Summary

- Calculating the EVSI using *fast* nested simulations
  - Moment Matching
  - Calculating the posterior variance
  - Estimating the EVSI across sample size
- Calculating the EVSI using the `EVSI` package
- Presenting the results of an EVSI analysis graphically
  - The HomeHealth intervention

References

Heath et al. (2017) *Efficient Monte Carlo Estimation of the Expected Value of Sample Information using Moment Matching*
Heath et al. (2018) *Estimating the Expected Value of Sample Information across Different Sample Sizes using Moment Matching and Non-Linear Regression*

EVSI Definition

Recall, the EVSI is defined as:

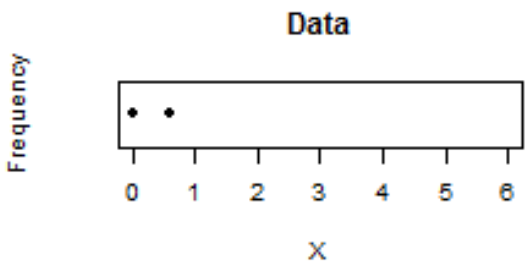
$$\text{EVSI} = \mathsf{E}_{\boldsymbol{X}}\left[\max\left\{0, \mathsf{E}_{\boldsymbol{\theta}|\boldsymbol{X}}\left[\text{INB}\right]\right\}\right] - \max\left\{0, \mathsf{E}_{\boldsymbol{\theta}}\left[\text{INB}\right]\right\}$$

Average over all possible $\boldsymbol{X}$

Value of Current Decision

Value of optimal decision for each $\boldsymbol{X}$

The posterior mean must be calculated by simulation for each of the different potential samples.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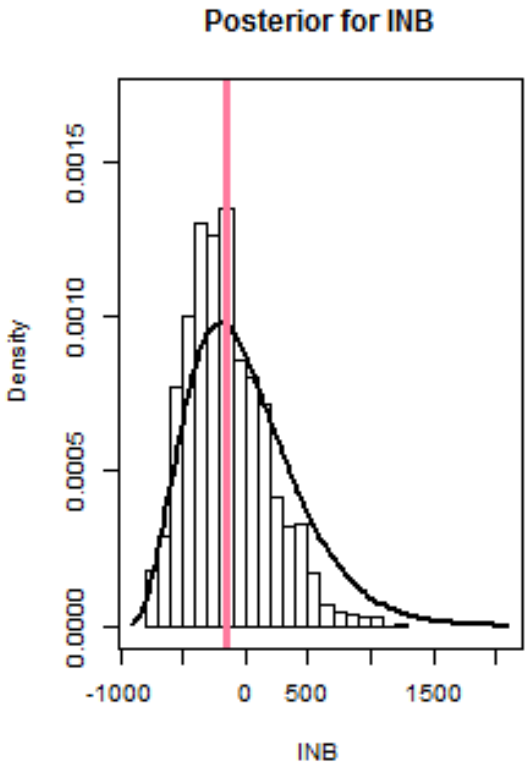
X


Posterior for INB
Density
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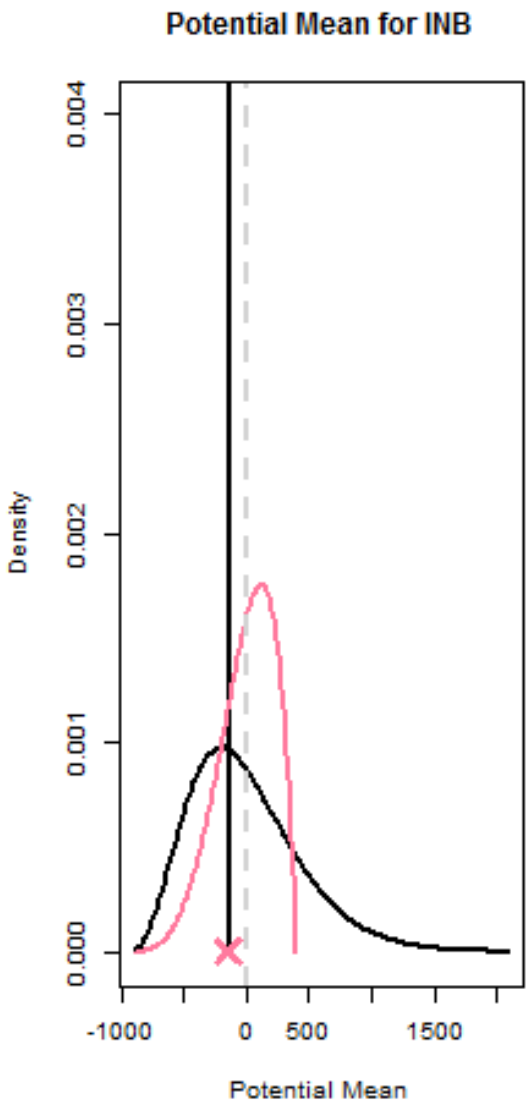
INB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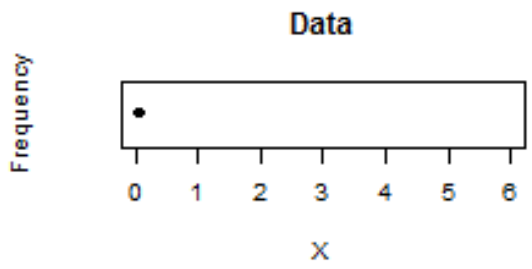
Potential Mean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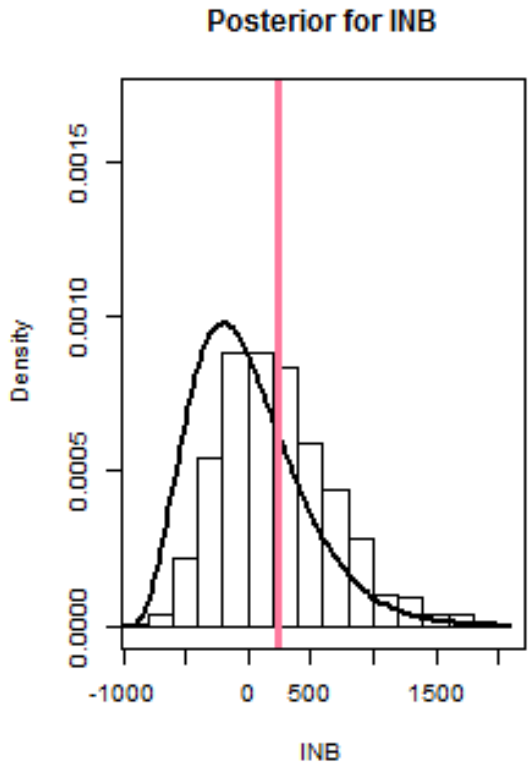
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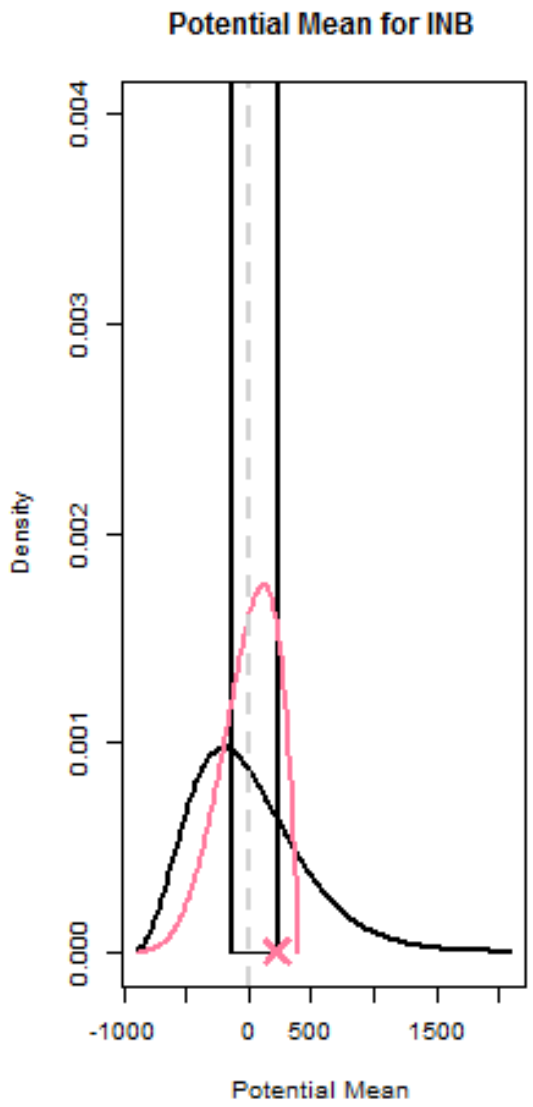
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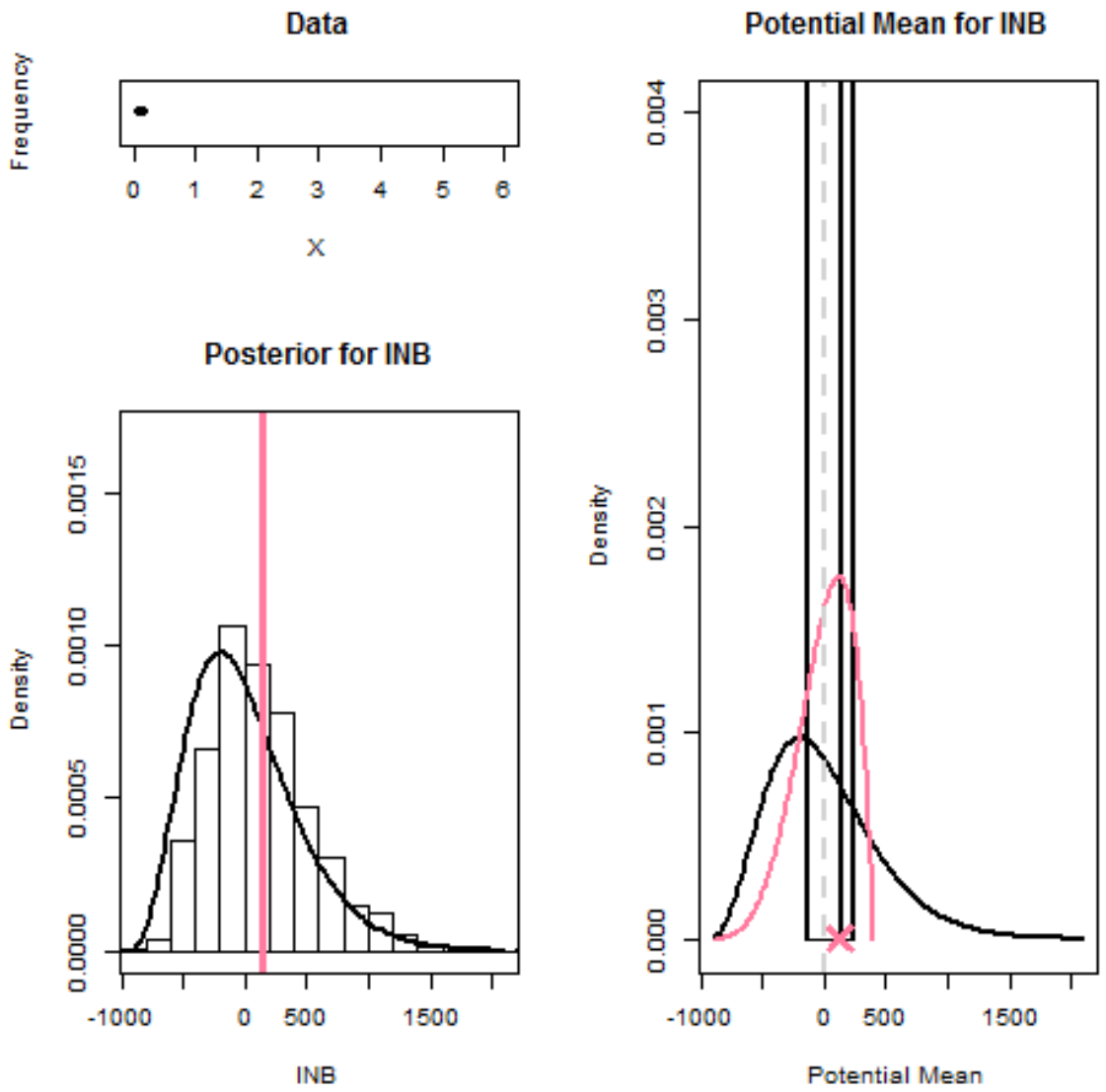
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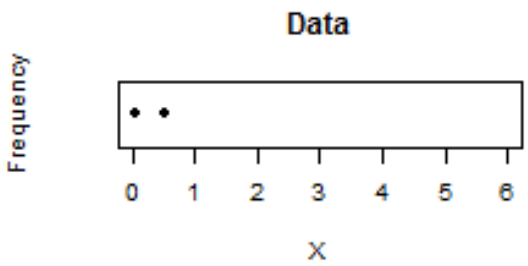
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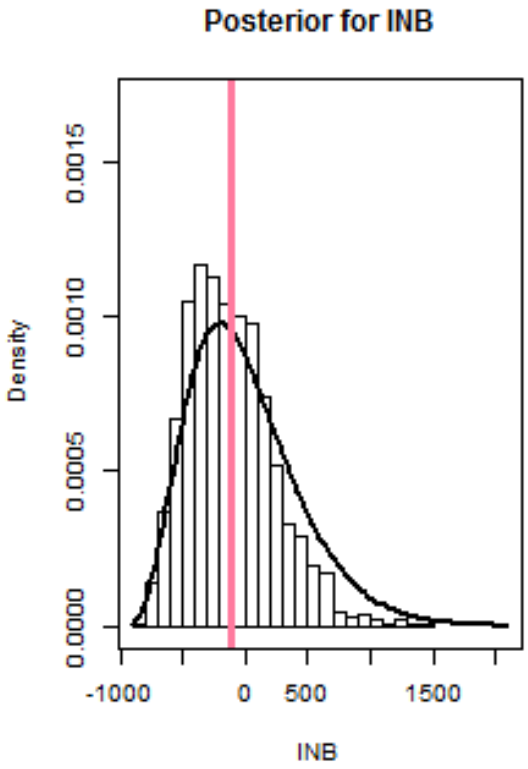
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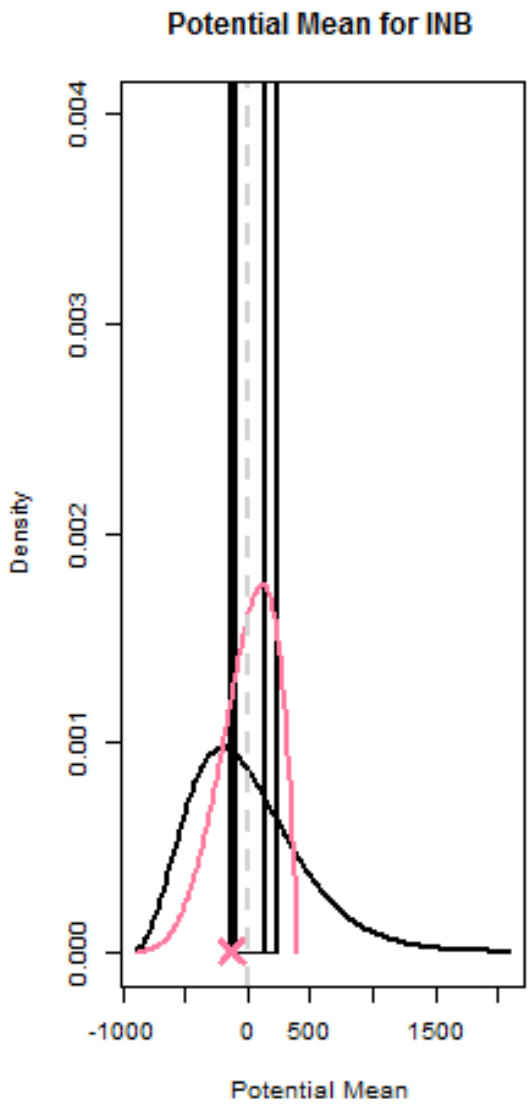
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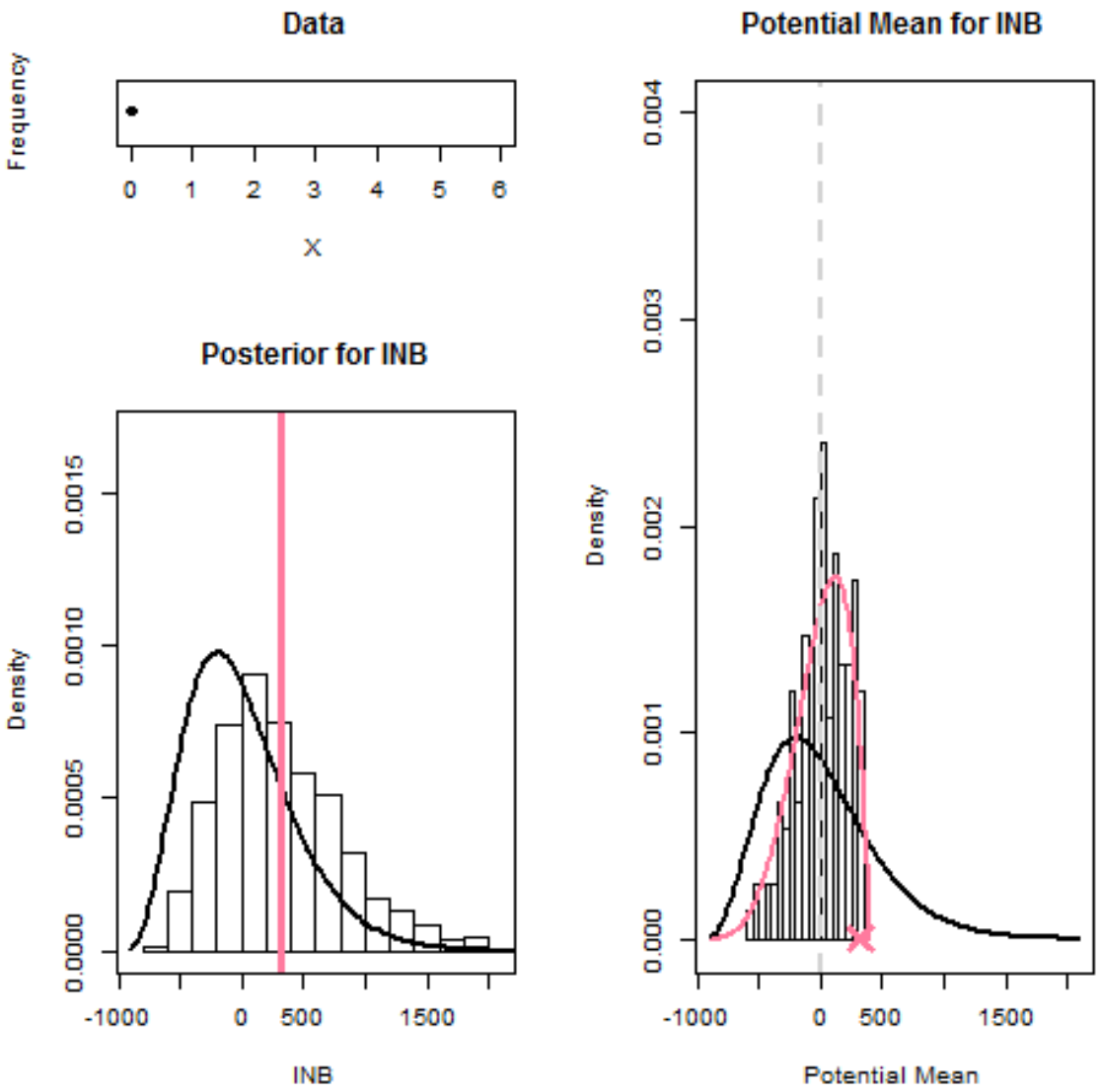
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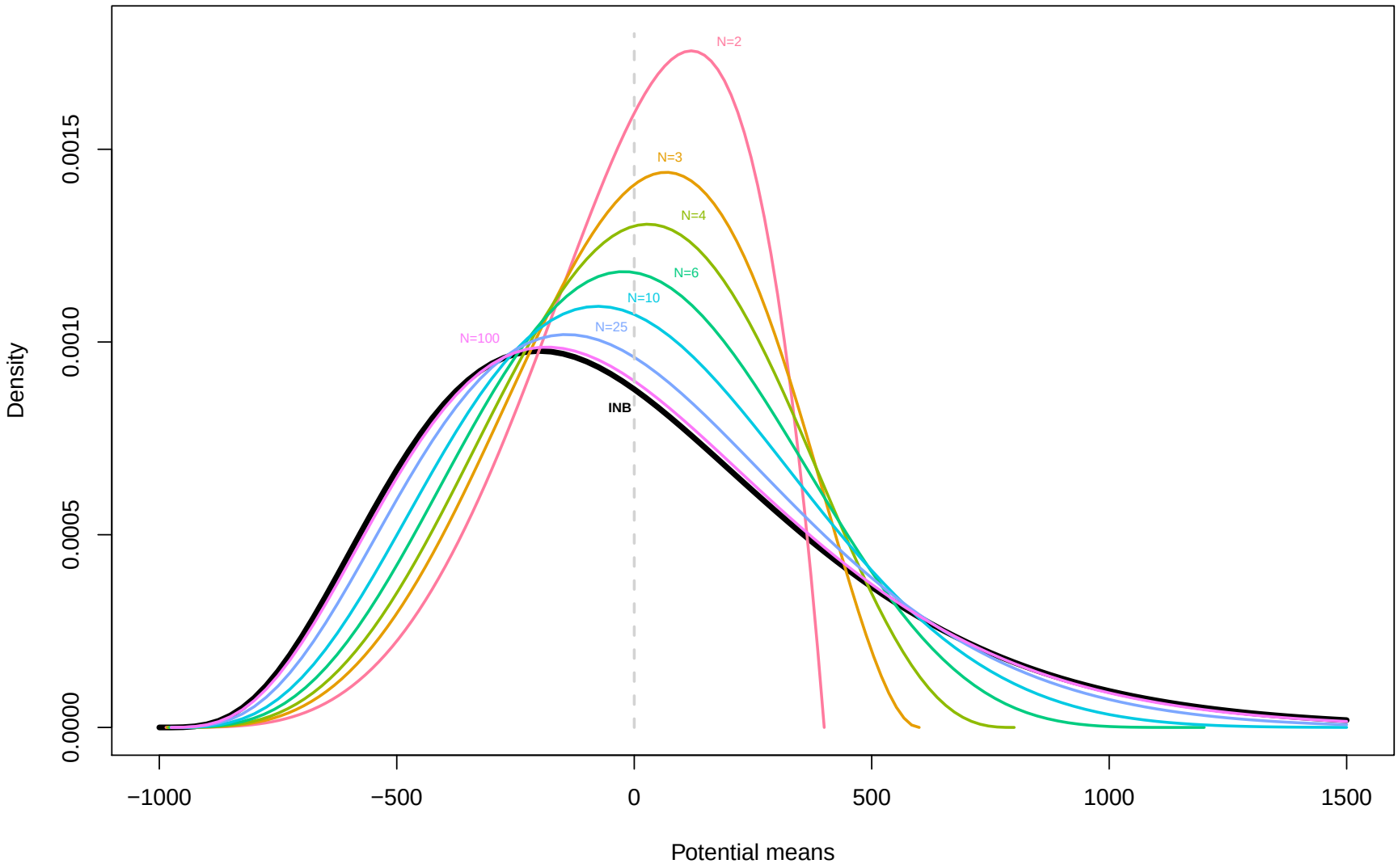
Potential Mean

Distribution of Posterior Mean



Moment Matching

We need to estimate the distribution of $\mu^{\boldsymbol{X}} = \mathrm{E}_{\boldsymbol{\theta}|\boldsymbol{X}}[\mathrm{INB}]$.

This distribution is:

1. Similar to the PSA distribution for INB (as $N \to \infty$)
2. Has the same mean as the INB.
3. The variance of $\mu^{\boldsymbol{X}}$ is *smaller* than for the PSA distribution:

$$\mathrm{Var}_{\boldsymbol{X}}\left[\mu^{\boldsymbol{X}}\right] = \mathrm{Var}_{\boldsymbol{\theta}}[\mathrm{INB}] - \mathrm{E}_{\boldsymbol{X}}\left[\overbrace{\mathrm{Var}_{\boldsymbol{\theta}|\boldsymbol{X}}[\mathrm{INB}]}^{\text{PSA variance for INB}}\right]$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}_{\text{Posterior variance for INB}}$$

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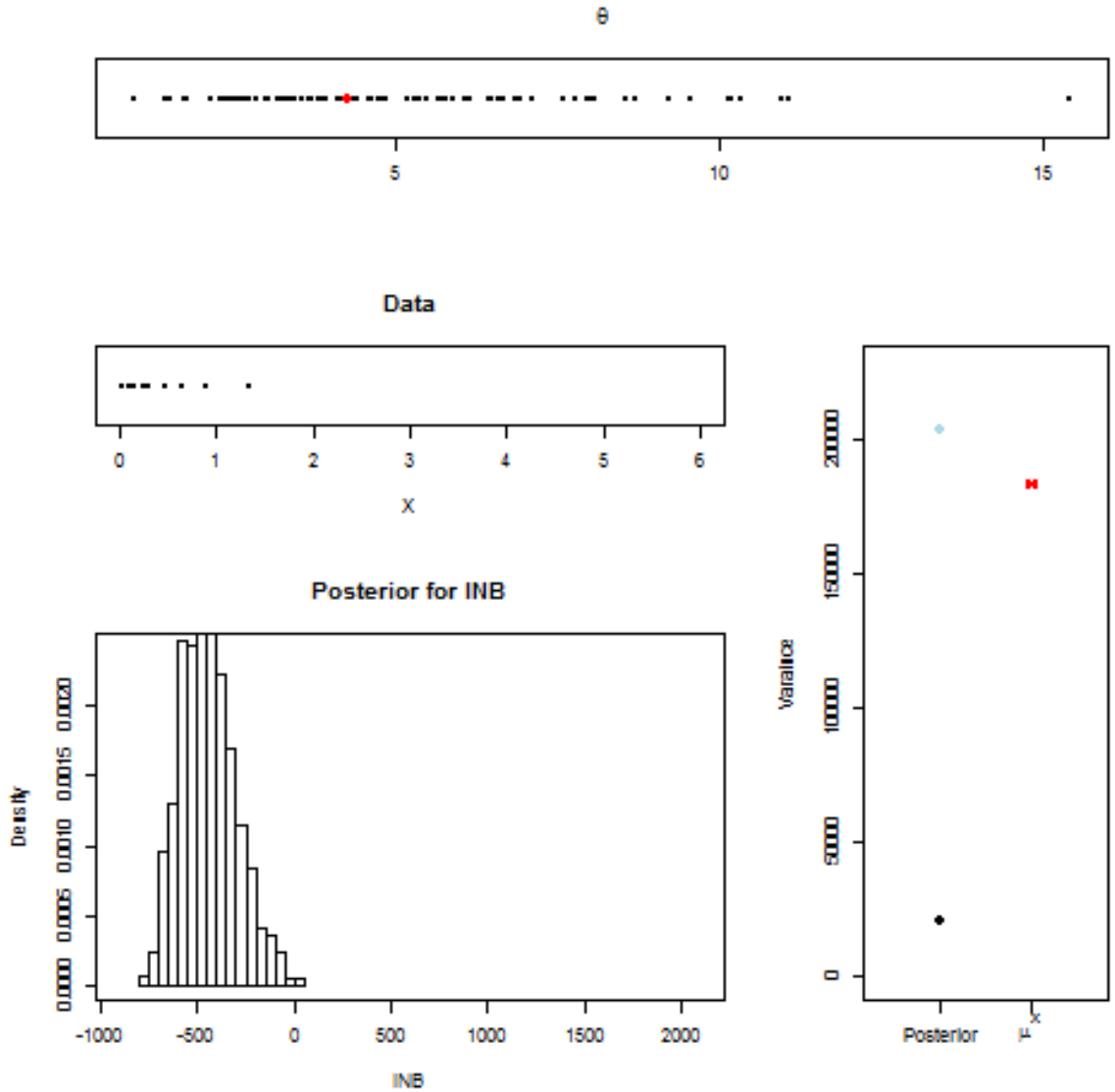
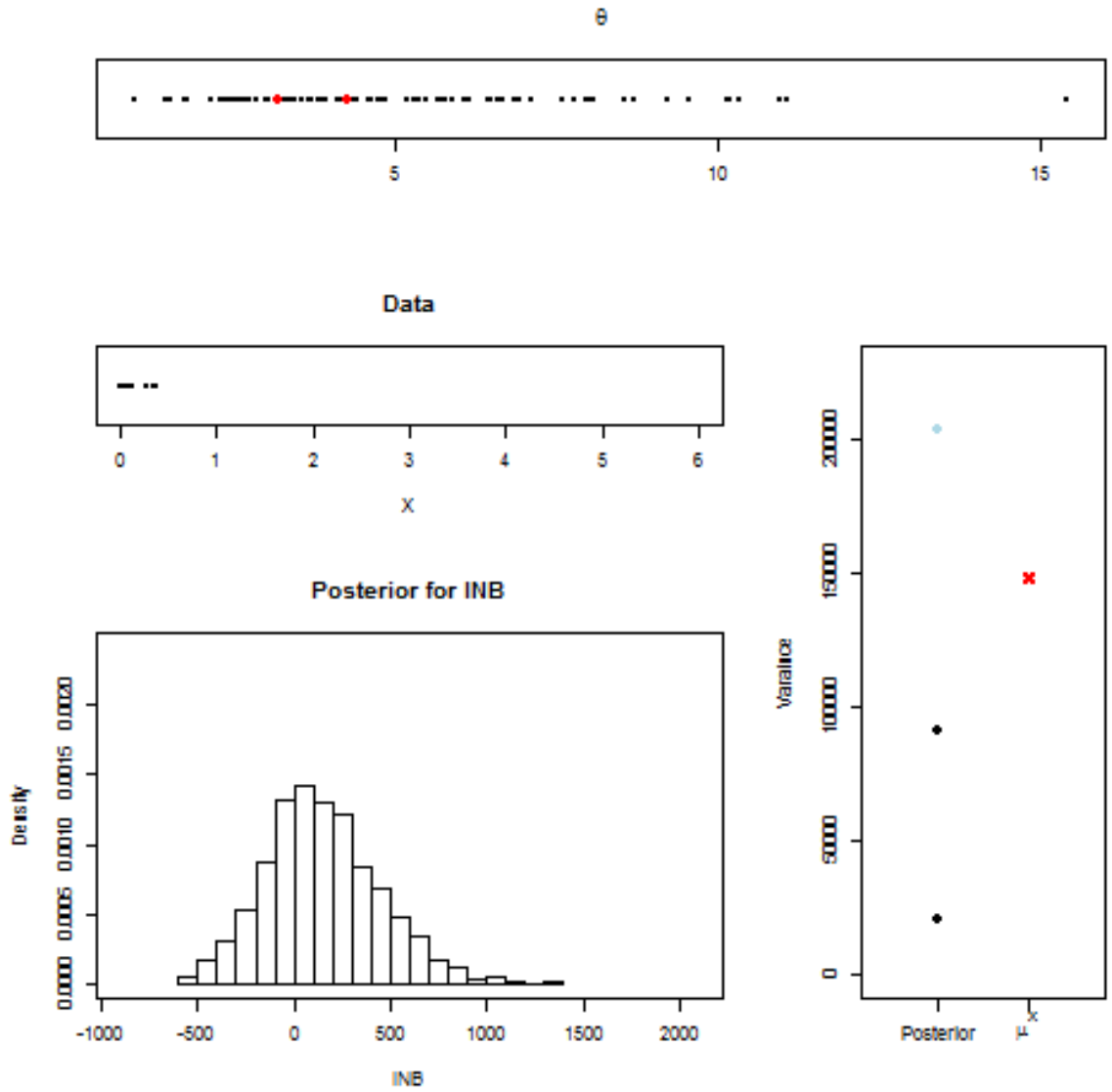
Calculating the EVSI: Rescale the PSA samples of the INB to have the correct variance.

All we need is to estimate the expected posterior variance...

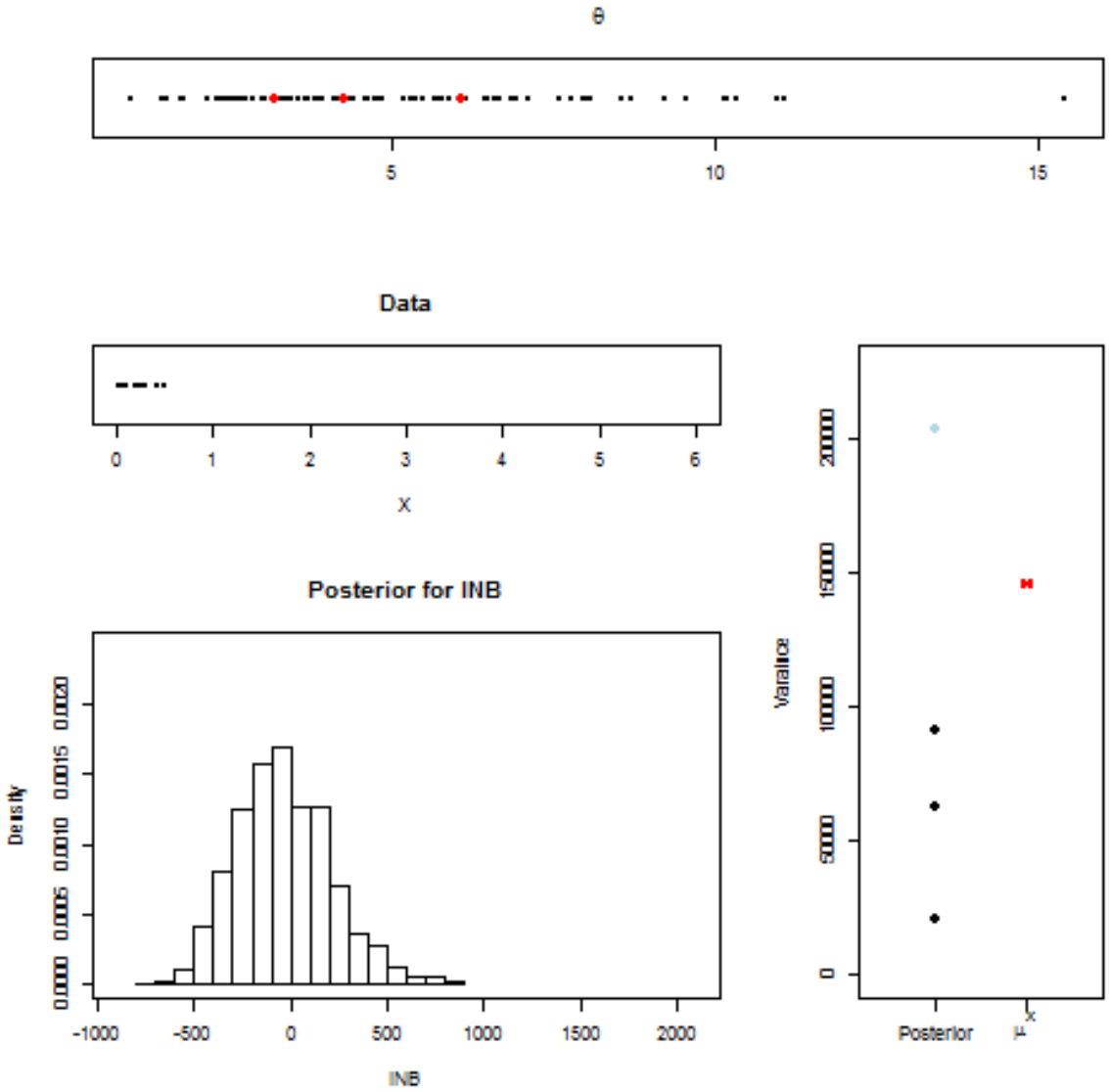
Expected Posterior Variance



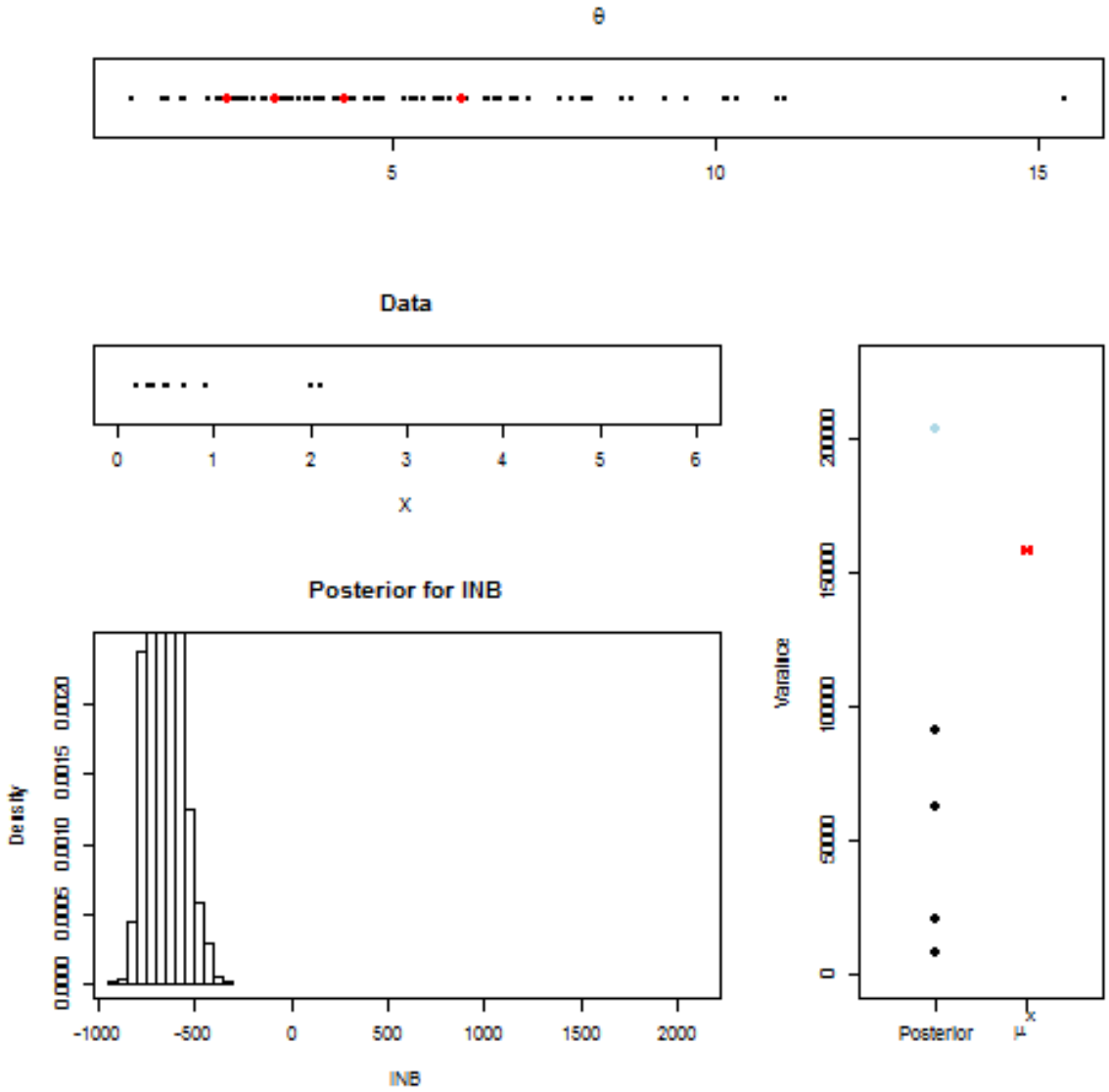
Expected Posterior Variance



Expected Posterior Variance



Expected Posterior Variance



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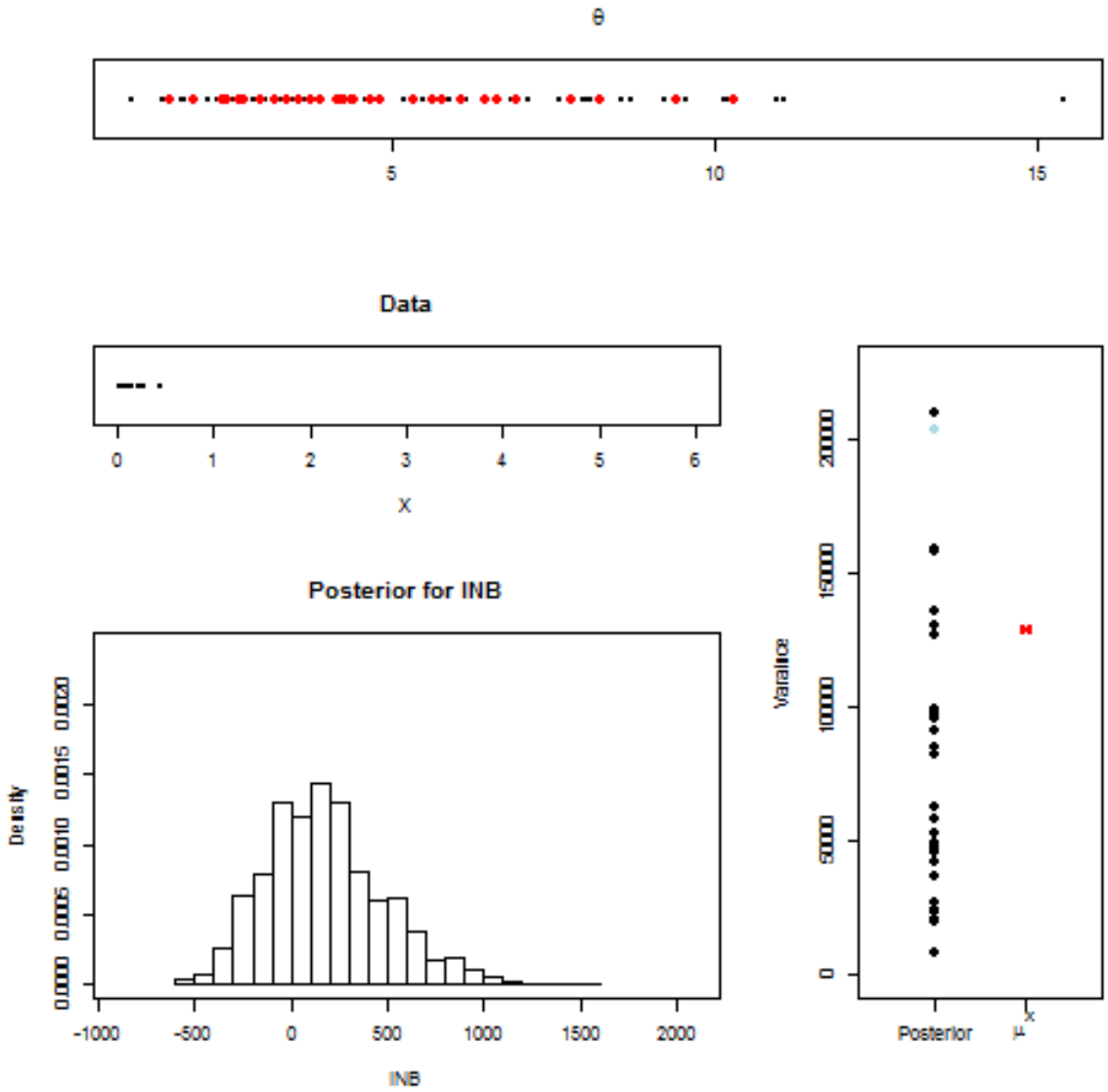


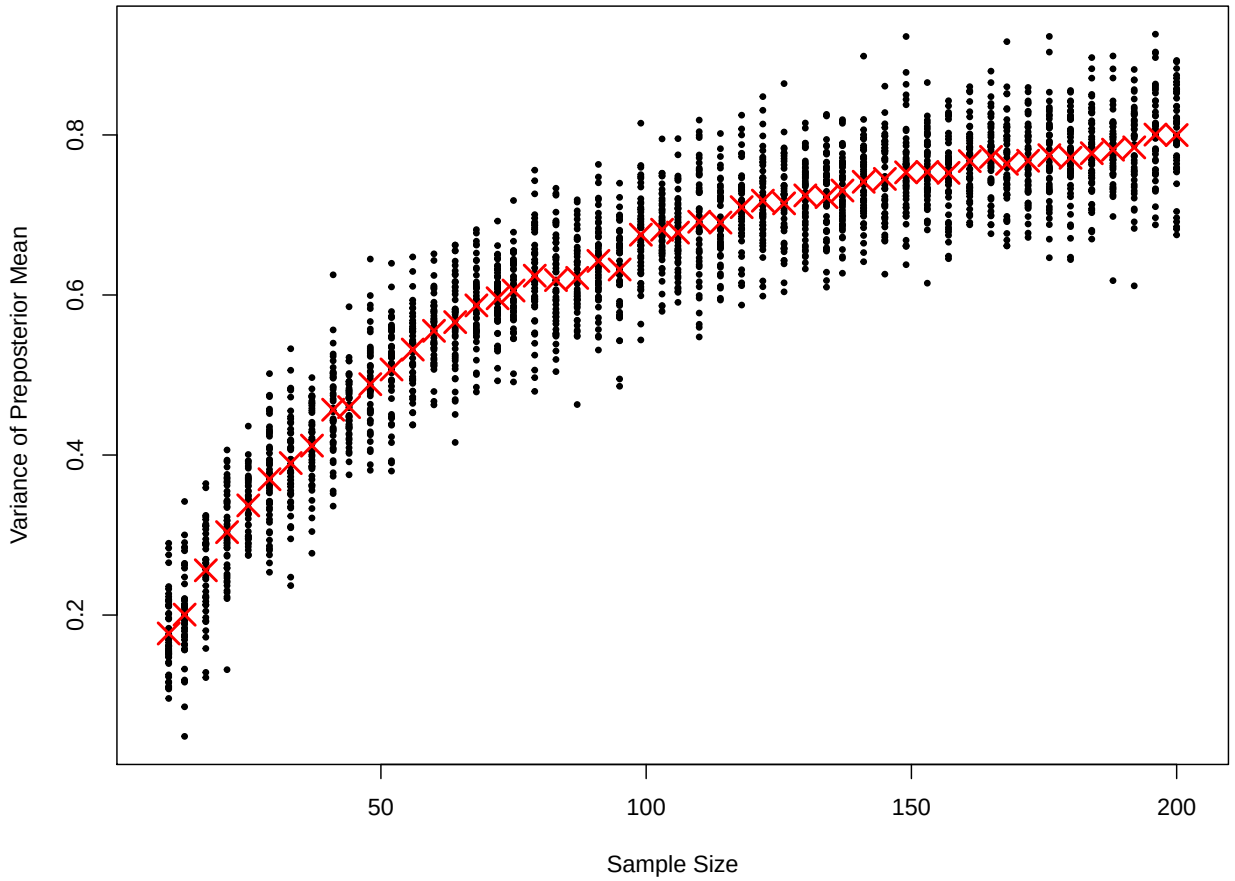
Expected Posterior Variance

The expected posterior variance only requires 30-50 nested simulations using the following method:

1. From the PSA samples of ϕ, find the Q sample quantiles.
2. Simulate *one* "hypothetical sample" $\boldsymbol{X}$ for each of these sample quantiles.
3. Use each of the Q hypothetical samples to find the posterior INB
4. Calculate the variance of the INB; σ_q^2

Different Sample Sizes

To estimate EVSI by sample size it would seem that you need to do $Q \times N$ samples from hypothetical posteriors.



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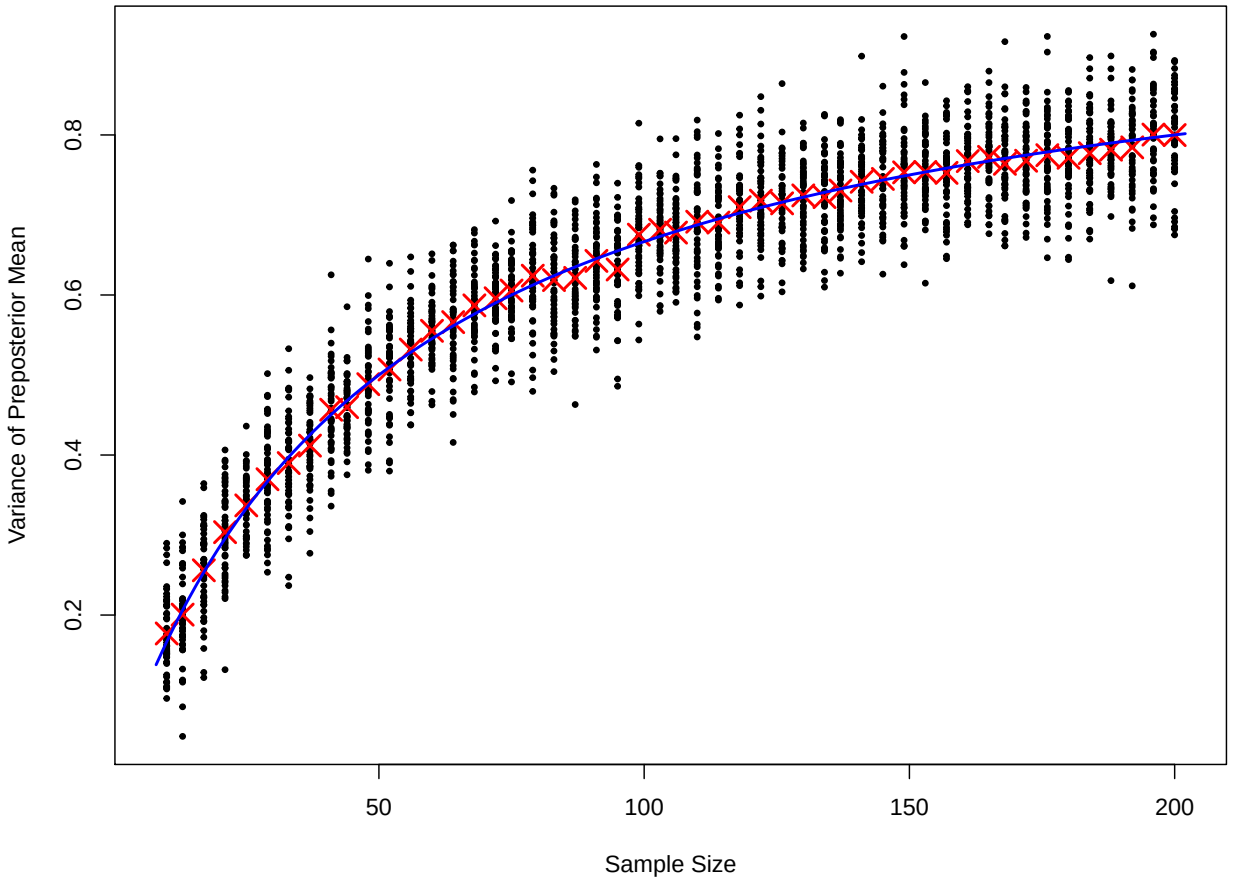
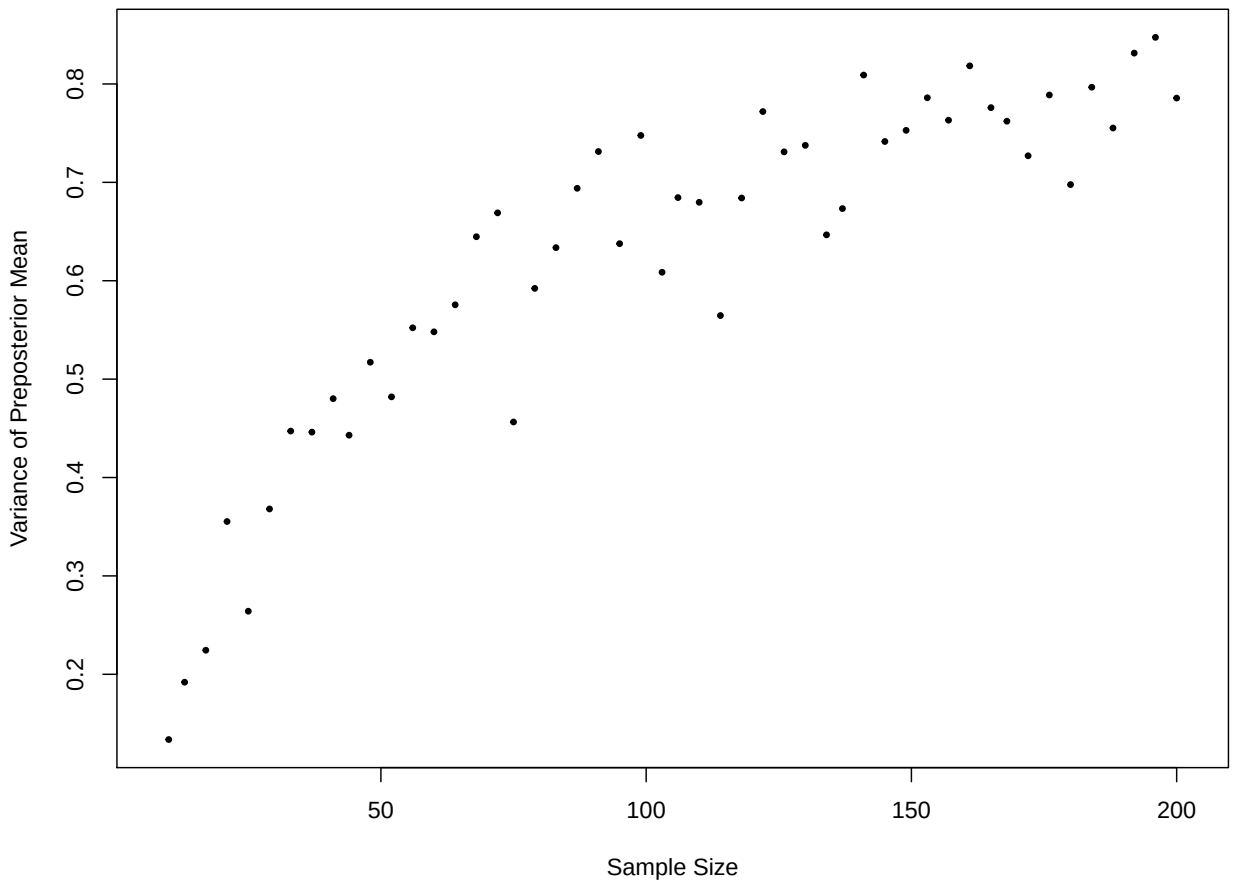


Regression for Different Sample Sizes



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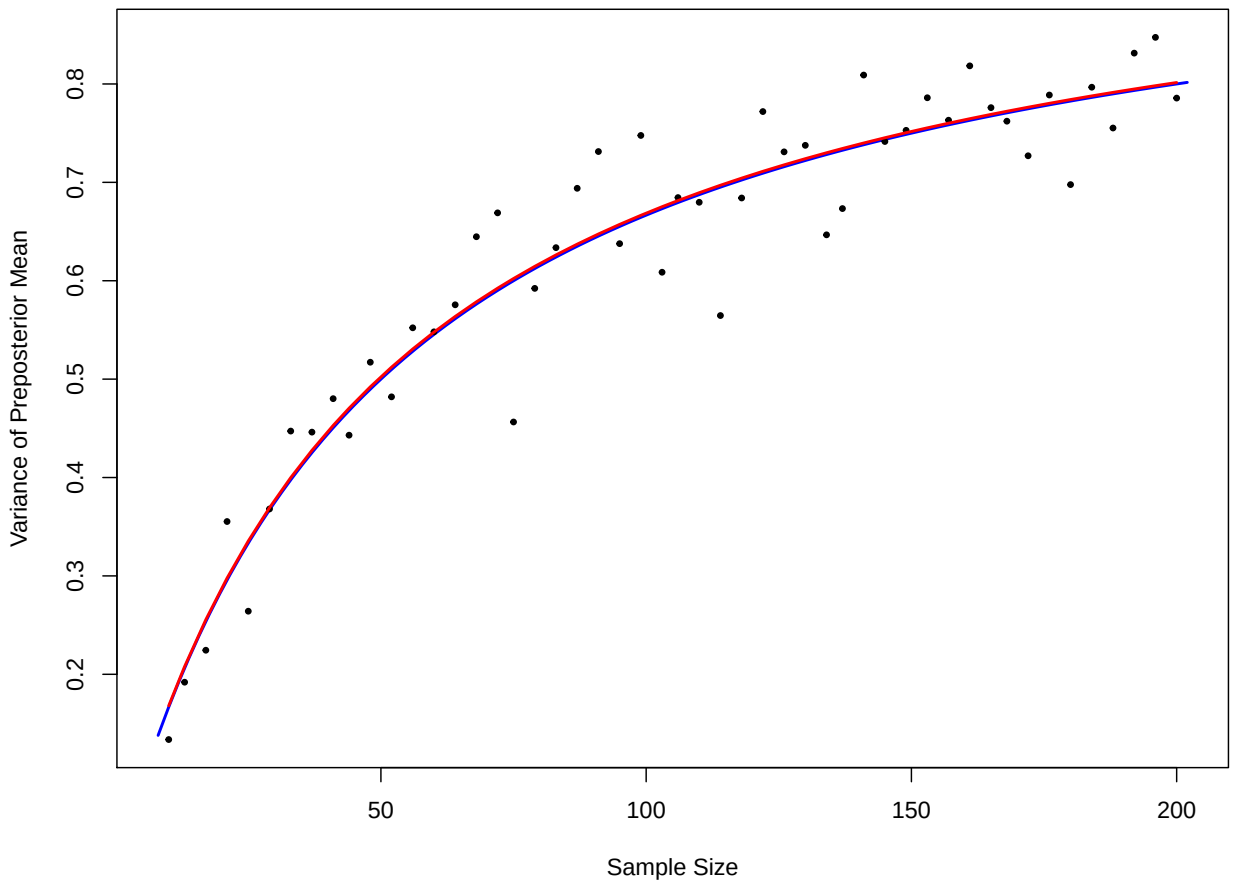


Exactly the same as calculating the EVPPI using regression...

Non-Linear Regression

For the posterior variance, we have information about what regression form should be used:

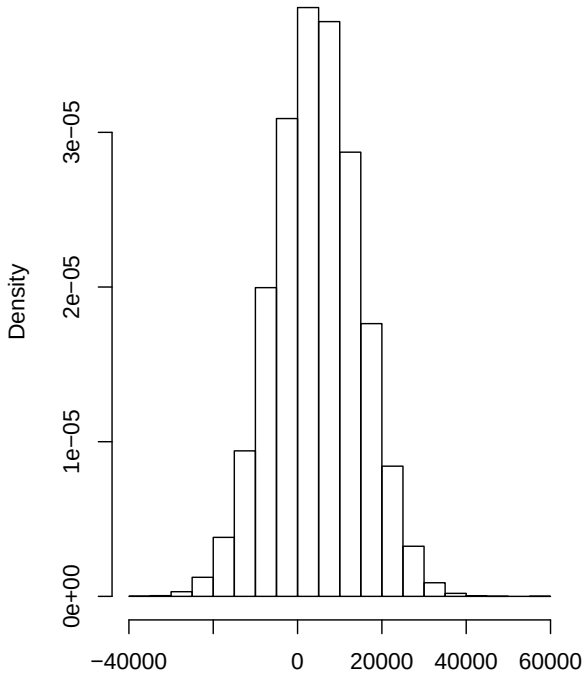
- The EVSI is bounded above by the EVPPI
- The variance of $\mu^{\boldsymbol{x}}$ *increases* as the sample size increase.

We fit a parametric curve to estimate the EVSI across sample size

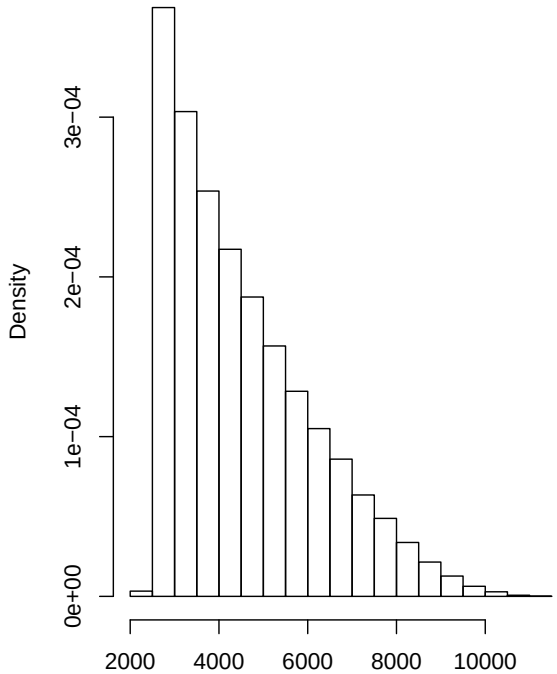
$$\left(\frac{N}{N+h}\right) \text{Var}\left(g_t\left(\boldsymbol{\phi}\right)\right)$$

A Small Technicality

- Only the focal parameters will be informed by the future study ϕ.
- The distribution of $\mu^{\boldsymbol{x}}$ is similar to the distribution of the fitted values — these come from EVPPI calculation.



$\text{INB}^{\boldsymbol{\theta}}$



$\text{INB}^{\boldsymbol{\phi}}$

The EVSI Package

- The EVSI package calculates and presents the results of an EVSI analysis
- To calculate, you need a Bayesian model for the parameters and future data.
- You also need a health economic model in a specific form (see practical)
- The EVSI package then calculates the EVSI across sample size and willingness-to-pay.
- It provides a number of graphs to present the results.
- Graphics can be used if EVSI is calculated using any method presented in this course.

https://github.com/annaheath/EVSI

An Example: HomeHealth Intervention

The HomeHealth Intervention has been developed to help pre-frail adults from developing frailty. It is a personalised nurse led intervention in the home and focuses on nutrition, exercise and habit formation.

Two trials were designed:

- A randomised control trial collecting information about the Barthel frailty index for patients receiving standard of care or the treatment. This also collect quality of life data.
- A similar trial to above but also collecting data about the health service and private costs incurred by the patients.

Should we fund an additional trial into this intervention?

Which trial gives the greatest value?