EE460

Tornado Diagrams Only Tell Us 5% of the Story: Recommendations for More Informative Reporting of One-Way Sensitivity Analysis

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INTRODUCTION

- Deterministic sensitivity analysis (DSA) is commonly employed within health technology appraisals (HTA) to assess the robustness of the model outcome to changes in individual key parameters of the model. Within such an exercise, parameters are varied within a specified range sequentially whilst holding other parameter estimates constant.
- A common output of DSA is a tornado diagram. Classically, the Tornado diagram displays the change in the model results when varying the parameter estimate between a lower and upper extreme value. These extreme values which determine the range should ideally be based on observed uncertainty for the parameter input (e.g. confidence intervals (CI) or standard errors (SE)) rather than arbitrary values.

Objectives:

- By examining recent HTAs which conducted DSA, this study investigates what information the range was based on, and whether the Tornado diagram presented displays the model results solely when utilising extreme parameter values or for other values. This study explores the usefulness of the Tornado diagram produced using classical DSA methods, and whether alternative approaches should be recommended.

METHODS

- The National Institute for Health and Care Excellence (NICE) website was searched to source HTAs in the last three years that mentioned either 'deterministic sensitivity analysis' or 'one-way sensitivity analysis'. For each HTA highlighted via the search methods, two key pieces of information was extracted:

1. The data that had been used to inform the range of parameters selected for DSA.
2. Whether the tornado diagram presented the key output (e.g. incremental cost-effectiveness ratio (ICER) or net health benefit (NHB)) solely for the extreme values in the range, or whether information was provided for the intermediate values in the range.

RESULTS

- 26 HTAs were identified which mentioned at least one of the search terms.
- 2 HTAs were removed from the extraction results due to high levels of redaction which rendered them unusable.

Data used to inform ranges

- 25% of HTAs used only 95%CIs or SEs to inform the upper and lower range estimates.
- 54% of HTAs used e95%CIs, SEs or arbitrary values to inform the upper and lower range estimates.
- 17% of HTAs used only arbitrary values to inform the upper and lower range estimates.

Information presented by the Tornado diagram

- In all usable cases the Tornado diagram presented the key output e.g. ICER or NHB for the extreme values in the range. In no instance was results provided for the intermediate values.

Extra value is hidden when using classical DSA methods

- The results indicate that the classic tornado diagram is the preferred visual aid to represent one-way sensitivity analysis.
- The corollary being that the value of leveraging more advanced techniques is being unrealised, value such as understanding how model outcomes change when utilising parameter estimates that are in the range between extremes.
- Employing such an approach elucidates a more nuanced relationship between a parameter and the model outcome with respect to linearity.
- When utilsing such an approach, the user can conclude at which point along the parameter range that the intervention begins to dominate the comparator.
- A benefit of obtaining such information is that more precise conclusions can be drawn from DSA and superficial ones discarded.

RECOMMENDATIONS

- The classic DSA approach assesses the change in the outcome of interest when utilising parameter estimates that have a 2.5% chance of occurring (i.e. at each end of the range). When these results are presented in a tornado diagram, they take the form presented in Figure 1.
- A recommendation to advance on the classic DSA approach is to use 'stepwise DSA' [1]. A novel DSA technique, to these authors knowledge first developed by Vreman et al. (2021) [1]. Using this, one can assess the variation in the outcome of interest when utilising the extreme estimates and also for a series of uniform intermediate steps as key points along the range. This allows the user to assess the variation in the outcome when using parameter estimates that have different chances of occurring. When presented in a tornado diagram, they usually take the form presented in Figure 2.

Figure 1: Classic DSA Tornado

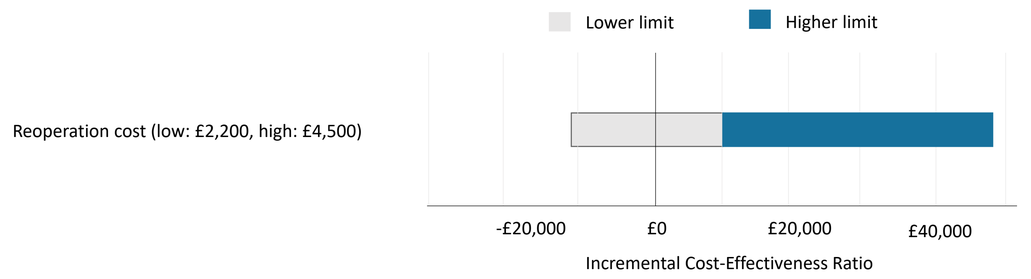
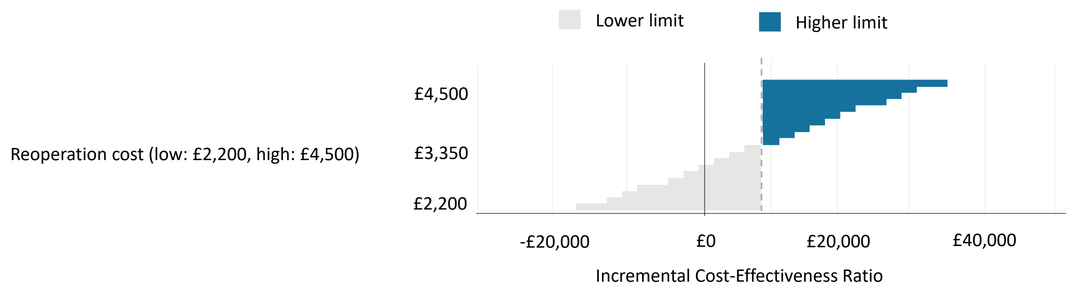


Figure 2: Stepwise DSA Tornado



- Stepwise DSA provides a more granular understanding of how the model outcome changes as the parameter estimate used tends toward the extreme. This allows for the assessment of the linearity of the parameter with respect to the model outcome and the examination of the marginal effects at different steps along the range. [1]
- Producing a tornado diagram using stepwise DSA techniques allows the user to determine at what point along the range the intervention begins to dominate the comparator. [1]
- When a classical DSA approach is taken, the user can only conclude that at the most extreme values the intervention either does or does not dominate the comparator.
- Employing advanced DSA approaches leads to a more nuanced understanding of parameter to model outcome dynamics compared with classical approaches.

CONCLUSIONS

Deterministic sensitivity analysis is a tool to help decision makers understand the degree of uncertainty associated with model inputs, and how that uncertainty affects the model's outcomes. Showing the results only for the extreme values deprives the decision maker of useful information. Instead, tornado diagrams could take a number of alternative approaches to show the impact of different values along the plausible ranges.

REFERENCES

1.Vreman, R.A., Geenen, J.W., Knies, S. et al. The Application and Implications of Novel Deterministic Sensitivity Analysis Methods. PharmacoEconomics. 2021.

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