Project no: 022936
Project acronym: Beneris
Project title: Benefit-risk assessment for food: an iterative value-of-information approach

Instrument: STP-Specific Targeted Project

Deliverable 42:

VOI analysis of fish

Due date of deliverable:	**1 May, 2009**
Actual submission date:	**15 Nov, 2009**
Dissemination level:	**PU**
Start date of project:	**April, 1st 2006**
Duration:	**3,5 years**

Organisation name of the lead contractor for this deliverable: **THL**

VOI analysis of fish in Beneris (D42)

The full contents of this deliverable (D42) can be reached on the Internet. For closer examination of the work, please logon to the wikipage:

> http://heande.opasnet.org/heande/index.php?title=VOI_analysis_of_fish_in_Beneris&printable=yes
>
> (username: "bioher", password: "qADaC4h")

On the following pages, the deliverable is documented in terms of a summary paragraph and a printout of the above wikipage.

VOI analysis of fish in Beneris looks at the value of additional information (VOI) in the decision assessed in the Beneris fish case study. VOI means that a rational decision-maker would be willing to pay for relevant information before the decision is actually made. Based on the analysis, it seems that the largest value of additional information in this case study relates to the characteristics of the age group of "55+ years". This is the group in which both the cardiovascular and cancer risks are substantial, and therefore the impacts are also potentially high. The highest value was about the intake variables of dioxin, PCB, methylmercury, and omega-3 fatty acids. The absolute value could not be estimated because we used an approach where decisions are treated as random variables. For more precise estimates, a counterfactual VOI analysis should be performed.

VOI analysis of fish in Beneris

Contents

- 1 Introduction
- 2 Materials and methods
- 3 Result
- 4 Discussion
- 5 See also
- 6 References

1 Introduction

Value of information (VOI) analysis is a statistical method for estimating the cost of remaining uncertainties in a decision situation.[1]. In other words, the decision-maker should be willing to pay for someone who could reduce the uncertainty, but not more than what is the expected improvement of the decision due to this additional information.

VOI analysis can be used to improve decision models by identifying critical knowledge gaps with this robust and scientifically sound method. For a detailed description of the method, see Appendix 1 found on the web page.

Before a VOI analysis can be performed, three things must be explicated. First, there must be an explicit objective, such as total amount of disability-adjusted life years in this case. Second, there must be an optimising function that tells which of the possible outcomes are better than others. In this case, the less life years are lost, the better. Third, there must be an explicit decision with at least two different options; the differences in the outcome due to the decision options are then compared. If the VOI of a particular variable in the model is assessed, that must of course be specified as well.

There is a problem with the decision in a Bayesian net (BBN). In a BBN, all variables in the model (more than a thousand in the fish case) can technically speaking be used as decisions. It is possible to conditionalise to a particular value or a range of values in any variable, and then study the impacts of the conditionalisation on the other variables, notably the outcome of interest. This flexibility offers a lot of possibilities, but it also poses a challenge: if you can analyse anything, how can you find out what things are important?

To help in this problem, we decided to develop a new way of calculating VOI so that it can be used in an easy way for a BBN, and identify variables that require further attention if certain decisions are of interest. It should be noted that the importance of a particular variable is always dependent on the outcome of interest and the decision at hand. Therefore, it is very useful to be able to screen lots of outcomes, decisions, and variables to get an overview.

The objective of the VOI analysis is to answer the following questions:

- Which are important uncertainties in the Benefit-risk analysis of fish in Beneris, where the outcome is the net health effect, and the decision is to affect fish intake in different age groups?
- How should VOI be calculated in a flexible way in a BBN?

2 Materials and methods

The case study is described in detail elsewhere (D38 Full benefit-risk analysis of fish). In brief, the fish consumption of the Finnish population was estimated for four age groups (0-2 a, 2-18 a, 18-55 a, and 55+ a). The intakes of several contaminants (dioxin, PCB, and methylmercury) and nutrients (eicosapentaenoic acid and docosahexaenoic acid, measured as total omega-3 fatty acids) were estimated. The impacts of these intakes on cardiovascular mortality and cancer incidence in adults and intelligence quotient (IQ) and dental defects in children were assessed based on published exposure-response functions. Finally, the different endpoints were summarised by converting them into disability-adjusted life years (DALYs).

A full BBN was created to capture the issues listed above. The whole model consists of more than a thousand variables, which are all treated probabilistically. A random sample with 10000 iterations was created from the model, i.e. the model was run 10000 times to get 10000 descriptions about how fish intake and health could be related. The sample was stored in a data file and opened in Analytica, where the statistical analyses were performed.

Most of the thousand variables are some intermediate results and not interesting as such. We ignored those in this analysis. Among the remaining variables, we chose a set that we thought, a priori, to represent some interesting phenomena in the case, or to be potentially important. We ended up to 42 variables that represent pollutant and nutrient exposures, exposure-response functions, background risks, health impacts, or health impact aggregates.

We used a novel statistical procedure, designed in Beneris for this specific purpose, to calculate VOI in a situation where the decision is actually a random variable in the model. The computing code is described in detail in Appendix 1 (logon to the web page).

3 Result

The VOI estimates are presented in Figures 1. and 2. The list contains important variables from the model, the VOI of which is estimated. Blank is a variable that is NOT part of the model; therefore, any VOI estimated to a blank is just noise, and any VOI smaller than that of a blank should be ignored. As we can see, many of the VOI estimates are smaller or similar size than the blank and therefore not important.

Only a few variables have a clearly larger VOI than the blank. If the outcome of interest is the total DALYs of the population (Figure 1.), the following variables show VOI:

- Dental defect risk in 2-18-year-old children
- CHD mortality in 55+ -year-old adults
- Dioxin intake in 55+ -year-old adults
- PCB intake in 55+ -year-old adults
- Methylmercury intake in 55+ -year-old adults

- Omega-3 intake in 55+ -year-old adults

In this analysis, mostly variables related to the oldest age group are interesting. This is not surprising, as also the expected health impact concentrate in this age group.

If the outcomes and decisions are looked at separately for each age group (Figure 2.), the following variables show VOI:

- CHD mortality in 18-55-year-old adults
- CHD mortality in 55+ -year-old adults
- Dioxin intake in 55+ -year-old adults
- PCB intake in 55+ -year-old adults
- Methylmercury intake in 55+ -year-old adults
- Omega-3 intake in 55+ -year-old adults
- Exposure-response function of methylmercury on coronary heart disease
- Exposure-response function of omega-3 fatty acids on coronary heart disease

Abbreviations used in the figures: CHD = coronary heart disease, IQ = intelligence quotient, DALY = disaability-adjusted life year, ER = exposure-response, n3 = omega-3 fatty acid, MeHg = methylmercury.

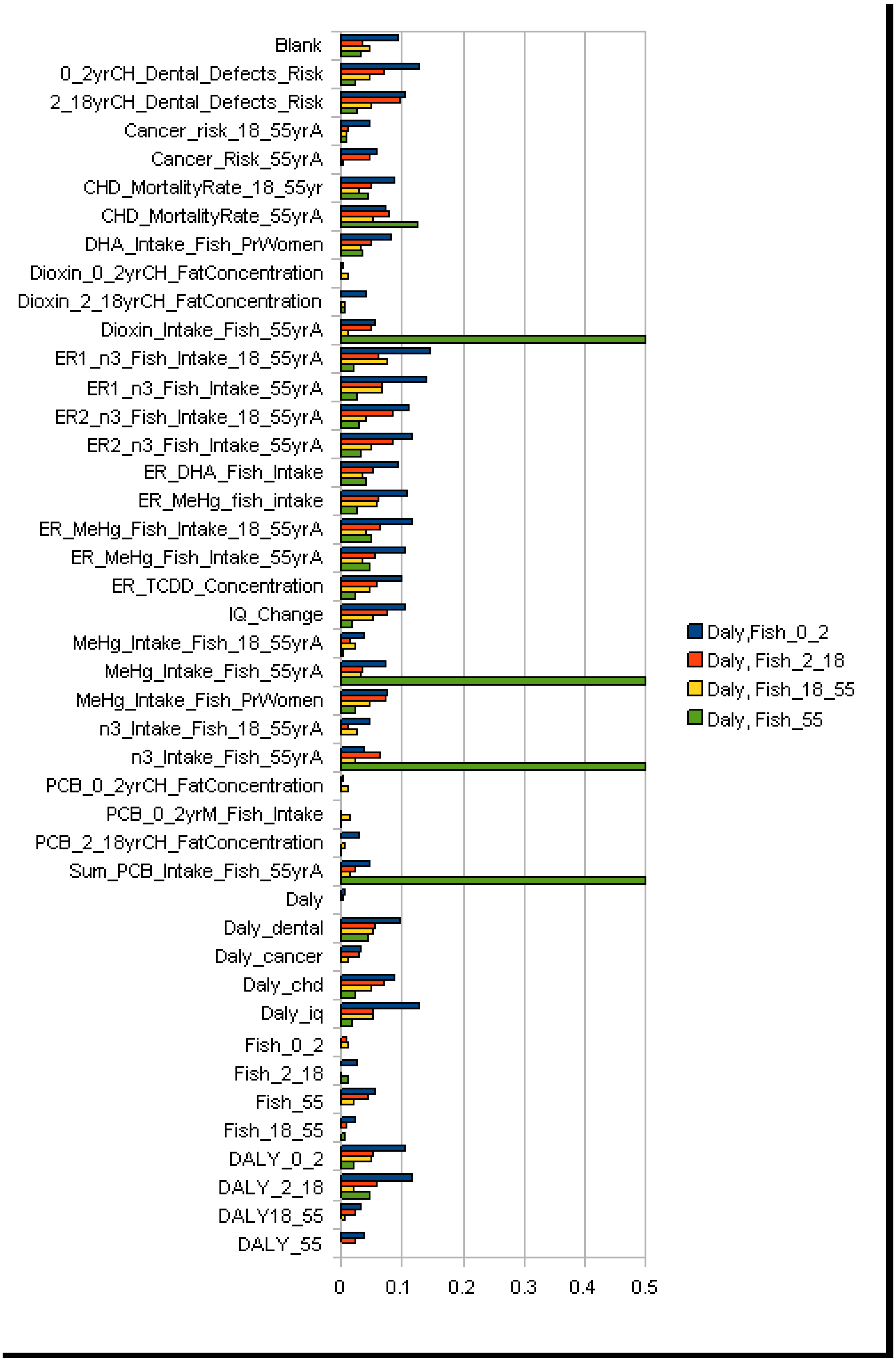

Figure 1. The VOI analysis result for the Beneris fish case study. This figure shows the value of information for selected variables without counter-factual analysis. The outcome is total DALY, and the decision is to affect fish intake in a particular age group.

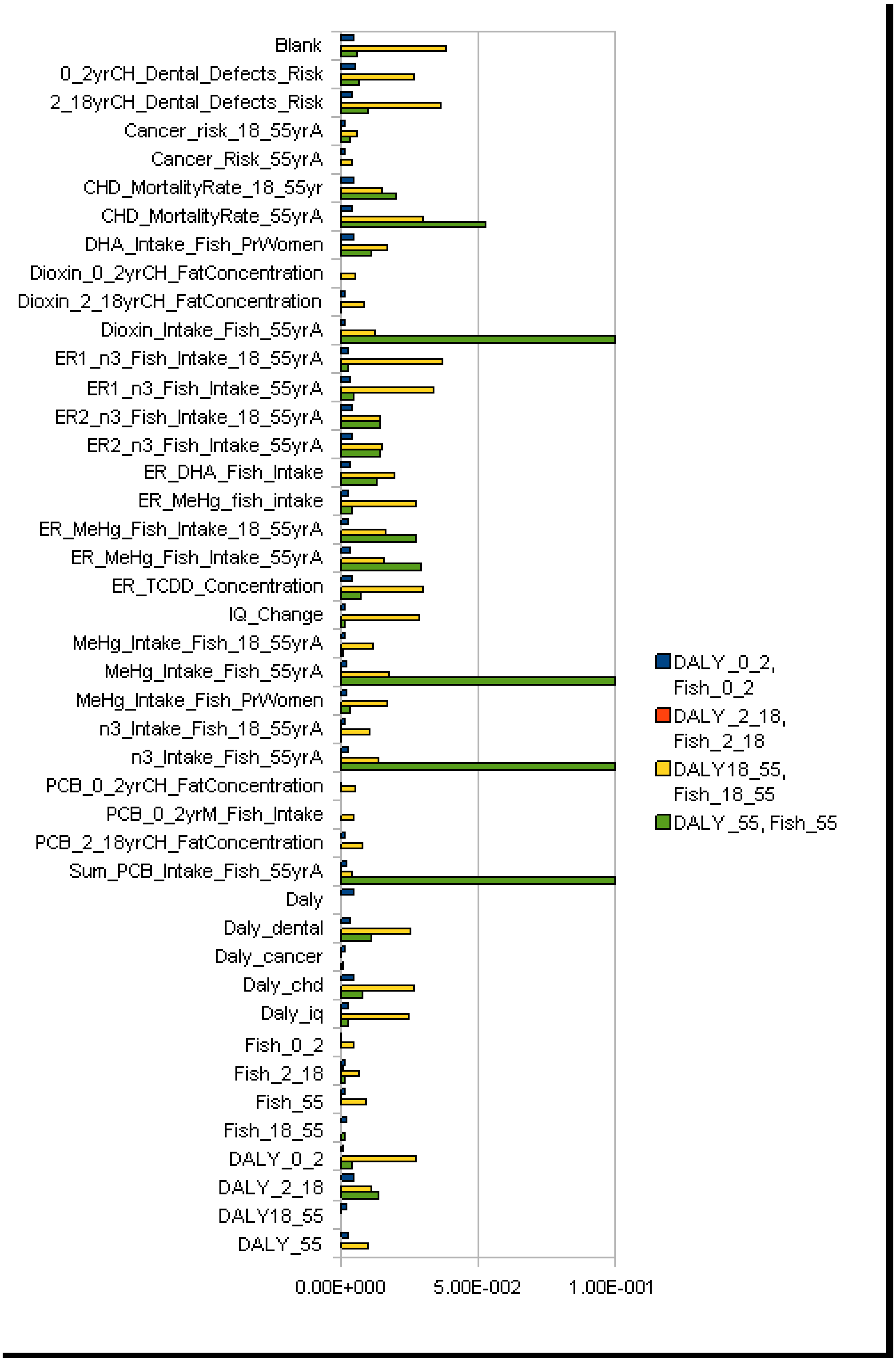

Figure2. The VOI analysis result for the Beneris fish case study. This figure shows the value of information for selected variables without counter-factual analysis. The outcome is DALY of an age group, and the decision is to affect fish intake in the age group.

4 Discussion

In both analyses, there are four intake variables that show very large VOI. However, this is an artefact and does not reflect reality. This problem in the method was identified when the fish case study was analysed. The issue is described in more detail in Appendix 1 (please logon to the web page). In brief, variables that are highly correlated with the decision may have many iterations related to one decision option and too few or none related to another option. If this is the case, then option comparison cannot be performed, and VOI gives unrealistically high values.

This phenomenon requires more research. At the moment it can be concluded that if these very high values are seen, the variables probably are interesting, and they warrant further analyses.

In any case, with a fairly simple analysis, it was possible to reduce the number of variables that may require further scrutiny with uncertainties from several dozens (originally hundreds) to 6-8. This is very helpful, although the absolute values from this analysis should be treated with caution, and in some cases even ignored.

There are two ways of doing a VOI analysis (see Appendix 1 on the web page). The one that was developed for screening was used here. A major advantage is that it can be applied on random variables instead of actual decisions. It is very common that a risk-benefit analysis is performed without predefined and realistic decision options. This severely hinders the usage of VOI analysis, which is otherwise a very good analysis for improving assessment models. The screening VOI can be calculated much more often than the actual VOI. The latter can be then used with more mature models, where the description of decisions is more mature.

Another advantage with the screening VOI is that it does not require counter-factual computations, but it can be performed based on a sample file from a BBN, which is a standard approach to analyse the model. This makes its calculations easier and straightforward, and it does not require additional computing.

5 See also

- Appendix 1
- VOI in Wikipedia
- Expected value of perfect information

6 References

1. Morgan MG, Henrion M: Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis. Cambridge University Press, 1992. ISBN 978-0521427449