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Engaging with Uncertainty:

Best Practices for Science Communication during the Climate Crisis and COVID-19

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Engaging with Uncertainty: Best Practices for Science Communication during the Climate Crisis and COVID-19

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Executive Summary

The rapid spread of the novel coronavirus has left policy makers looking urgently to science for accurate information to inform mitigation efforts. Due to both the inherent uncertainty associated with studying an ongoing pandemic, as well as the limitations of expedited research, establishing best practices for the communication of scientific uncertainty is critical. The challenges of communicating science related to climate change offer key comparative insights.

Based on this comparison, I recommend that scientific communicators report uncertainty in a manner that prioritizes transparency and trusts the public's ability to accurately interpret this uncertainty when it is well-defined. The approach described below aims to (1) provide clear and accurate information by expressing uncertainty explicitly, numerically, and in detail, (2) earn and maintain trust in science by acknowledging and explaining shifts in knowledge as they occur, and (3) minimize the spread of misinformation by identifying incomplete areas of research and reminding the public of the targeted standards for research consensus.

Climate Crisis Can Inform COVID-19 Communication

The emergence of SARS-CoV-2, the virus that causes COVID-19, has forced both policymakers and the public to rely on emerging scientific findings to inform decision making and guide massive public mitigation efforts, despite the presence of significant uncertainties. This is reminiscent of the role climate scientists have long played in influencing environmental policies by providing information about the potentially disastrous impacts of climate change. Climate scientists have continuously grappled with how to acknowledge uncertainties in their work without undercutting the field's consensus.[1, 2] However, in contrast to the climate crisis, COVID-19 has swept across the world in only a few months, placing scientists under pressure to arrive at conclusive results and answer pressing questions much quicker than the standard research process allows.

The Meaning of Uncertainty

Scientific uncertainty is the degree to which a finding or conclusion is known. It differs subtly, but significantly, from the common understanding of the word 'uncertainty' and does not carry an implicitly negative connotation.[1] There are two types of scientific uncertainty: aleatory and epistemic.[3] Distinguishing between these types in science communication is critical to defining uncertainty clearly and influencing the public response. Aleatory uncertainty stems from the complexity and unknowability of the world and typically describes projections of the future. Epistemic uncertainty is due to incomplete knowledge and generally describes uncertainties about the past or present.[3, 4] While aleatory uncertainty is irreducible, epistemic uncertainty could be reduced by the revelation of new information. For example, uncertainty in the number of

COVID-19 cases to date is largely epistemic because widespread, effective diagnostic testing could greatly reduce that uncertainty. However, projections of COVID-19 spread have both epistemic and aleatory uncertainty because multiple variables may impact future outcomes in addition to existing gaps in data. While both data points are the same type, namely number of COVID-19 cases, understanding the difference in their uncertainty is critical to an accurate interpretation.

Pandemic Science is Politicized

Citizens' responses to climate change have taught us that political leanings, as well as personal values, can significantly impact receptiveness to scientific findings.[5, 6, 7, 8] When an area of research becomes politicized, policy makers and the public alike often readily accept findings that affirm their political identities while challenging and diminishing contradictory findings.[8, 9] Political bias can also hasten the spread of dangerous misinformation as data is warped, ignored or misinterpreted to fit a set of political priorities.[10] Scientific uncertainty, while unavoidable, can be exploited or misunderstood as a result of political bias.[4, 10, 11, 12] Research into both climate change and the COVID-19 pandemic is politically charged due to the responses of political leaders, as well as the severity of both crises and their enormous potential influence over both public and governmental actions.[8] This fraught environment heightens the importance of clarity and accuracy in scientific reporting, particularly in regard to communicating scientific uncertainty.

Learning from Climate Science

Detailed Uncertainty Reporting Improves Understanding and Trust

Communicators often hesitate to report scientific uncertainty for fear of undermining or overcomplicating the data's main message. However, research from the climate case shows that audiences with varying levels of cognitive skill can understand and interpret uncertainty if it is reported explicitly.[4, 13, 14, 15] Quantitative expressions of uncertainty, such as a numerical range surrounding an estimate or a percent likelihood, maximize the clarity of uncertainty expression and either maintain or increase an audience's level of trust in the data's source. In contrast, qualitative descriptors of uncertainty can lead to varied interpretations of data.[4, 14, 15, 16] For example, reports by the Intergovernmental Panel on Climate Change use terms such as "likely" and "unlikely", to express uncertainty. Readers interpret these descriptors inconsistently, and with bias according to their pre-established beliefs.[17, 18] General indications of uncertainty, such as the qualifiers "estimated" or "about", are even more imprecise and do not effectively convey uncertainty. [15]

As I've previously stated, established beliefs and political views can heavily influence a person's willingness to accept scientific claims.[3, 8, 9] However, when uncertainty is reported in adequate detail, it does not further undermine message acceptance, even in the case of politicized research.[15] Additionally, attempts to control the response to data by only partially reporting uncertainty, such as listing only a worst-case scenario, cause distrust in the data and do not effectively spur readers to action.[14] In the midst of a global pandemic, people expect some uncertainty in data and can be informed about it accurately.

Acknowledging Unknowns Prepares the Public for Shifts in Knowledge

To model phenomena, scientists must define a large number of parameters. Climate models, for

example, rely on assumptions about global emission rates and their impacts to predict changes in the environment over time in addition to environmental data. These assumptions, as well as the innate unpredictability of the climate system, introduce significant uncertainty.[19] Epidemiological models, which predict possible progression paths of disease, similarly rely on assumptions about human interventions and their effectiveness.[20] However, many additional parameters, such as the virus' fatality rate[21] and the rate of asymptomatic spread[22], remain undefined in the case of COVID-19. This epistemic uncertainty means that models are changing rapidly as the virus itself is studied. If citizens and policymakers accept an epidemiological model and respond by increasing mitigation efforts, disease progression may decline in a manner that makes the original model appear inaccurate.[20] The same model may also change if expanded virus testing reveals higher existing case counts.[23] Because of this constantly shifting landscape, underlying assumptions, as well as major areas of incomplete knowledge, should be readily acknowledged alongside pandemic models.[24] A history of clearly defined uncertainty will allow researchers to acknowledge and guide the public through shifts in knowledge as they inevitably occur.[4]

Understanding the Scientific Process Requires Guidance

Over many years of climate research, misinformation has spread alongside validated science.[12] While some reports are entirely false, the most convincing and prevailing forms of misinformation contain some truth, typically when valid data is misinterpreted or the reliability of a single new study is overinflated. Climate scientists commonly respond to misinformation campaigns by emphasizing high levels of expert consensus[25, 26] and reiterating that only reports based on peer reviewed literature results are reliable.[27] However, this response to misinformation is not always possible during the COVID-19 pandemic.[4, 10] Unlike climate science, which has established consensus on key points and has a library of peer-reviewed publications, the field of COVID-19 research is developing rapidly as I write. The urgency of this crisis precludes the possibility of waiting for consensus to develop before acting in response to limited data.[24] However, this necessity does not lower the standard by which scientific findings should be evaluated. The typical peer review process for a scientific manuscript involves months of expert scrutiny and revisions before a submitted work is published in a scientific journal. Researchers wishing to share their research more quickly can release an unreviewed report known as a "pre-print" before the peer review process is complete. Yet while sharing pre-prints can increase valuable communication and knowledge sharing between scientists, such reports, even from reputable sources, cannot be regarded as conclusive and should not be reported to the public as established information.[28, 29]

Despite the rigors of peer review, challenged or retracted studies are a normal part of the scientific process.[30] Contrasting opinions and findings, when analyzed rigorously, are important for consensus building[31] and the scientific process typically resolves such contradictions over time. However, the public is largely unfamiliar with the time and process required to establish consensus in a scientific field. In the current push for understanding, individual studies and particularly those with contrarian claims are making headlines.[32, 33, 34] It is therefore necessary to pull back the curtain and explicitly inform people about how scientific knowledge is developed. As research emerges that opposes the current state of

knowledge about COVID-19, it must be examined and independently validated before the state of knowledge can shift. By making the public aware of the ideal standards for research, communicators can uphold public trust in the scientific research as a whole and maintain the authority to challenge misinformation.

Recommendations

Define Uncertainty Explicitly and in Detail

The failure to report and adequately define uncertainty in data reduces the accuracy of the information presented and can skew its interpretation. Reporting only a best- or worst-case scenario is an example of poorly defined uncertainty and causes skepticism. To maximize public trust and comprehension, uncertainty should be expressed explicitly and quantitatively, as in a numerical range surrounding an estimate or a percent likelihood, while avoiding purely qualitative approximations such as "likely" or "estimated".

Honestly Acknowledge Assumptions and Unknowns

The urgency of the ongoing pandemic means that policy decisions must be made based on the best available knowledge. In the face of high epistemic uncertainty, scientists and science communicators must be proactively transparent, clearly acknowledging assumptions made and gaps in available data. By prominently reporting the sources of uncertainty in epidemiological modeling, researchers can respond to and guide the public through shifts in knowledge as they inevitably occur.

Manage Expectations of the Scientific Process

The public is unfamiliar with the process of peer review and consensus finding in scientific research. As emerging research is reported, it must therefore be properly contextualized. Pre-print studies should be identified clearly and reported cautiously, and not as established knowledge. Isolated, peer-reviewed findings that challenge or significantly alter the current state of knowledge about COVID-19 should be examined by unaffiliated experts in the field and reported alongside a call for independent validation. By reiterating that research consensus develops over time through a series of rigorously examined conflicts, communicators can maintain trust in the scientific process and retain the authority of scientists to challenge misinformation.

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