POLICY FORUM: PUBLIC HEALTH

Decision-Making When Science Is Ambiguous

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When mad cow disease (bovine spongiform encephalopathy, BSE) first made headline news in 1987, little was known about its implications for human or animal health. Nearly 15 years later, U.S. restrictions on European blood imports and an independent report on the UK's handling of the crisis confirm the profound scientific ignorance that existed. What, if anything, have we learned about decision-making when uncertainty is pervasive?

One simple, general message is that decision-making without scientific evidence, or well-defined probabilities, is far from unusual. No one knew whether BSE would transmit to humans. Now we know humans are susceptible, but we still don't know how many human fatalities to expect. Such uncertainties extend to other hazards; environmental dilemmas and terrorist attacks exemplify risks about which our knowledge is incomplete. How should policy-makers, scientists, and the public think about such decision problems?

Examination of reactions to BSE (*1*) suggests that an obvious approach is the framework of hypothesis testing. However, hypothesis testing is not always appropriate where decisions need to be made before relevant data can be generated. Another approach requires that we establish probabilities for the different states, use these to calculate expected outcomes, and then pick the act that maximizes the expected outcome. Where there are no objective probabilities, we should use subjective ones (*2*). Unfortunately, there are two important and ultimately fatal reasons why subjective probabilities do not help in this kind of problem. First, it turns out that people are sensitive to ambiguity in a way that can be shown to be mathematically incompatible with subjective probability (*3*, *4*). Second, policy is a matter of social choice in which different individuals have quite different beliefs. Often, because of the negotiated nature of policy-making, stakeholders have incentives to exaggerate those differences, with the result that any attempt to specify a particular set of probabilities is almost certain to be contested.

A more relevant decision-making framework, known as decision-making under ambiguity, allows actions to be mapped onto an act-state matrix, without probabilities. Within this framework, we can use a variety of decision rules. Here are three of the most common (*5*), using the example of BSE: "Maximin" suggests picking that course of action that has the best of the worst outcomes and is regarded as very pessimistic. This would, for the figures shown in the table above, be represented by the restriction of food processing. At the other extreme, "maximax" picks out the action that has the highest, best possible payoff—illustrated by maintaining the status quo, or "doing nothing" in the table. Last, an intermediate rule, based on Laplace's Principle of Insufficient Reason, assigns equal likelihood to each state and calculates an expected outcome for each action on that basis. In this case, the recommendation is to ban the sale of beef. When scientific knowledge about probabilities is absent, thinking about possible outcomes takes on particular significance.

ACT-STATE MATRIX

	Actions		
States	**Ban sale of beef**	**Restrict food processing**	**Do nothing**
High risk	0.9	0.3	0
Low risk	0.6	0.7	0.4
Safe	0	0.3	1.0
Maximum	0.9	0.7	1.0
Minimum	0	0.3	0

Act-state matrix with illustrative outcomes; 1 is the best outcome, 0 is the worst.

This kind of analysis has been the subject of research by decision theorists for many years, and one conclusion on which there is agreement is that all these rules are potentially reasonable, depending on individual preference. And it may even be that the set of options itself suggests a rule: if the worst outcome is indeed very dire, then perhaps many people would choose the more "cautious" minimax. However, if the outcomes are all positive, the relatively more optimistic choices might seem preferable.

There is no single, correct response or decision rule that can be followed. Social norms, laws, and policies may lead some people to be more "precautionary" than others. Furthermore, when an issue becomes the subject of intense media scrutiny, accepted procedures are themselves examined, and they cannot act as resources for conflict resolution. This may be a reason for identifying a small number of different possible outcomes and concentrating on understanding what might happen in these situations.

It is certainly clear that public-sector bodies should not only consider different scenarios but also reflect this in the way they communicate with the public. For BSE, it was left to people outside the government to articulate alternative scenarios. Those academics who did so were not always beneficiaries of the government's gratitude.

A key conundrum for many risk regulatory systems remains the role of the politician and how he or she should relate to experts and the public. A risk communication strategy seems increasingly vital for government bodies. Politicians have realized that scientists themselves are dealing with uncertain situations and cannot be counted on to help them achieve consensus. So there is a profession of interest in public deliberation and transparency among agencies. But will more openness and transparency reduce the scope for conflict?

In practice, there is no reason to expect that they will. Rather, the fact that more stakeholders with legitimate, but different, world views will be sitting around the table means we have to look at ways in which opposed interests are reconciled. In conditions of uncertainty, the emphasis shifts, perhaps surprisingly, to preferences. Preferences may be amenable to formal analysis, but when events become politicized, the issues that are considered relevant expand quickly.

Historically, public deliberation has offered an alternative to formal decision analysis, but both are essential. Crudely put, deliberation identifies who should be consulted, whereas decision analysis indicates what it is they should be consulted about. If decisions have to be made under conditions of substantial uncertainty, then decision analysis indicates that people should be consulted about their values.

When uncertainty is extensive, what really matters are the consequences of different actions. One of the key institutional challenges lies in the fact that expertise about consequences is often held within the commercial organizations most affected by its use in policy. Nonetheless, if we can treat consequences with the same rigor we hope for in the analysis of causes and probabilities, we shall have the ingredients for a more comprehensive view of decision-making.

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