The Decision Uncertainty Toolkit

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Funding Acknowledgements

- Canadian Network for Modelling Infectious Diseases (CANMOD)
- One Society Network

CANMOD
Canadian Network for Modelling Infectious Diseases
Réseau canadien de modélisation des maladies infectieuses
Strengthening the community of people who are making and using infectious disease models to improve public health both inside and outside of Canada

One Society Network
Interdisciplinary Pandemic Impact Modelling

Models were an important part of decision making during the COVID-19 response internationally

The NEW ENGLAND JOURNAL of MEDICINE

WRONG BUT USEFUL

Wrong but Useful — What Covid-19 Epidemiologic Models Can and Cannot Tell Us

Inga Holmdahl, S.M., and Caroline Buckee, D.Phil.

Successes

Challenges

THE UPSHOT

The New York Times

SUBSCRIBE FOR A$0.50

What 5 Coronavirus Models Say the Next Month Will Look Like

By Quoctrung Bui, Josh Katz, Alicia Parlapiano and Margot Sanger-Katz April 22, 2020

In the last few weeks, we've all become a little more familiar with epidemiological models. These calculations, which make estimates about how many people are likely to get sick, need a hospital bed or die from coronavirus, are guiding public policy — and our expectations about what the future holds.

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Successes and Challenges

- The explicit use models for decision making on such a large scale.
- Huge opportunity for evidence-informed decision making.
- Not all decision makers were prepared to interface with modellers, and vice-versa.
- When there are gaps in the communication of model assumptions and uncertainty, the results of models are difficult to interpret for decision makers.

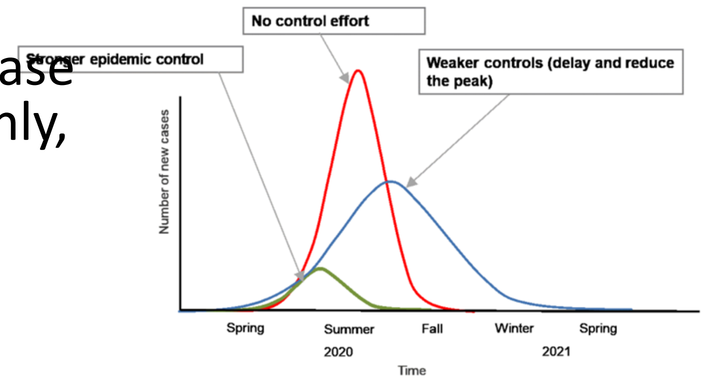
Why are we doing this? The Problem

- Decision makers are typically provided infectious disease (ID) models in many forms, some with mean values only, mean values with some uncertainty bands, and/or scenarios.

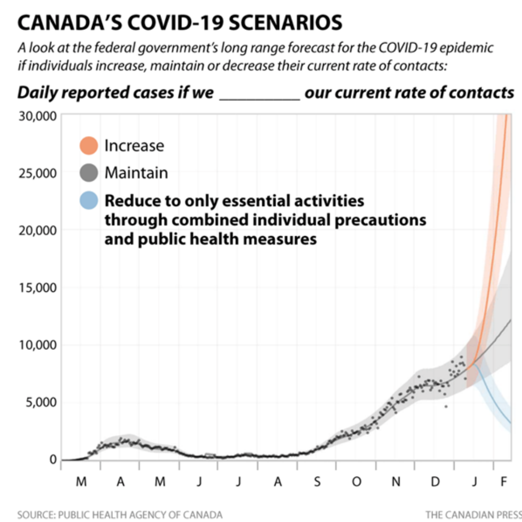
- Means do not provide information about outcome uncertainty and therefore risk.

- Important for skewed distributions such as cases, hospitalizations, or deaths.

- Essentially, decision makers can be unaware of the risk associated with alternative policy options, and/or without tools to consider this risk.



https://www.canada.ca/en/public-health/services/publications/diseases-conditions/covid-19-using-data-modelling-inform-public-health-action-april-28-2020.html



https://www.cbc.ca/news/politics/phac-modelling-covid19-1.5874530

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Some Types of Modeling Uncertainty

- Structural assumptions i.e., SIR or SEIR , how many vaccine compartments? - model selection methods (Portet, 2020)
- Parameter assumptions: i.e., one-way sensitivity, probabilistic sensitivity analysis or PSA, partial rank correlation coefficient (PRCC) methods etc. of known, unknown, and/or estimated parameters
- Decision uncertainty: e.g., scenarios, what should we do? Risk tolerance i.e., scenario A is under a threshold, but 95% UCL is very high versus scenario B is over the threshold, but 95% UCL is not as high?

What are we doing? The Aim

- Adapt and build from health economics methods to characterize, visualize, and communicate decision risk, for infectious disease models.

- Develop the 'Decision Uncertainty Toolkit' in partnership with decision makers and ID modellers
  - Visualization tools
  - New measures of risk
  - R bookdown document with standard description text and codes (living repository)

The Decision Uncertainty Toolkit

Visualizations, Risk Measures, & Descriptions

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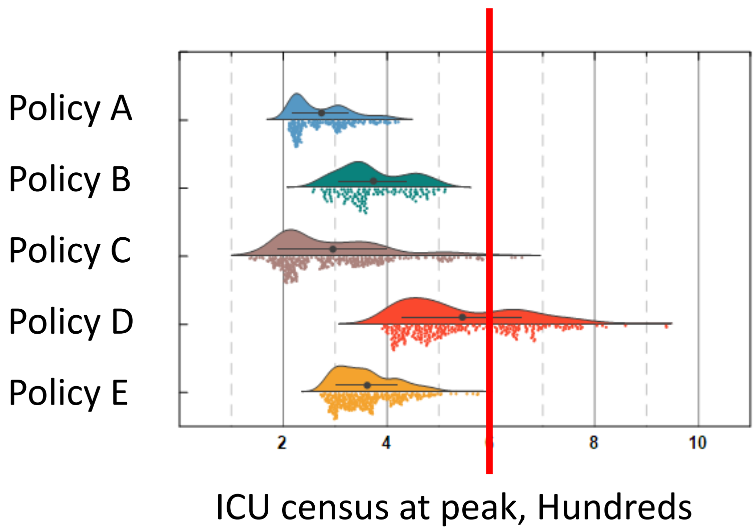
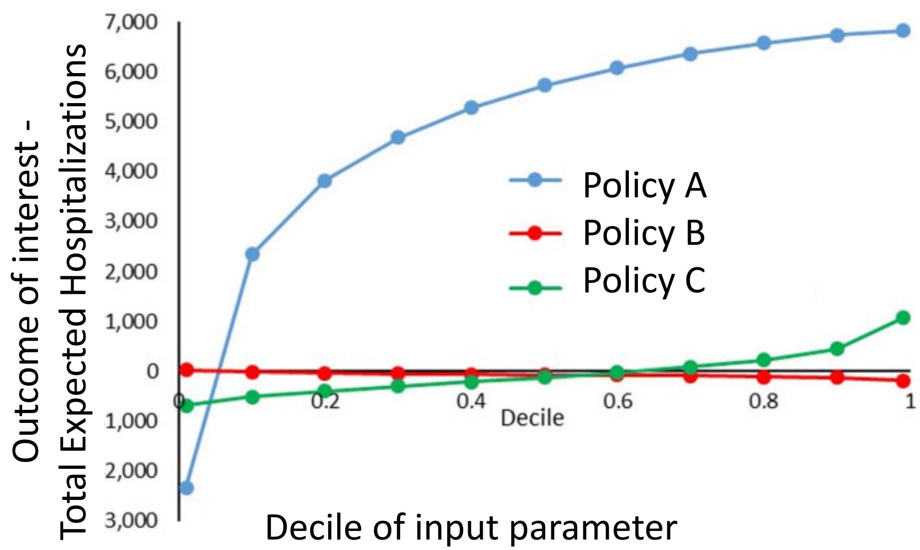
Part 1: Visualizations I

Raincloud Plots



Probabilistic one-way sensitivity



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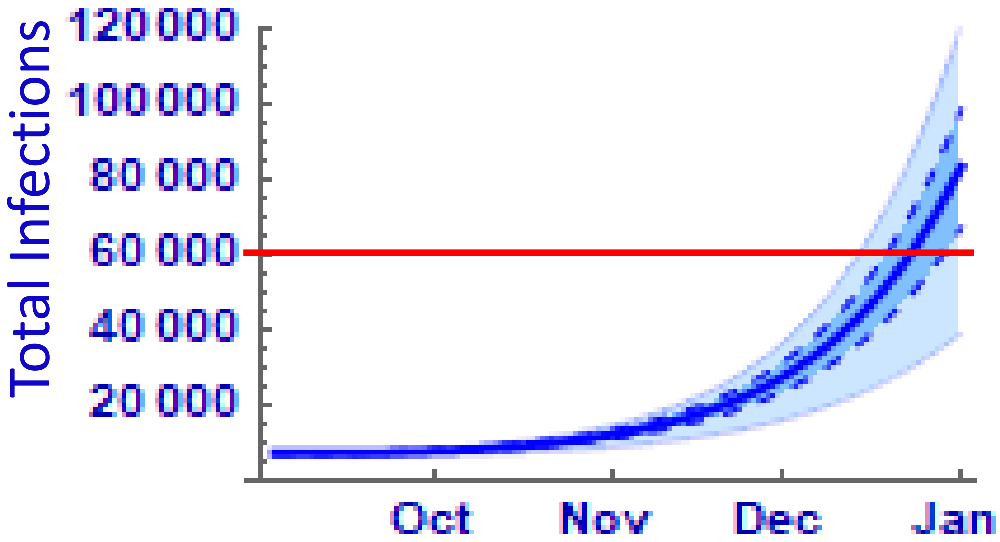
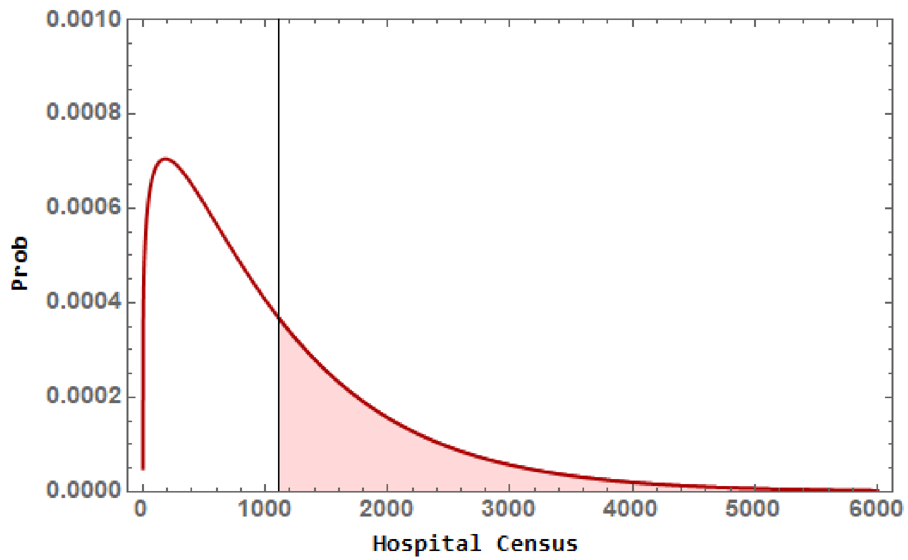
https://link.springer.com/article/10.1007/s40273-019-00869-3
https://www.originlab.com/www/products/GraphGallery.aspx?GID=599

Part 1: Visualizations II

Fan Plots



Risk Shading

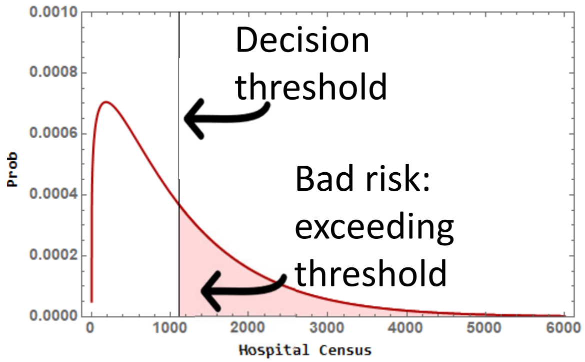


Part 2: Risk Measures I

- Work with decision makers to define policy thresholds that can be used to measure risk **across scenarios**

- Evaluate uncertainty in outcomes relative to these thresholds
  - Quantitative risk measures
  - Relative comparisons across scenario alternatives
  - Cumulative threshold (risk over time)

Part 2: Risk Measures II



Quantitative risk measure

$$Expected\ Risk = \left[\sum_{n=1}^{N} (\max(D,O) - D)\right] / N$$

D = decision threshold, O = observed outcome, N= #simulations

- Interpretation of risk value is easier with a relative comparator (ex. what does a value of 370 mean?)
  - Define a 'baseline' comparator and calculate relative values
  - Ex. baseline risk is 500, scenario risk is 370
  - (370-500)/500 = -0.26, **so risk is reduced by 26%**

- What about over time? Bad outcomes can persist
  - Sum the risk measure over fixed time period
  - Dynamic threshold value or weights

Part 3: Descriptions

Descriptions of toolkit elements

- Standard descriptions and examples for each toolkit element

- Aim is to use common or example language that has been supported by decision makers through engagement

Descriptions of approaches to uncertainty

- ID modellers use methods to communicate uncertainty e.g. 95% CI bands.

- Aim is to describe different approaches to communicating uncertainty that is supported by modelers through engagement

Example Decision Scenario

Example: Decision Scenario

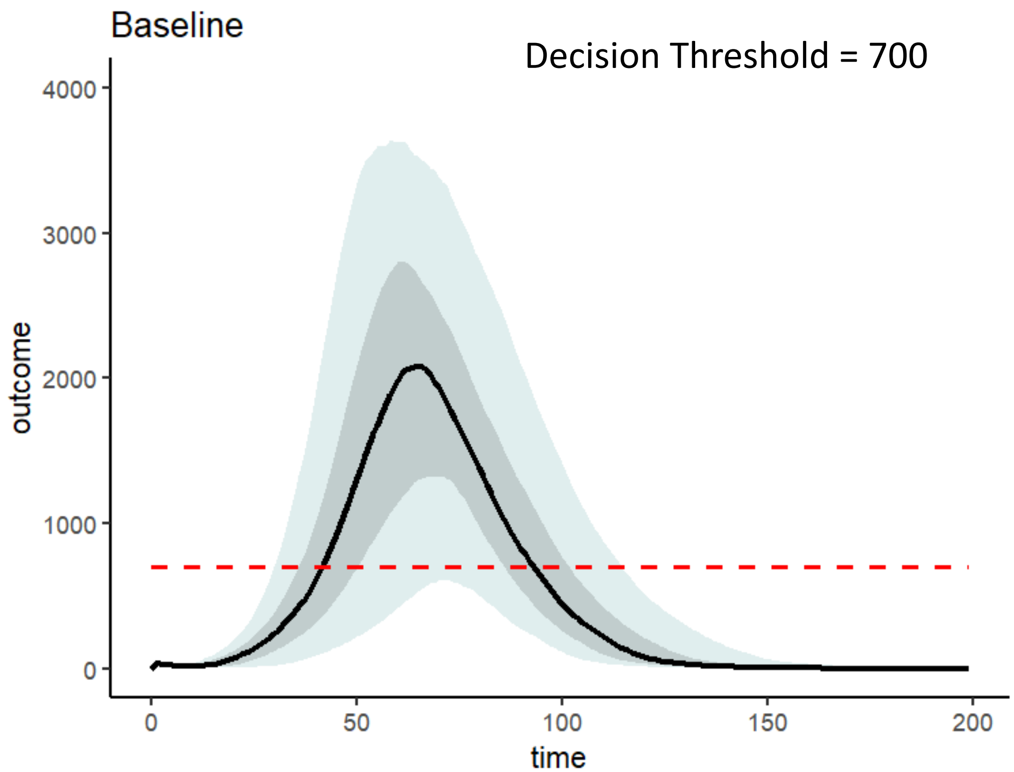
Decision maker is selecting between multiple policies:

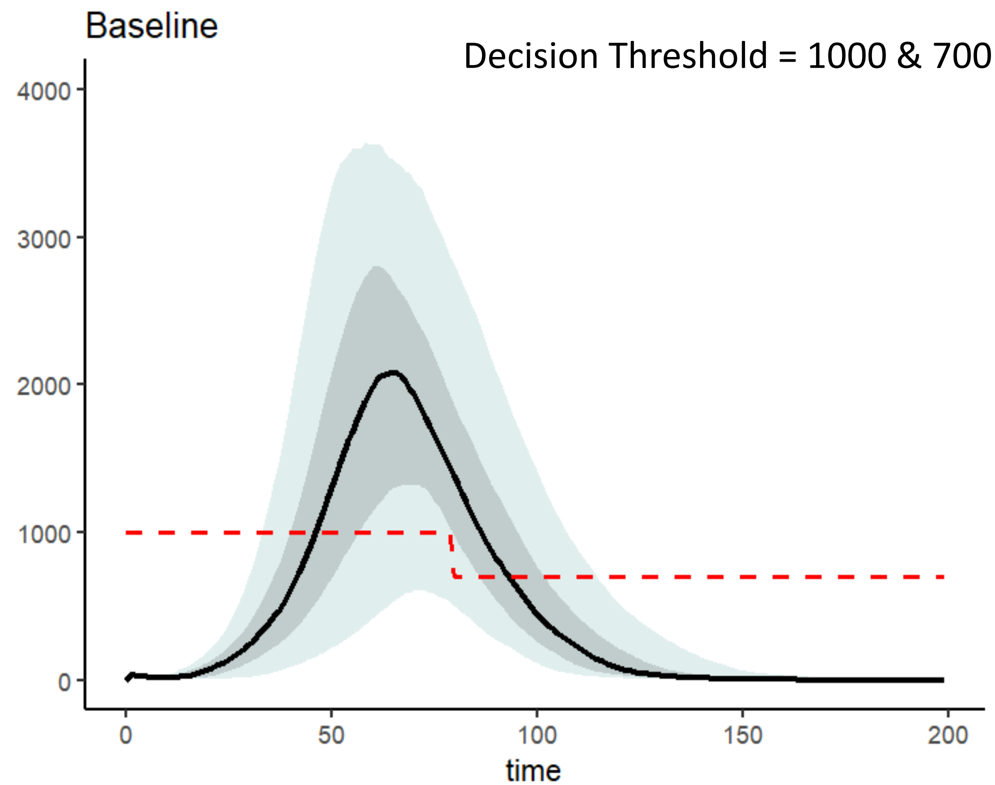
A. Baseline – do nothing
B. Intervention 1 – e.g., close schools
C. Intervention 2 – e.g., mandatory masking
D. Intervention 3 – e.g., close schools + mandatory masking

Policy target: keep hospitalizations under 700 (capacity maximum)

Note: All these graphs are synthetic simulations and used for illustration purposes only

Decision Uncertainty Toolkit Example Plots





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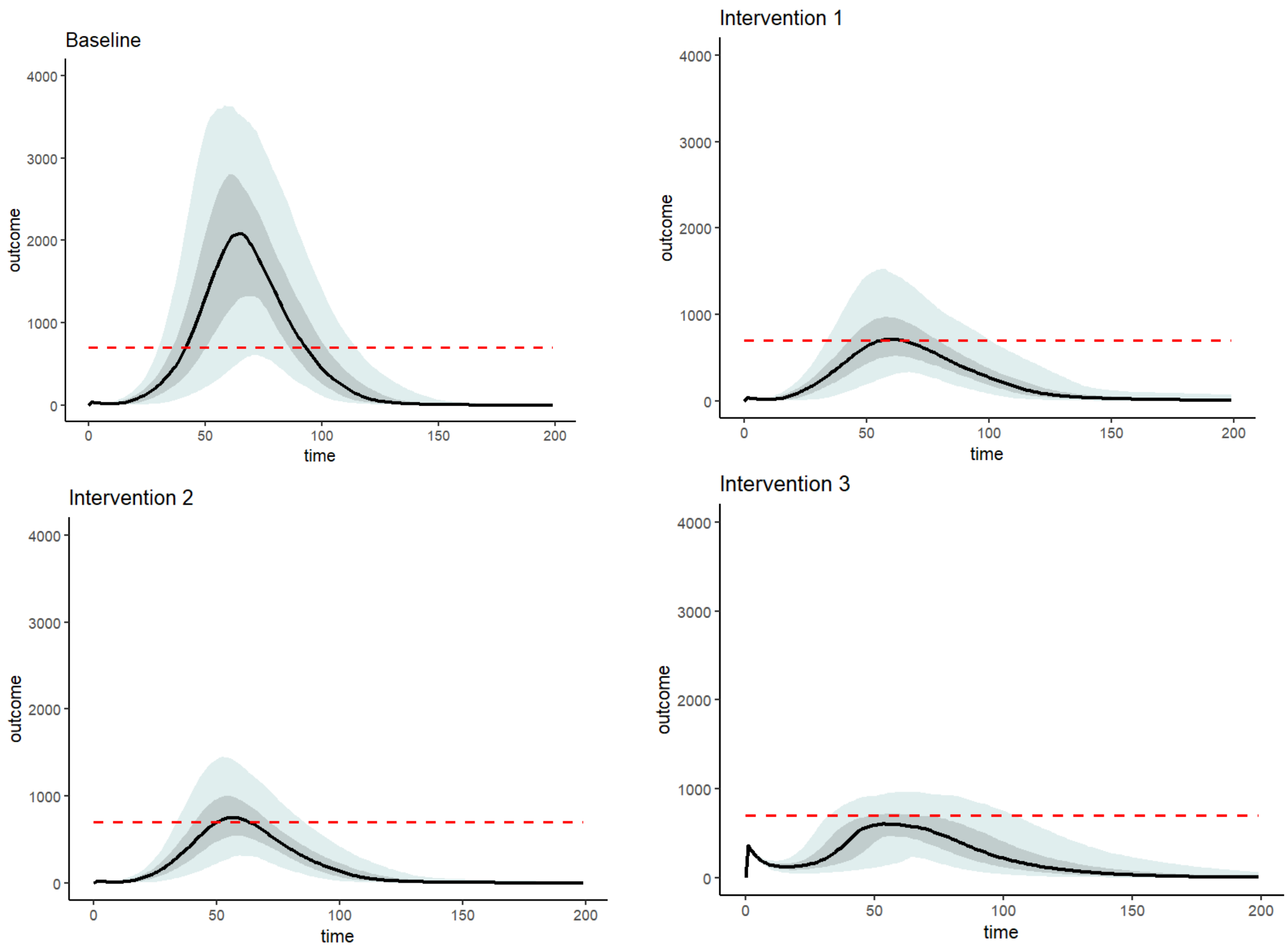
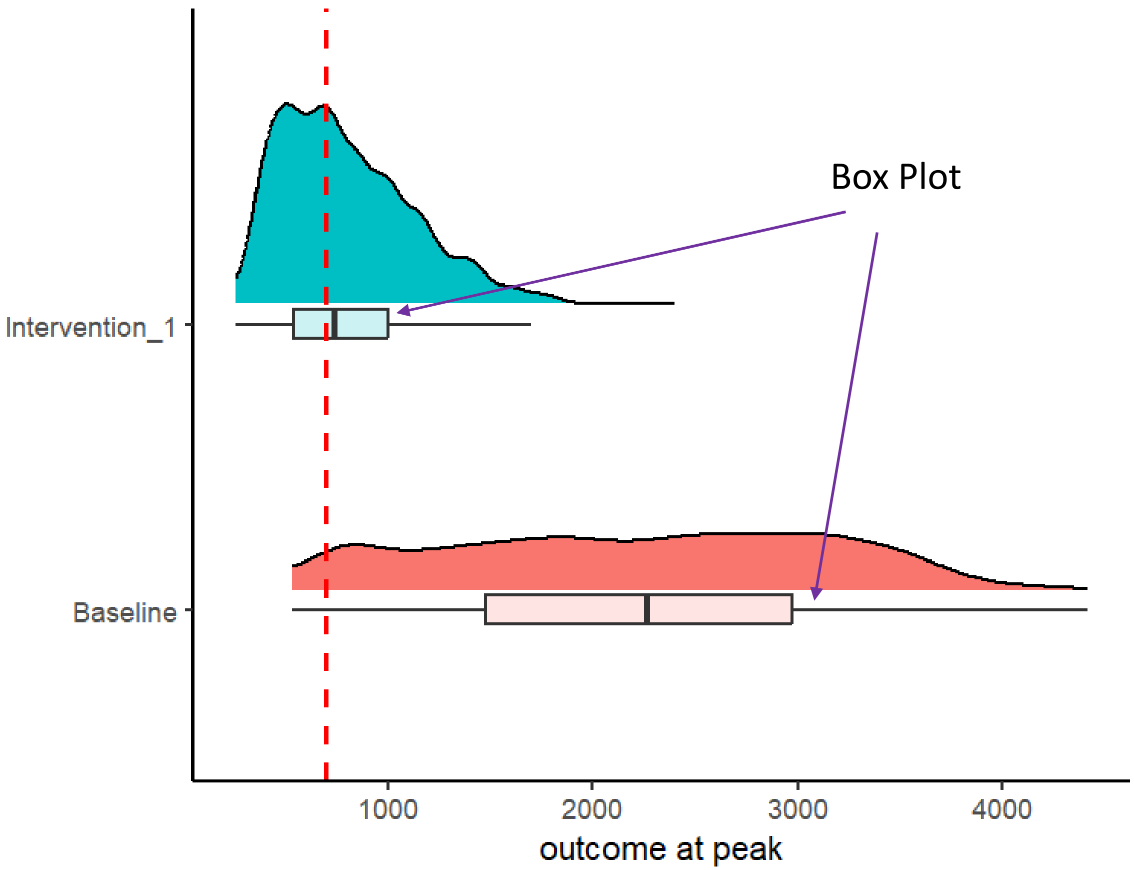
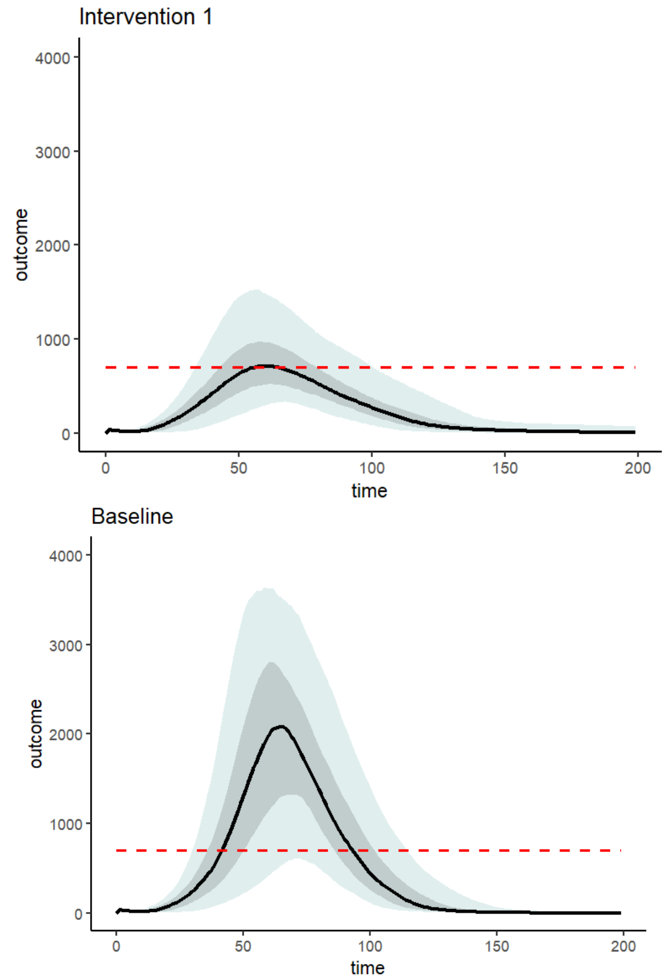
Decision Uncertainty Toolkit Example Plots

Decision Threshold = 700



Decision Uncertainty Toolkit Example Plots





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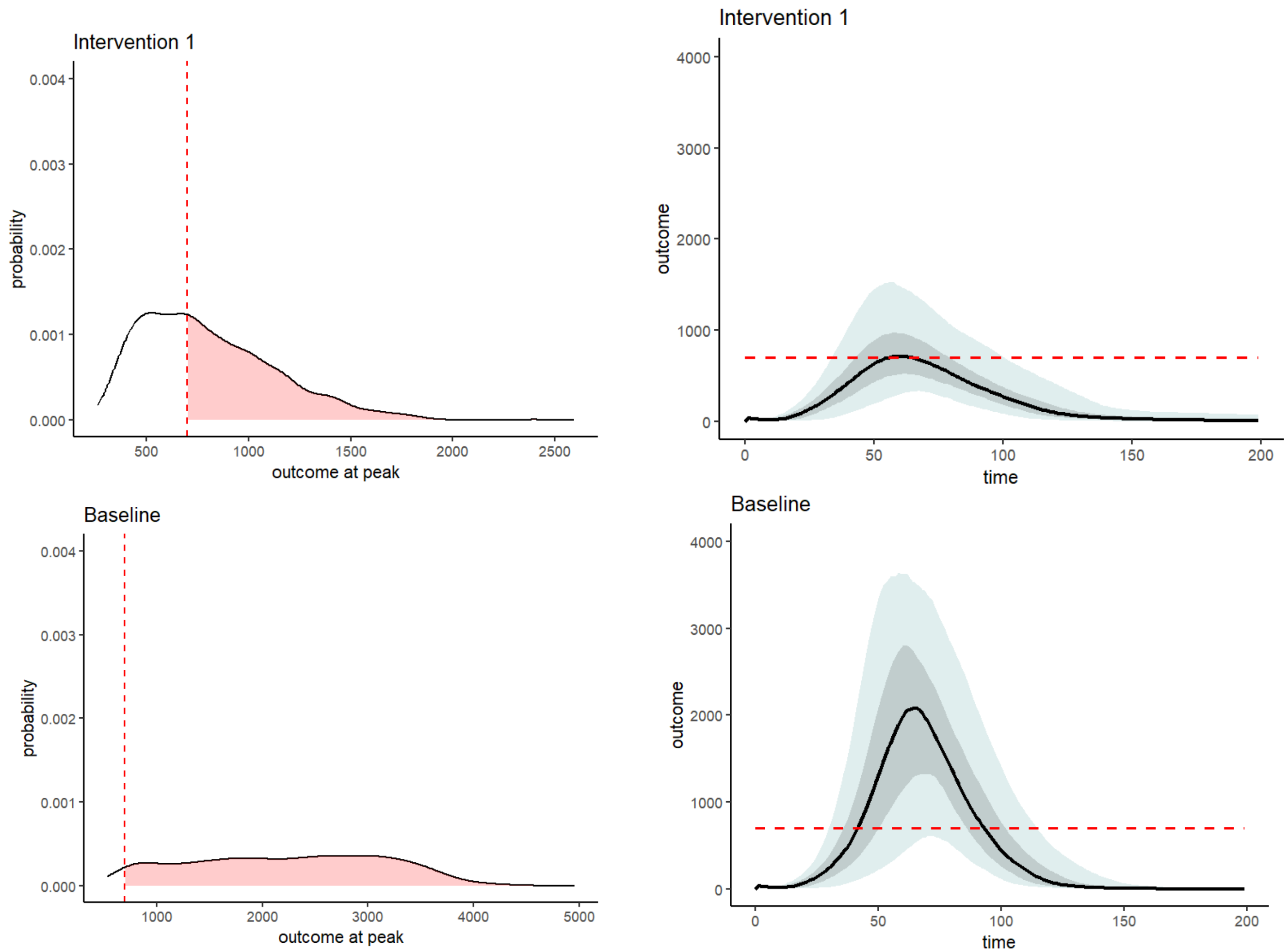
Decision Uncertainty Toolkit Example Plots



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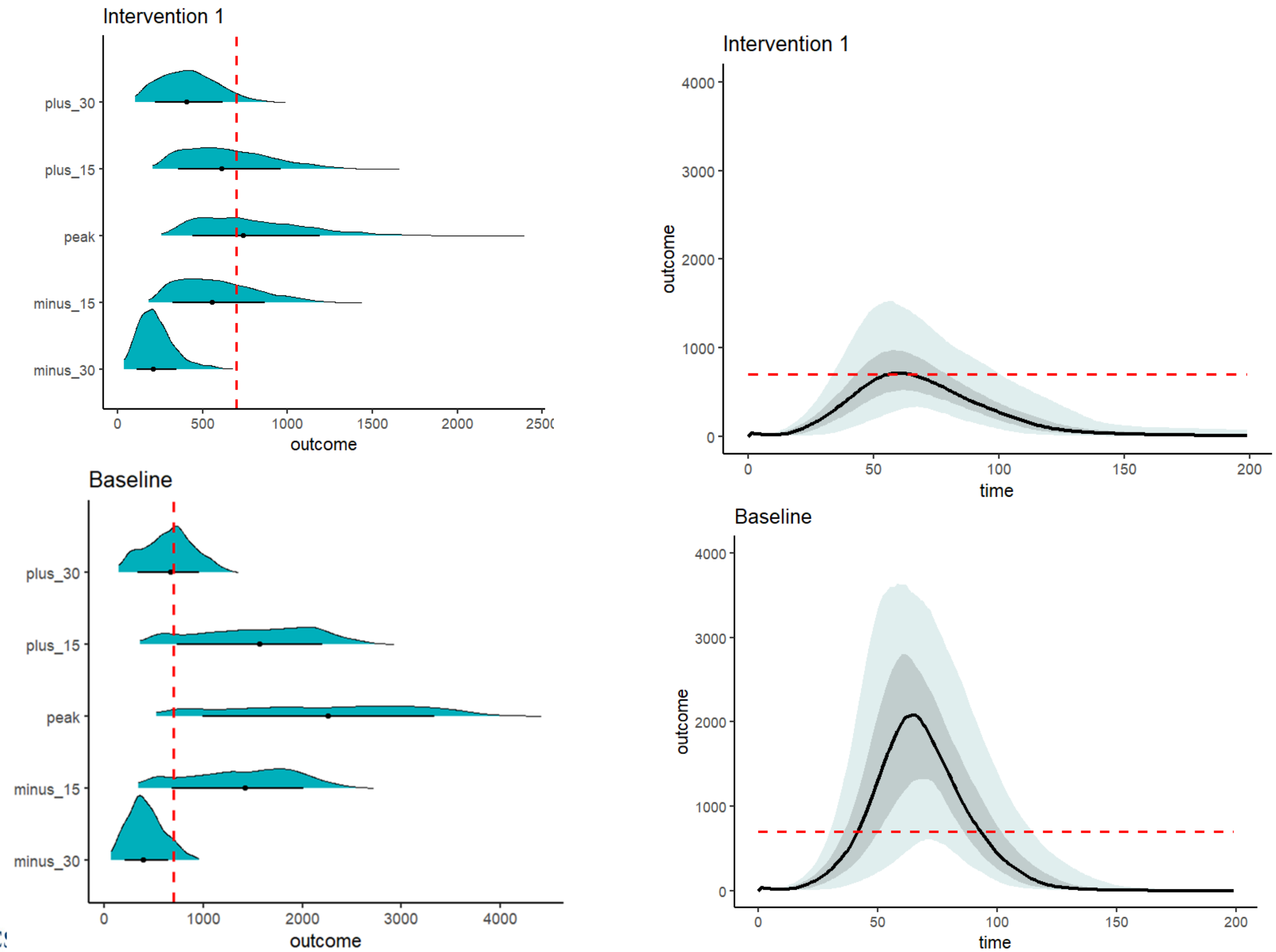

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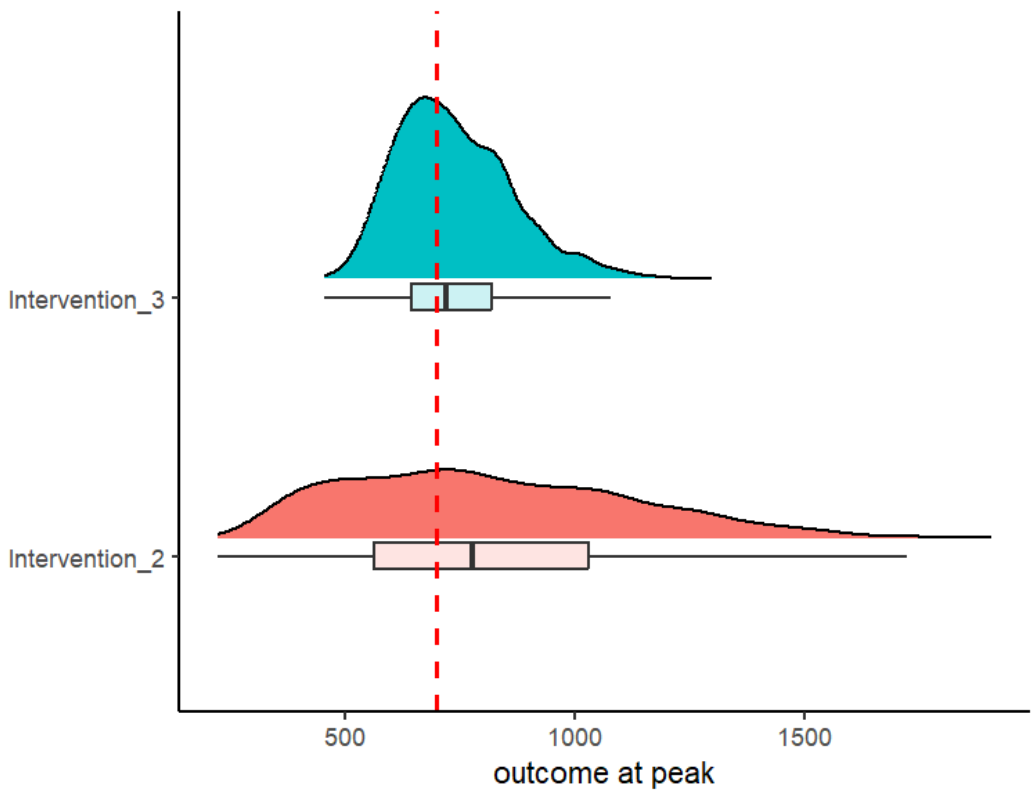
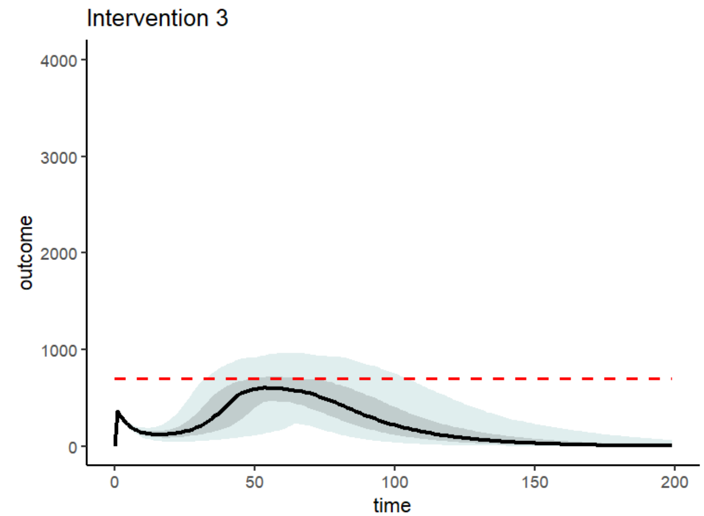
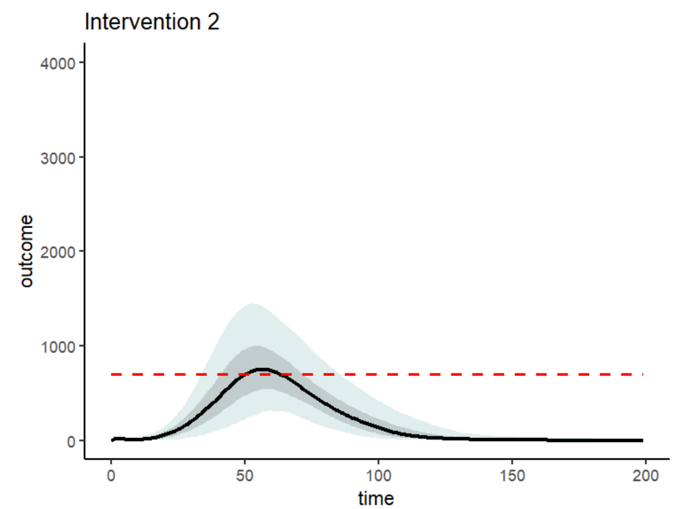
Decision Uncertainty Toolkit Example Plots







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Decision Uncertainty Toolkit: Expected Risk

Quantitative risk measure

$$Expected\ Risk = \left[\sum_{n=1}^{N}(\max(D, O) - D)\right]/N \qquad Expected\ Risk_t = \left[\sum_{t=t_{min}}^{t_{max}}\sum_{n=1}^{N}(\max(D_t, O_t) - D_t)\right]/N$$

D = decision threshold, O = observed outcome, N= #simulations

- Expected risk considers the magnitude and density of curves from a decision threshold (D)
- These values are relative compared to a baseline scenario, but are better interpreted as a percentage change from baseline as a quantity of risk

Decision Uncertainty Toolkit: Expected Risk

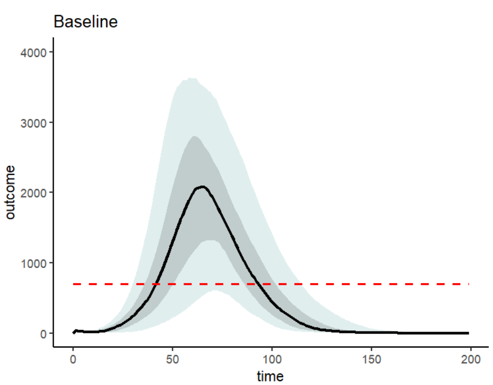
$$Expected\ Risk_t = \left[\sum_{t=t_{min}}^{t_{max}} \sum_{n=1}^{N} (\max(D_t, O_t) - D_t) \right] / N$$

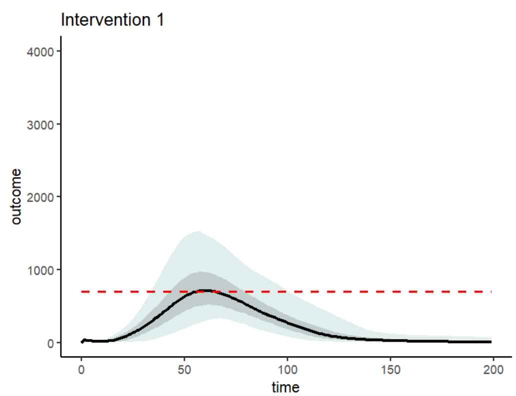
	Baseline	Intervention 1	Intervention 2	Intervention 3
Expected risk	47,661	4,777	4,035	1,374
Policy risk impact	-	-90%	-92%	-97%

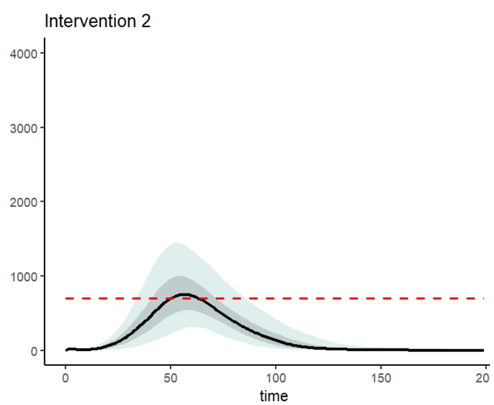
- Time range: 0 to 199 days
- Relative comparison to baseline model (no intervention)
- Interpretation of expected risk is relative to baseline
- e.g., for Intervention 1 - (4777 – 47661)/47661 = -90%

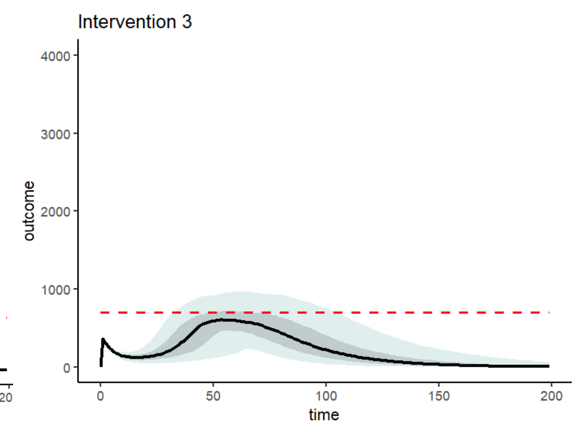
Decision Uncertainty Toolkit: Expected Risk

	Baseline	Intervention 1	Intervention 2	Intervention 3
Risk	47,661	4,777	4,035	1,374
Policy risk impact	-	-90%	-92%	-97%









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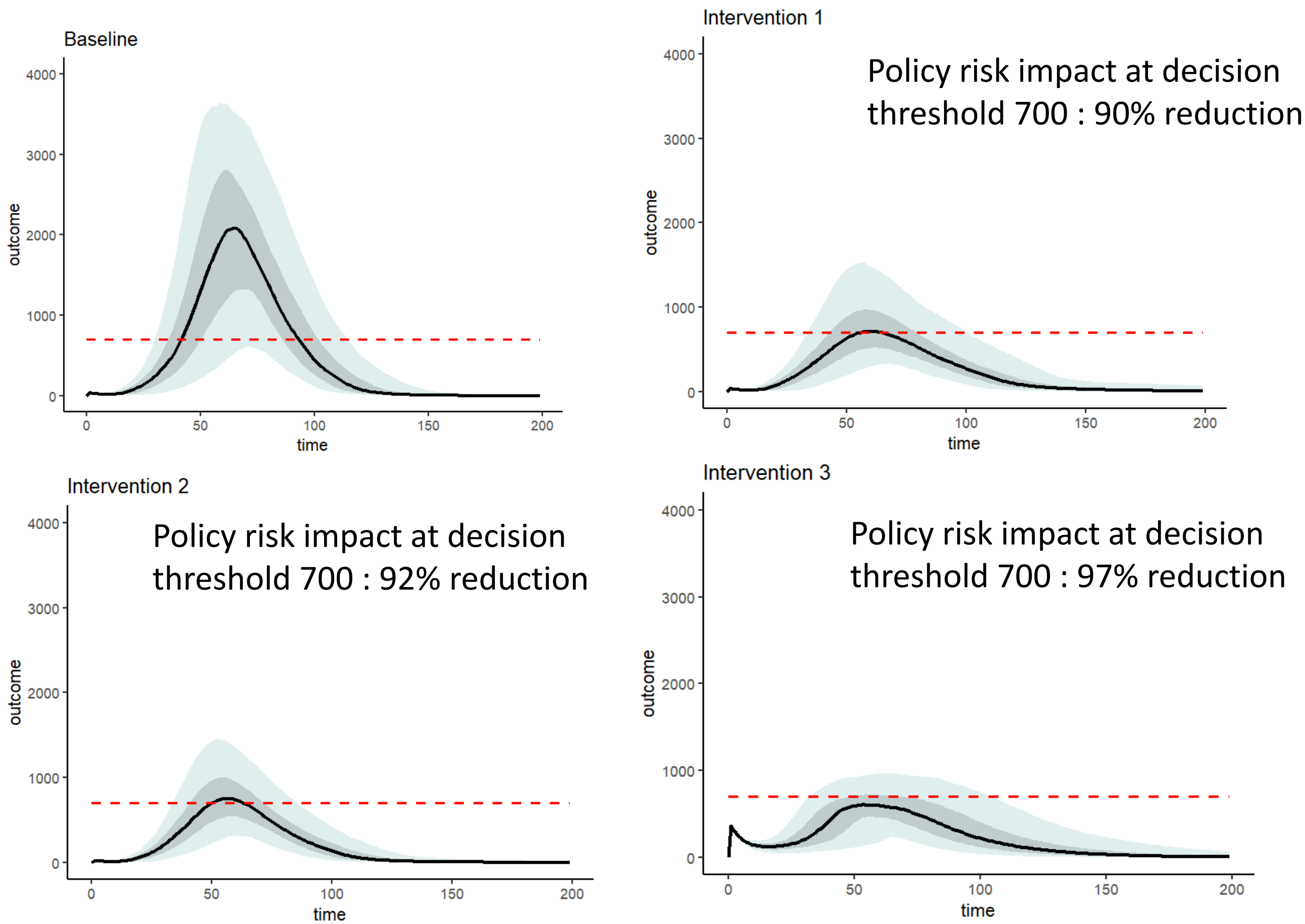
Decision Uncertainty Toolkit: Expected Risk

Decision Threshold = 700



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Next Steps

- Engagement with ID modelers:
  - Donation of scenario data samples to try with the decision uncertainty toolkit
  - Inputs on application to current modelling initiatives and descriptions/wording
  - Can provide a working version of decision uncertainty toolkit code for feedback. The results obtained could be helpful for us for discussions with decision makers ?

- Engagement with decision makers
  - Examine risk tolerance
  - Feedback on descriptions/wording and decision uncertainty risk measures and graphs i.e., what works, what could be better, what is needed?

- Dissemination
  - R bookdown to provide modelers the ability to read in simulated modelling runs for various scenarios and generate visuals and risk measures
  - Repository of descriptions, vignettes, and suggested communications for decision uncertainty
  - Manuscript

Interested in Workshops?

- Please contact Nicole Oak at noak@ihe.ca if you are interested to participate in workshops by **January 5, 2024**. In the email, if you can provide us:
  - Contact information
  - Role: ID modeler, decision maker, and/or other
  - General availability in January 2024
- We will send out a doodle for dates and times that will maximize participation for the workshops
- Your feedback, insights, and suggestions will help complete this work

Thank-you

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