illuminated just how important anticipatory scientific research can be in responding quickly to global crises. An anticipatory mission-driven research program, led by both government agencies and individual scientists, allowed for unbelievably fast development of a vaccine, which saved millions of lives. As with COVID, climate change also presents an existential threat with vastly uneven impacts across the globe. As with COVID, this threat demands we explore all possible ways to mediate these climate change impacts, even if that exploration ultimately means we must reject the technologies because they prove too dangerous or ineffective. At the same time, a research program with such large potential risks cannot be pursued without extreme care and caution. The COVID experience offers a non-exhaustive set of lessons here as well. Any solar geoengineering research program must prioritize public safety, balance scientific goals with social concerns, ensure clear and transparent communication, and prohibit private interests from capturing decision making for profit. These are all achievable goals through thoughtfully constructed and robust systems of governance. Governance is necessary, possible, and ready to launch.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Abramson, J. (2022). *Sickening: How Big Pharma Broke American Health Care and How We Can Repair It*. Harper Collins: New York.

Barry, M., and Molyneux, M. (1992). Ethical dilemmas in malaria drug and vaccine trials: a bioethical perspective. *J. Med. Ethics* 18, 189. doi: 10.1136/jme.18.4.189

Bekker, L., and Mizrahi, V. (2020). COVID-19 research in Africa. *Science* 368, 919–919. doi: 10.1126/science.abc9528

Biermann, F., and Siebenhüner, B. (2009). *Managers of Global Change: The Influence of International Environmental Bureaucracies*. Cambridge and London: MIT Press. doi: 10.7551/mitpress/9780262012744.001.0001

Buck, H., Geden, O., Sugiyama, M., and Corry, O. (2020). Pandemic politics—lessons for solar geoengineering. *Commun. Earth Environ*. 1, 16. doi: 10.1038/s43247-020-00018-1

Cherry, T. L., Kroll, S., McEvoy, D. M., Campoverde, D., and Moreno-Cruz, J. (2022). Climate cooperation in the shadow of solar geoengineering: An experimental test of the moral hazard conjecture. *Environ. Politics*. 1–9. doi: 10.1080/09644016.2022.2066285

Chhetri, N. D., Chong, K., Conca, R., Falk, A., Gillespie, A., Gupta, S., et al. (2018). Governing Solar Radiation Management. *Forum Climate Eng. Assess.*

Jinnah, S., Nicholson, S. and Morrow, D. (2021). Splitting geoengineering governance: how problem structure shapes institutional design. *Global Policy*. 12, 8–19. doi: 10.1111/1758-5899.12900

Koremenos, B., Lipson, C., and Snidal, D. (2001). The rational design of international institutions. *Int. Organiz.* 55, 761–99. doi: 10.1162/002081801317193592

Kruger, M., Ndebele, P., and Horn, L. (2014). *Research Ethics in Africa: A Resource for Research Ethics Committees*. Sun Press, Pawcatuck. doi: 10.18820/9781920689315

Long, J. (2017). Coordinated action against climate change: a new world symphony. *Issues Sci. Technol.* 33, 3.

Long, J., Loy, F., and Morgan, M. G. (2015). Start research on climate engineering: safe, small-scale experiments build trust and road-test governance. *Nature* 518, 29–31. doi: 10.1038/518029a

Makoni, M. (2020). COVID-19 vaccine trials in Africa. *Lancet Respiratory Med.* 8: e79–80. doi: 10.1016/S2213-2600(20)30401-X

Miles, E. L., Andresen, S., Carlin, E. M., Skjærseth, J. B., and Underdal, A. (2002). *Environmental Regime Effectiveness: Confronting Theory with Evidence*. Cambirdge: MIT Press. doi: 10.7551/mitpress/2784.001.0001

Mitchell, R. B. (2006). Problem structure, institutional design, and the relative effectiveness of international environmental agreements. *Global Environ. Polit.* 6, 72–89. doi: 10.1162/glep.2006.6.3.72

Morin, J., Jinnah, S., and Orsini, A. (2022). "Global health and environmental politics pandemics: a multilateral approach," in eds P. Bourbeau, and J.-M. Marcoux (Oxford, UK: Oxford University Press).

National Academies of Sciences, Engineering, and Medicine (NASEM). (2021). *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance*. Washington, DC: The National Academies Press.

Rittberger, V., and Zürn, M. (1991). Regime theory: findings from the study of 'east-west regimes'. cooperation and conflict, XXVI, 1991, 165–183. *Cooperat. Conflict* 26, 165–83. doi: 10.1177/001083679102600401

Rogin, J. (2020). *Did COVID-19 Escape Wuhan Lab?*. Washington Post. Available online at: https://www.washingtonpost.com/opinions/2021/03/22/did-covid-19-escape-wuhan-lab-who-report-cant-be-final-word/ (accessed April 14, 2020).

Sarewitz, D. (2016). Saving Science. *The New Atlantis*. Available online at: https://www.thenewatlantis.com/publications/saving-science (accessed September 13, 2022).

Smith, P. T. (2020). "Legitimacy and Non-Domination in Solar Radiation Management Research," in *The Ethics of "Geoengineering the Global Climate,* eds G. Stephen, C. McKinnon, and A. Fragniere (Routledge: Milton Park). doi: 10.4324/9781003049012-7

Zuckerman, G. (2021). *A Shot to Save the World: The Inside Story of the Life-or-Death Race for a COVID-19 Vaccine*. Penguin Random House: New York.