Introducing the Parameter-Outcome Overview Plot: A New Addition to the Sensitivity Analysis Armoury for Economic Models

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Background

Most economic models are probabilistic, as an explicit recognition of our imperfect knowledge about parameters. Modelling typically involves substantial sensitivity analysis to explore decision uncertainty. However, sensitivity analyses themselves are frequently one-way and deterministic. While this approach is easy to implement and helpful for understanding broad associations, it ignores when parameters are correlated and potentially masks important uncertainty.

To counter some of these limitations, we have developed a new approach to supplement existing methods for sensitivity analysis. We present the Parameter-Outcome Overview Plot - analogous to the cost-effectiveness acceptability curve (CEAC) - supporting probabilistic one-way sensitivity analysis and also applicable to threshold analyses. We apply this approach using a case-study of a childhood varicella vaccination programme.

Methods

Instead of varying the willingness-to-pay (WTP) threshold as per a CEAC, a single parameter is varied. Using a moving window with a ±2.5 percentile width, a subsample of simulations can be identified where the parameter of interest has the approximate value of the window mid-point. The simulations within the window are used to characterise the distribution of outcome values associated at that parameter value.

By effectively having a set of simulations for a specific parameter value, uncertainty can be quantified.

For this analysis, the outcome of interest was the probability of being the most cost-effective (at a WTP of €45,000/QALY).

The method was applied to four parameters from an economic evaluation of childhood varicella vaccination assessing four strategies: no vaccination, single dose, a short two dose strategy (at ages 12 and 15 months) and a long two dose strategy (at ages 12 months and 5 years). The model was run for 20,000 simulations. For each simulation, costs and QALYs were recorded for each strategy, along with the parameter values used.

Results

There were no simulations where having no vaccination was the most cost-effective strategy. The probability of the two-dose short interval strategy being the most cost-effective strategy was negatively correlated with the cost of the vaccine (Figure 1) and of administering the vaccine. The switch to a single dose strategy being most cost-effective occurred at the mean value for this parameter. Focusing on just the one-dose and two-dose short interval strategies, while there was a large difference in the probability of being most cost-effective, there was little difference in the net monetary benefit and substantial overlap in the confidence bounds (Figure 2).

Changing the probability of hospitalisation had a limited impact on which strategy was most cost-effective. For the disutility associated with varicella infection, low parameter values were associated with a greater likelihood of a single dose strategy being the most cost-effective (Figure 3).

Figure 1. Probability most cost-effective by vaccine cost

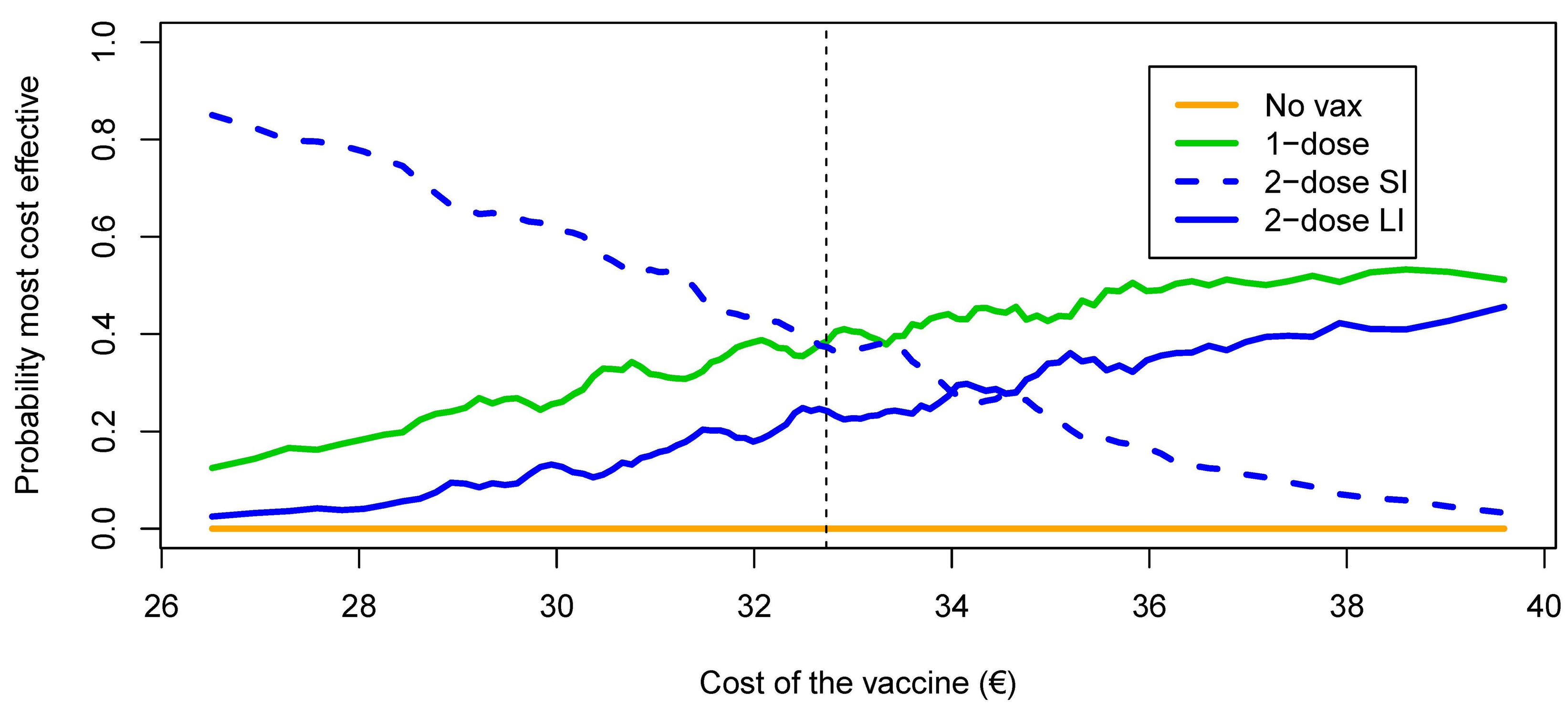


Figure 2. Net monetary benefit by cost of the vaccine

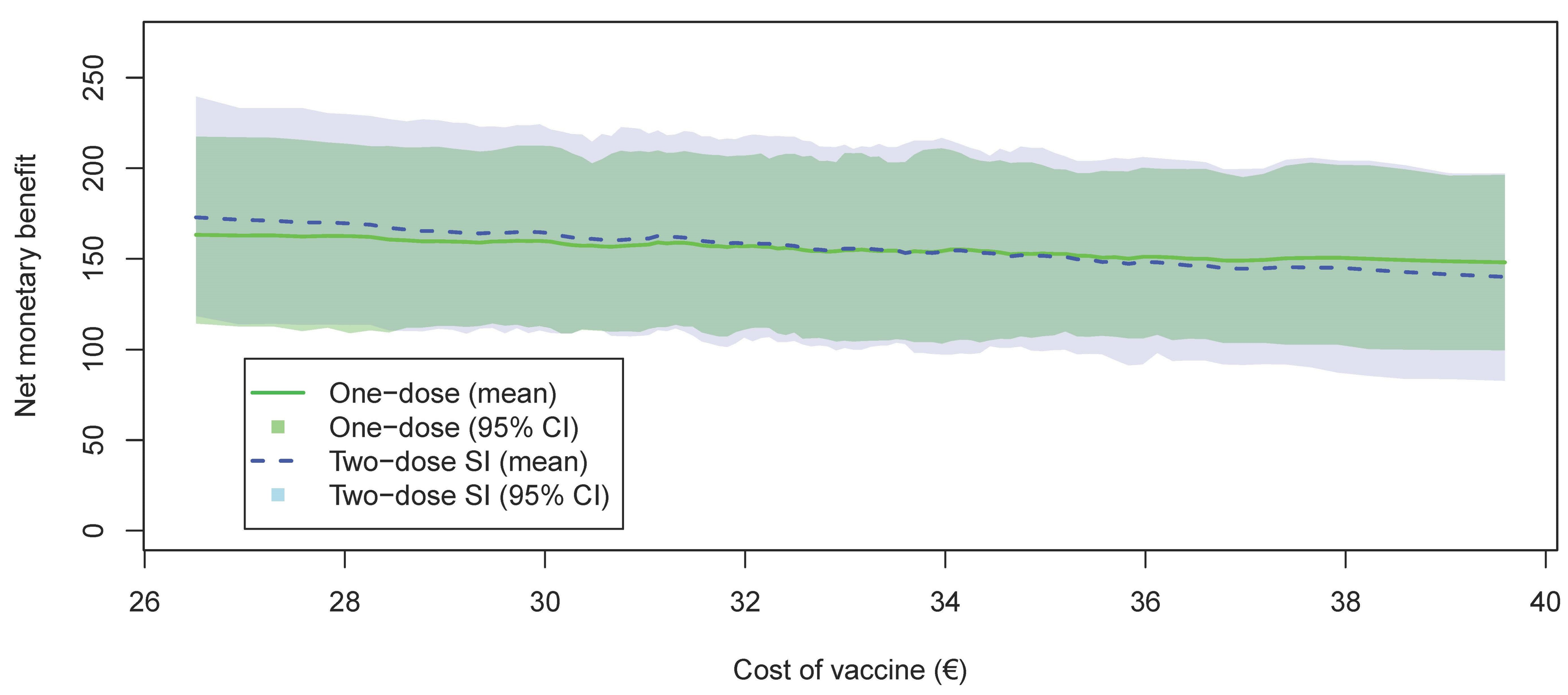
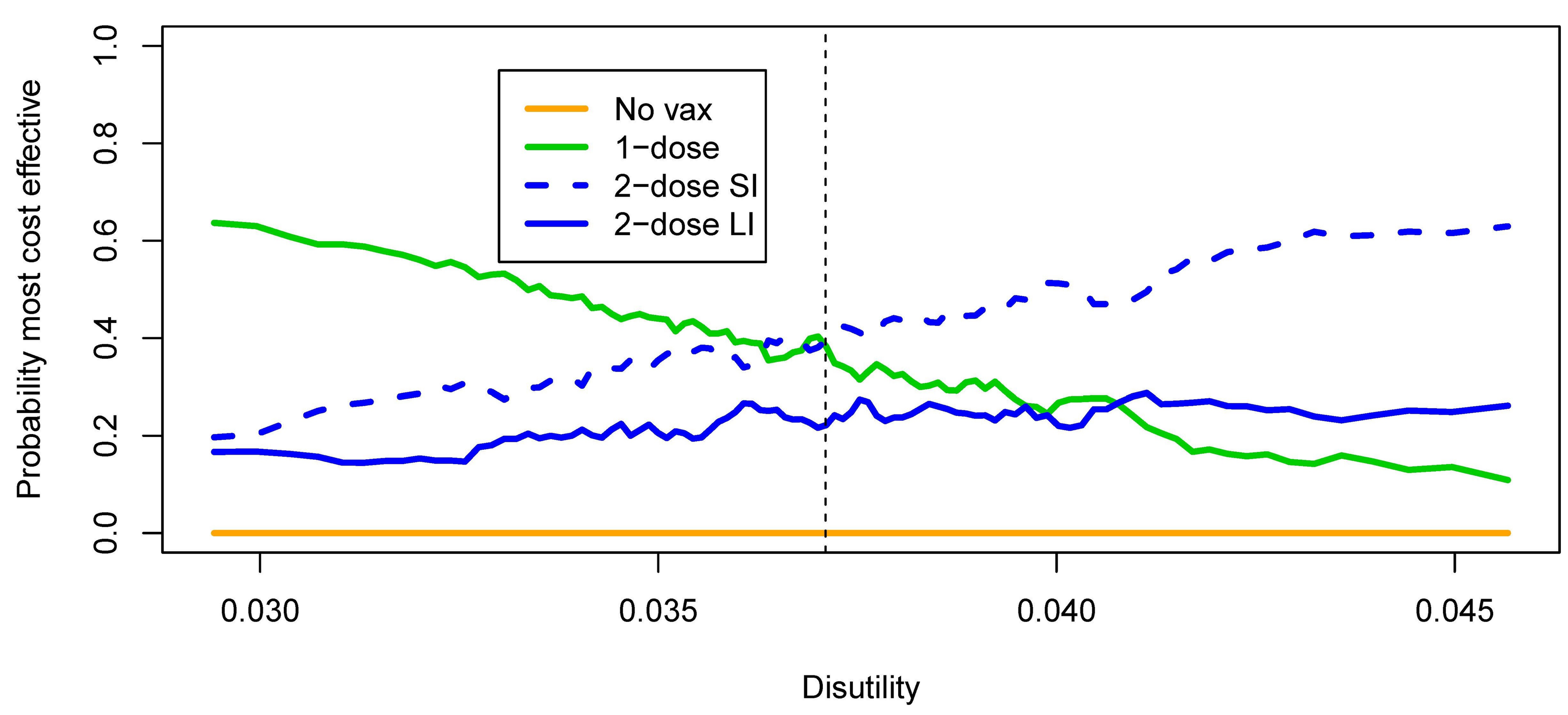


Figure 3. Probability most cost-effective by disutility of Varicella



Discussion

The standard approach to sensitivity analysis often uses deterministic approaches to explore the association between individual parameters and outcomes of interest, such as the incremental cost-effectiveness ratio (ICER) and net monetary benefit (NMB). These are often presented in the form of a tornado plot, that focuses on extreme parameter values and fixes all other parameters at their mean. They also involve looking at a single intervention-comparator combination at a time.

We have presented a new approach that is analogous to the CEAC, with the difference being that a parameter is varied rather than the willingness-to-pay. By using subsamples of the simulation data, it is possible to capture uncertainty in the outcome of interest at any value of a specific parameter. This could be particularly helpful when looking at parameters that the decision maker may have some control over, such as intervention cost.

Strengths and limitations

This method leverages off the outputs that are generated as part of running a probabilistic model, and creates a minimal computational burden. However, for stable estimates it requires sufficient simulations available within the moving window, so it would be recommended to run the model for 15,000 to 20,000 simulations. It can be applied to any model outcome, including ICER, NMB, health outcomes, and resource use.

Conclusions

By using a visual language familiar to decision makers through the use of CEACs, we have developed a simple tool to aid presentation of one-way sensitivity and threshold analyses. Importantly, it has the advantage of expressing uncertainty and considering all interventions simultaneously. As it is estimated from the probabilistic model outputs, the computational burden is minimal.