This paper offers a perspective on integrating advice from epidemiologists and economists to inform policy on disease control. The fields of epidemiology, economics and social research have become increasingly integrated over the years, though this process is still in transition. Recent examples of this transition are presented below, including the UK experience with infected koi carp, foot-and-mouth disease and rabies control. There is clearly great value in integrating these three fields, though significant challenges remain. Important information must be conveyed in a clear and concise way to policy makers, and risk must be communicated more clearly, without relying too heavily upon central estimates. Ultimately, policy makers must consider a wide range of evidence and factors when making disease control decisions, and must weigh them accordingly.

* This paper has been edited by Amar Toor based on a transcript of the audio recording of the Workshop.
In this paper, we provide a perspective on integrating advice to inform policy on disease control. The proposition put forward is that we are in a state of transition. We are progressively getting better at integrating epidemiology, economics and social research into a multidisciplinary approach to inform policy formulation, though several challenges remain. Below, we cite examples of this transition and describe the challenges in conveying information to policy makers.

We conclude there is a real value in bringing together the disciplines of epidemiology, economics and social science, because they consider different areas of relevant evidence and can enrich the analysis that informs policy decisions. There are often, however, high levels of uncertainty in these areas, and one must therefore take care to avoid false precision. Integrating these disciplines to produce an analysis is not a decision, in itself; analysis can only inform the policy maker’s consideration of available options.

**Transition in the use of integrated advice to support disease control decisions**

There was a time when economic analysis barely played a role in disease control policy making (Figure 1). Instead, policy makers relied heavily on expert veterinary advice, while assuming, rather than quantifying, expected benefits. That began to change, for example with global rinderpest control policies, which were formulated based on cost-benefit analysis and resulted in tremendous success.

More recently, diseases such as brucellosis, rabies and bovine tuberculosis have posed major public health threats. Some of these diseases have since been eradicated, while others continue to pose risks. In each case, policy makers were faced with important questions of whether they could implement a policy that would control the disease, and whether they could afford to deliver it. Costs were weighed against benefits, and in these cases, the outcomes were clearly worth the expenditures.

Enzootic bovine leucosis has been eradicated in the United Kingdom and most of the European Union, though this case was rather unique in nature; it posed no public health risk and impacts only on adult cattle production. Today, in fact, there is an on-going debate in the OIE over whether enzootic bovine leucosis should even remain reportable. Yet as with the diseases mentioned above, the fundamental cost-benefit questions remained the same: Does a proposed policy pass cost-benefit tests, including whether it will result in disease-free status, thus ensuring long term benefits at reduced costs?
Infected koi carp and the separate application of economics

Recently, UK policy makers were faced with the question of whether to eradicate a herpes virus that had infected koi carp. As with any decision, there were winners and losers. Anglers, of course, did not want the carp to be diseased, because their enjoyment of their sport depended in part on the health of free-living carp. But if disease control measures had been implemented, they would have had a severe impact on the thriving ornamental fish industry, including on imports of koi carp. Once the data was analysed, it was clear that the costs of pursuing disease control were very large (GBP 220 million over two years, according to estimates), while the benefits for stakeholders were comparatively small (estimated at less than GBP 50 million). As a result, policy makers decided against eradication, choosing instead to declare an “infected status” for the United Kingdom and maintaining control measures short of eradication.

The associated costs and benefits of this decision fell on different parties, underscoring the difficult decisions that policy makers often have to make. No single decision was going to please everyone, and there were serious social issues to consider, as well. Ultimately, though, the analysis helped support the decision, and allowed various stakeholders to understand how it came about.

Integrated epidemiology and economics: FMD vaccination analysis

In the case of foot-and-mouth disease (FMD), UK policy makers were planning for the decision of whether or not to implement a vaccination program in the event of an outbreak of the disease. Here, economic (cost-benefit) analysis was integrated with epidemiology and veterinary science. Broadly, policymakers considered the FMD outbreaks most likely to arise, the scenarios that might play out under a vaccination program, and where the associated costs and benefits would fall. Key drivers were identified, as were scenarios under which vaccination would have a net benefit. Economics and epidemiology were used to project costs of different control strategies, and to evaluate the potential trade-off between costs of vaccination and the estimated reduction in the number of culled animals (Figure 2).

When this analysis is done in an integrated way — with epidemiologists, veterinarians, and economists iterating the process to produce useful outcomes — one finds that the costs fall differentially, with overall benefits flowing indirectly to government through maintenance of a competitive livestock industry that contributes to national finances. One also finds that the chances of an overall benefit depend on the size of the outbreak. There are small outbreaks where costs of vaccination exceed benefits, but in a larger outbreak, the benefits are greater. However, this remains a very complex analysis, and it does not provide an answer as to whether or not a government should vaccinate. This becomes especially evident when one considers the levels of uncertainty involved with predicting how big an outbreak will be. In short, this is an aid to decision making, albeit one with significant uncertainty.
CHALLENGES FACED WHEN INTEGRATING ADVICE FROM EPIDEMIOLOGISTS AND ECONOMISTS TO INFORM POLICY MAKERS

Figure 2. Effects of vaccination on projected average costs of the outbreak

Impact of social factors

The final example concerns the United Kingdom’s decision on controlling the risk of rabies. The United Kingdom has been free of rabies for a long time, and has maintained that freedom through severe import controls. The public was made aware of the risks that rabies posed, and a very strict quarantine regime was put into place. Policy makers spent the past decade debating this disease and the enormous risks it posed. The European Union, meanwhile, had been successfully controlling rabies in parallel, reducing risks to very low levels through vaccination. This dramatically lowered risks for the United Kingdom (incursions were estimated at one every 220 years), while costs for control programs remained high. Analysis showed that the benefits of removing import control measures dramatically outweighed the estimated extra costs of a potential incursion (Figure 3).

Figure 3. Rabies: Costs and benefits of the United Kingdom adopting the EU regime

- **Scenario 1:** Single infected animal
  - Probability: 90%
  - Weighed average extra cost: GBP 2.2 M
  - Extra benefit: GBP 7.2 m/yr

- **Scenario 2:** Spread in domestic animals
  - Probability: 9%

- **Scenario 3:** Spread to wildlife
  - Probability: 1%
  - Mean cost of outbreak: X
  - Increase in risk under new policy + one incursion every 220 years: 1/220
  - Expected extra cost/year: GBP 0.01 m/yr
Given this discrepancy between costs and benefits, one would assume that the United Kingdom would immediately adopt the EU regime. But this decision was complicated by several important social factors — namely, whether a change in policy would be politically and socially deliverable. This is where understanding of the social context comes into play. The decision on rabies control was as much about the social acceptability of a change in policy as it was about cost-benefit and practical deliverability. Changes were ultimately put into place, though only after significant consultation and dialogue on how to best deliver the message to politicians and the public. If these changes had been implemented prematurely, they would have likely been overturned.

**Challenges for policy makers**

Policy makers face several challenges when integrating various disciplines into the decision making process. When analysing low-likelihood, high-impact events, the confidence levels associated with given estimates can be very large — especially for diseases that have not occurred in decades. These estimates are then used in economic analysis, which itself has levels of intrinsic uncertainty. As a result, projected outcomes have very wide confidence intervals, though that does not mean that they are useless. Even with wide confidence intervals, such systematic analysis allows policy makers to understand the factors that must be considered when making decisions. Nevertheless, expressing risk and uncertainty around central estimates remains an area for future improvement.

However, danger arises when economists take the central estimate, run analyses, and come out with a single figure. Much progress has been made in building levels of uncertainty into integrated analyses, though it is important for disease and economic models to provide ranges and likelihoods for their outcomes, in order for policy makers to arrive at informed decisions. This is especially critical in situations where “zero risk” status is impossible or prohibitively costly.

**Conclusions**

In conclusion, decisions on disease control should integrate an entire range of disciplines — especially epidemiology, economics and social research. As a result, building communication and understanding among these disciplines (and with society, at large) is increasingly important. Multi-disciplinary evidence can be very useful in informing decision making, by providing an empirical underpinning and highlighting the bounds within which decisions can be made. Ultimately, however, models, scenarios and estimates can only inform a decision — they cannot tell policy makers what they should do. Policy makers must consider a wide range of evidence and factors when making disease control decisions, and must therefore weigh them accordingly (Figure 4).
Figure 4. Policy makers make use of evidence from a variety of sources