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► **To cite this version:**

Ignacio Bravo, François Buton. Protecting science in times of crises. *Anaesthesia Critical Care & Pain Medicine*, 2023, 42 (1), pp.101187. 10.1016/j.accpm.2022.101187. hal-03905887

HAL Id: hal-03905887

<https://hal.science/hal-03905887v1>

Submitted on 4 Sep 2023

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Protecting science in times of crises

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

KEYWORDS

Science, medicine, scientific method, social perception of science, crisis

Science and engineering are the most powerful tools evolved by humans, for better and worse. Medicine is also a human creation of a particular nature, because the subjects and the objects of medicine are humans themselves. As in the roman adage [1], the three of them are human creations that allow us to go beyond ourselves, beyond our nature of mere primates. Science (including social sciences) and medicine are profoundly human approaches to the world, but they have laid different philosophical foundations to interact with it. They may share a single source and use often common tools, but their objectives are different: science aims at understanding the world; engineering and medicine aim at acting on the world, in the case of medical praxis by identifying, treating, healing and preventing disease. Further, the fundamental assumption in science is that the human brain can actually understand the world, while medicine does not necessarily require understanding for acting. Because of these differences in core and in objectives, science is different in essence from medicine, and their products, their expectations, their pace are different. Being aware of these essential divergences is imperative, because the COVID-19 pandemic has exacerbated the disturbing trend equating medicine to science. This amalgam is problematic when it comes from decision-makers (most often with limited or null scientific understanding, anyway) and when it regards the social misconception of science, but it is especially worrying when it erodes the self-image and the self-concept of science among scientists ourselves.

Science is a human community construction with a historically acquired autonomy of function, as scientific questions are formulated and answered by scientists themselves. The timing for science to define these questions and to seek for answers is a long one and often transcends the life and work of individual scientists. During this construction process, scientists agree on telling the truth -and thus implicitly agree on believing in the existence of truth(s)-, on making the difference between data and interpretation, on allowing others to verify and validate their findings, and on letting evidence decide when confronting interpretations arise [2]. This is the glue of the community of scientists. Scientific work is nevertheless far from virtuous, because scientists as individuals may often be narcissistic [3] (as indeed a good dose of narcissism is required to believe that one can understand the world), but also because a trust-based system is most susceptible of failure when individual scientists are submitted to short-term pressure for success (e.g. project-based funding) and to attack by parasite elements (e.g. the publish-or-perish injunction that has paved the way to predatory journal practices). The outcome of this tension is that fraud (more or less conscious) is constantly present even if very negatively regarded [4], and that opponents may be reluctant to loyally accept new interpretations and scientific truths [5]. Notwithstanding, the label of “scientific” connotes an aura of credibility, objectivity and soundness that is transferred when used as in “scientific data”, “scientific knowledge” or “scientific decision”.

It could be claimed that one of the effects of the COVID-19 pandemics has been a repositioning of science as a central piece of contemporary society, but our analysis does not sustain this view. During the COVID-19 pandemics, science (or better said the image of science) has been requisitioned by the political power to provide with practical answers for problem-solving in a very short term, and with very limited knowledge. This objective is actually the definition itself of applied epidemiology, created by the *Center of Disease Control* in the 1950s under the name of “field epidemiology”, together with the *Epidemic Intelligence Service Program* “with the goal of immediate action to address a public health problem of concern” [6,7]. Defined as such, “field epidemiology” does not seek a scientific understanding

of the problem, but rather to identify a number of interventions and field approaches to confine and control it. It is thus conceptually closer to medicine than to science. But for the control of pandemics, it was the name of science that was invoked, rather than that of field epidemiology. This control was the immediate objective of decision makers, and for this, political instances have largely resorted during the crisis to “scientific councils” to provide with an argument of authority for political and administrative decisions. These scientific councils have complemented or displaced pre-existing systemic instances that historically gather and transmit information, such as sentinel networks that provide with down-top intelligence [8]. This systematic appeal to the alibi of “science” is not innocent and is biased. i) It is not innocent, because decision-makers borrow authority and image from science, as if they tried to appear to stand “on the shoulders of giants”. But the scientific and the decision makers communities are largely divergent. Decision makers trade and negotiate for solving problems, allocating resources and identifying priorities between competing interests of individuals, groups, corporations or states. The glue of the decision-makers community is their belief in their authority and legitimacy for defining long-term strategies and short-term tactics in the interest of the *res publica*. The glue of the decision-makers community is not the quest for truth, and letting evidence decide among opposing interpretations is not their common practice. The ethics of the scientific and of the decision-makers communities are thus radically different [9]. ii) It is biased, because the “scientists” mobilised and showcased by the political power have often been politically powerful medical doctors, while positions and proposals from non-medical scientific experts were often neglected. The most cogent example in this regard might be the delay in the acceptance of the airborne transmission of SARS-CoV-2 by the WHO but also by many other medical and political instances, that was ignored or minimised despite the wealth of evidence accumulated by non-medical disciplines [10,11].

The image of science has been thus seized by the decision makers during the COVID-19, and this fact is not devoid of consequences. A first consequence has been the change in the scientific publication culture. The landmark of scientific communication, *i.e.* peer reviewed articles, has been superseded during the pandemics by preprints in open repositories of articles that have not undergone yet formal peer review. Such preprints are cited and used more often than before the pandemics [12], allow to short-circuit a sometimes-faulty peer-review publication system and facilitate rapid release of results, essential for guiding a timely intervention in the field. Notwithstanding, many preprint (and published) analyses about the utility and application of non-pharmaceutical interventions have remained ignored if they did not match the official decisions and the mainstream administrative position. This change of attitude towards preprint release might reflect the growing discontent of scientists with the overall publication system, any may result in future positive changes to overcome it.

A second consequence, linked to hasty result dissemination, is the wrong impression conveyed to the public opinion about the volatility of scientific knowledge. A substantial novelty during the pandemics is that preprints and preliminary results have been commonly used by journalists and decision-makers [12], and very often treated and communicated as sound, stable and verified scientific knowledge. This is largely due to recent developments in journalism: on the one hand, there are fewer high-level science (or medical) journalists; on the other hand, the COVID19 pandemic, as a major political and social crisis, has seen political journalists -without scientific training- take over information treatment and communication.

The slow pace of science construction, requiring criticism and cross-validation, has been disregarded for the sake of result generation itself, with the commendable hope of proposing solutions. But in this process, certain non-validated findings that were presented as “scientific data” and used to substantiate political choices were later on softened or refuted. This constant questioning and reworking fits well the scientific standards (especially during pandemics) but less well the standards of decision makers (especially also during pandemics). When decisions showed themselves inappropriate, excessive or not ambitious enough, “science” was to blame. The price, far too high, to be paid in this regard may a durable crisis of trust in science.

A final consequence, the most worrying one and against which we explicitly warn here, is the growing blurry definition of science, with the obvious risk that if everything is labelled as “science”, if everything is “scientific”, then “science” becomes devoid of meaning and becomes a mere brand with a reputation. Two main trends can be identified in this respect.

i) A first trend equates capacity of making predictions and acting on or modifying a system with understanding the system, with having a scientific knowledge about it. On the contrary, a large wealth of evidence shows that predicting does not necessarily mean understanding. The history of humans abounds with examples in which we have been able to define protocols for reproducing outcomes in complex processes that we do not fully understand yet: making cheese, curing ham, brewing beer or making wine are only examples of them. Similarly, researchers can make predictions about the behaviour of complex systems, using for instance dimensionless numbers, without necessarily having a precise understanding of the underlying molecular events that govern transitions between states. Further, establishing accurate statistical predictions at the population level does not necessarily mean understanding the basis of individual variation. We know for instance the mathematical functions that describe how a population of radioactive atoms decay, and we can use them to know that the shroud of Turin is medieval, but if we look at a single radioactive atom, we have no idea when it will decay.

ii) A second trend misidentifies technology-based health interventions and innovations, such as vaccine development, with science. We have a detailed knowledge about the vertebrate adaptive immune system, but the COVID-19 has bitterly reminded us that our understanding lags far behind practice in the design and use of vaccines. It has been this way since the smallpox vaccine. Nevertheless, we still fail at predicting the immunogenicity, durability, cross-reactivity or side-effects of our vaccine design armoury. We don't really know why some vaccines work very well on the long run while others don't; nor what the ideal time between booster doses is; nor against how many viral variants one can be simultaneously immunised; nor, in the case of limited supply, whether it is better to vaccinate as broad as possible or to administer several booster doses to the most susceptible. We do not know, because we understand little, but often we do not even know why we understand so little. And in this groping we are all, at the frontiers of what we know, with science as a candle in the dark [13], trying to see where we can go next.

Among many other things, this pandemic has highlighted how little we know about the different natural histories of viral infections, how little we understand about how and how well vaccines work, how limited our repertoire of responses is. But it has shown us above all that neither science alone nor engineering alone nor medicine alone are capable of understanding the world nor of solving a problem in real time when the crisis is global, when

local interventions are costly and have limited effects in time and space, when decisions have to be made rapidly based on fragmentary and imprecise data. This pandemic is unfortunately not the worst crisis we humans will face in the next thirty years. If we are smart, science will be part of the solution. If we are not, it will probably be the alibi to justify bad decisions. Or it will become the scapegoat, guilty of having made it possible for humans to go all the way to the edge of the precipice.

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