



LETTERS

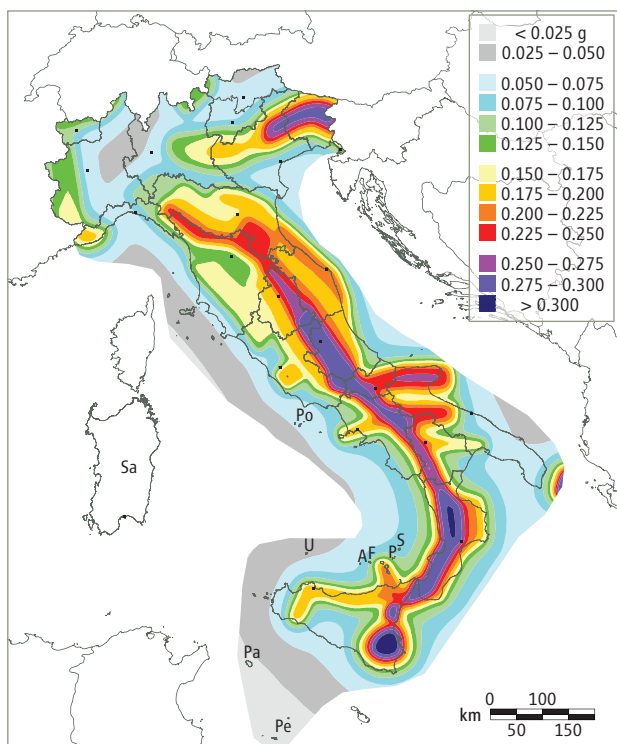
edited by Jennifer Sills

L'Aquila's Aftershocks Shake Scientists

I HAVE BEEN SENTENCED TO 6 YEARS OF IMPRISONMENT FOR FAILING TO GIVE ADEQUATE advance warning to the population of L'Aquila, a city in the Abruzzo region of Italy, about the risk of the 6 April 2009 earthquake that led to 309 deaths. I have been found guilty despite illogical charges and accusations that set dangerous precedents for the future of the scientific process.

The judge's ruling claims that citizens of L'Aquila would normally rush outside upon feeling an earth tremor, but that they did not in 2009 because a Major Risks Commission (CGR) meeting in L'Aquila, one week beforehand, had given them a false sense of security. However, this meeting was run, not by the National Institute of Geophysics and Volcanology (INGV), but by an arm of the Prime Minister's office: the Civil Protection Agency (CPA). An agreement between the INGV and the CPA states that the latter is exclusively responsible for communicating any state of risk. The INGV has always scrupulously adhered to that regulation. As a former president of the INGV, I never spoke to the media about the seismic situation at L'Aquila, and no relative of the victims suggested otherwise.

Rather, the "proof" used by the public prosecutor was the CGR meeting minutes. At that meeting, I (and others) stated that Abruzzo, and particularly L'Aquila, is one of the worst earthquake zones in Italy. I then explained that earthquakes are not predictable for good scientific reasons and discussed some of the seismic mechanics involved. The Mayor of L'Aquila, Massimo Cialente, testified that he was struck by my statement about the local seismic risk at this meeting, and as a result he decided to close certain schools and recommend a state of emergency be declared.



Seismic Hazard Map distributed by the National Institute of Geophysics and Volcanology.

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At the CGR meeting, we also distributed the Seismic Hazard Map, made official in 2003 (1), which was largely the work of the INGV under my presidency. The map clearly shows Abruzzo as a hazardous zone. One of its goals was to inform administrators of what action to take to reduce seismic risk in the areas they governed. The maps were later

made available to the public prosecutor, who ignored them just as he ignored the testimony of Mayor Cialente.

As further evidence of my guilt, the public prosecutor completely distorted the argument of one of my journal publications (2), effectively putting science itself on trial. In that 1995 work, my colleagues and I highlighted the statistical importance of temporal "clustering": various strong earthquakes in a (geologically) brief time span. We posited that the high probability rate calculated for the Aquilan territory is not statistically meaningful because it is based on three events that occurred between the 17th and 18th centuries—hardly a sufficient basis to describe what would happen in subsequent centuries.

The public prosecutor's superficial interpretation of scientific results to bolster his argument sets a grave precedent for not only seismology but many other disciplines as well. Science is constantly evolving; research proceeds by trial and—as knowledge grows—error. When I wrote the "indicted" work, I was addressing my worldwide peers and awaiting their verification, as must be the way of all modern scientific research.

In publishing an official map, seismologists have done all they currently can to protect society from earthquakes. I can hardly be blamed for the poor quality of buildings or for people's failure to conform to anti-seismic laws—these are the responsibilities of other authorities. The local CPA is responsible for accurate communication of risk and effective management of emergency situations. I did not disseminate false or imprudent information. My question is: What could I do to avoid conviction? I suppose I should have foreseen the earthquake!

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References and Notes

1. M. Stucchi et al., *Bull. Seismol. Soc. Am.* **101**, 1885 (2011).
2. E. Boschi, P. Gasperini, F. Mulargia, *Bull. Seismol. Soc. Am.* **85**, 1475 (1995).
3. I want to express my strong friendship to Giulio Selvaggi, who was also wrongly accused in the L'Aquila trial.

Low Marks for Education Funding Priorities

ANYONE INVOLVED SUBSTANTIVELY IN SCIENCE education during the past five decades will see the irony in the decision by the Office and Management and Budget (OMB) to trim the federal government's science, technology, engineering, and mathematics (STEM) programs on the grounds that many of them lack evaluation data on efficacy ("An invisible hand behind plan to realign U.S. science education," J. Mervis, *News Focus*, 26 July, p. 338). Although federal funding often supported formative evaluation (assessment in the pilot phase to improve the program itself) during the development of new curricula, it was virtually impossible to secure funding for summative evaluation (assessment of effectiveness after implementation) because of the costs and time frames involved. At the Biological Sciences Curriculum Study (1), where the value of summative evaluation always has been self-evident, we often lamented that the federal government funded a series of 90-meter dashes, supporting development of new instructional materials but not their evaluation. Funding from the Institute for Education Sciences for efficacy trials (2) that provide one type of summative evaluation constitutes some progress, but it is not enough.

It is perverse for OMB to blame STEM projects for deficiencies that were inherent in the government's funding priorities. Perhaps an evaluation of those priorities is in order.

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References

1. Biological Sciences Curriculum Study (www.bsccs.org).
2. J. K. Spybrook, S. W. Raudenbush, *Educ. Eval. Pol. Anal.* **31**, 298 (2009).

Bayes' Confidence

NEITHER THE PERSPECTIVE "BAYES' THEOREM in the 21st century" (B. Efron, 7 June, p. 1177) nor the responding Letter "A statistically significant future for Bayes' rule" (R. van Hulst, 26 July, p. 343) refer to the mystical flavor often associated with Bayes in their discussions of the theorem's popularity.

Bayes had a propensity to use names that suggest something more than what is directly being described. For example, "Bayes' rule" is just conditional probability applied in a specialized context. The "controversial theorem" is nothing more than a formula for conditional probability.

Perhaps more disconcerting in Bayes is the term "objective prior" for the uninformative priors used by Pierre-Simon Laplace. Such priors, of course, are just imagined; they are not in fact objective themselves, but rather aim to produce objective conclusions. Indeed, many of Laplace's calculations of posterior probability using uninformative priors are numerically equal to frequentist calculations of confidence.

van Hulst mentions that the life sciences need a "synthesis of multiple categories of evidence." Certainly Bayes provides a simple and accessible means of combining different data results: Just multiply the likelihoods together. But this option is also available to the frequentist: Just combine the likelihoods and ignore what's left. The typical frequentist, however, realizes that this method would lose information and is unwilling to make this tradeoff for simplicity. Thus, he would choose an exact confidence interval when available.

Treating Bayes as a route to approximate confidence could go a long way toward resolving the presence of two theories in statistical inference.

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Research Funders Should Take the Field

WE SUPPORT EFFORTS TOWARD "LEVELING the playing field" (M. McNutt, Editorial, 26 July, p. 317) in science, technology, engineering, and mathematics (STEM) disciplines through organizations such as the Committee on Women in Science, Engineering, and Medicine (CWSEM). Targeting interventions at early career researchers is vital.

The Wellcome Trust's Basic Scientist Career Tracker (1) demonstrates the disproportionate number of women exiting academia early in their careers. Although an academic research career brings rewards, it remains a risky long-term career choice (2), and as McNutt describes, childbearing years typically coincide with the time when a faculty member needs to build a strong portfolio and gain tenure, thereby securing a less risky future.

Academia needs to attract and retain high-quality, highly trained researchers; research funders such as the Wellcome Trust can play an important role by following these steps: (i) Funders need to ensure that career awareness and mentorship are inte-

gral components of their training provision. (ii) Funders must ensure that their eligibility and/or funding guidelines do not discriminate against certain researchers (for example, a bias in funding decisions toward grant applications that include a move between institutions may inadvertently discriminate against those with established local ties). (iii) Funders need to promote and develop opportunities for researchers to use their funding flexibly, including options for career breaks, reentry fellowships, opportunities to work in posts other than as a principal investigator, and part-time schedules. (iv) We need to expand the opportunities for female role models working across academia to tell their story; this should be a core component of training programs.

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Reference

1. Wellcome Trust, "Wellcome Trust Basic Science Career Tracker: Results of Wave 4 (2012)" (2013); www.wellcome.ac.uk/Funding/Biomedical-science/Career-tracker/Basic-tracker/index.htm
2. Ipsos MORI, "Risks and rewards: How PhD students choose their careers" (Ipsos MORI, London, 2013).

CORRECTIONS AND CLARIFICATIONS

This Week in Science: "Pushy black hole" (6 September, p. 1041). The last line should be "possibly limiting star formation and galaxy growth" instead of "possibly contributing to star formation and galaxy growth." The HTML and PDF versions online have been corrected.

Reports: "Pandoraviruses: Amoeba viruses with genomes up to 2.5 Mb reaching that of parasitic eukaryotes" by N. Philippe *et al.* (19 July, p. 281). In the first sentence of the legend to Fig. 1, the "(1)" and "(2)" should not have been italicized, as they refer to panels A1/A2 and B1/B2 and not to references 1 and 2. In the legend to Fig. 1E, the "a" and "b" labels should have been transposed. In addition, a reference to panels B1 and B2 is now included. In the acknowledgments, the GenBank accession numbers were incorrectly listed. They should read KC977571 and KC977570 (not KC977471 and KC977470). Also, the financial support of the Provence-Côte-d'Azur Région was missing. The HTML and PDF versions online have been corrected.

Letters to the Editor

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