A modelling approach to estimating the economic benefits of intervention for disease in aquaculture

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The Issue:

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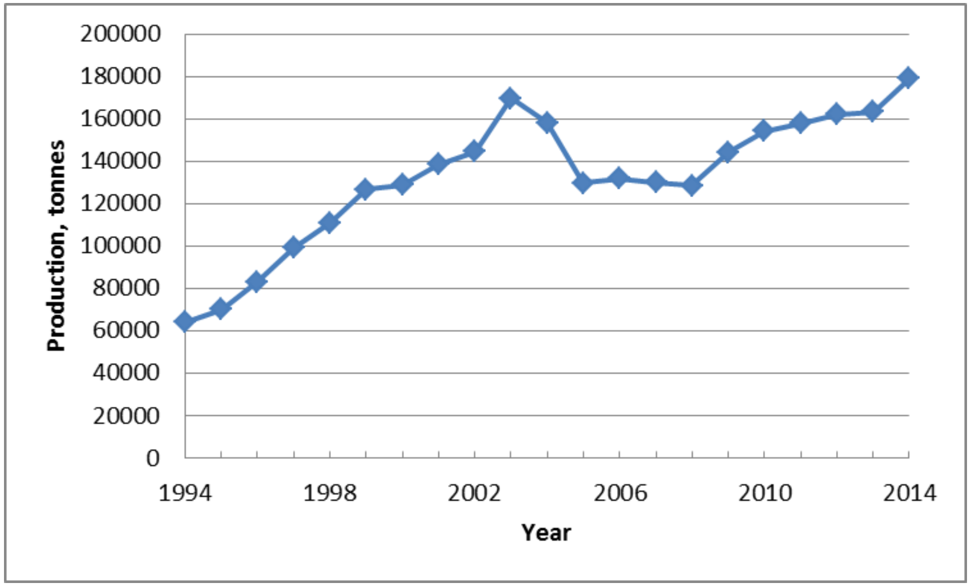
Salmon aquaculture is a major activity in Scotland
- annual production >£550M,
- UK's largest food export 2014
- 179,022 tonnes 2014
- sites of upto 2,500 tonnes consented

Much of this in relatively remote areas with few year-round employment options



Food and Drink Federation

Disease:

However, disease cause substantial losses

- disease approximately 30% of marine losses
- occasional big epidemics

Different impacts of different diseases

- mortality
- reduced productivity
- reduced marketability
- welfare
- treatment costs

Combine two types of modelling:

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To assess economic impacts of disease we combine epidemiological models and economic models

Epidemiological modelling

- Spread of infection
- Disease from this infection and biological scale of losses
- Effectiveness of controls in preventing spread/disease

Economic model

- Cost of controls
- Benefits of controls
- Value of losses to disease
- Losses of potential production

So using epidemiological and economic Models we assess policy

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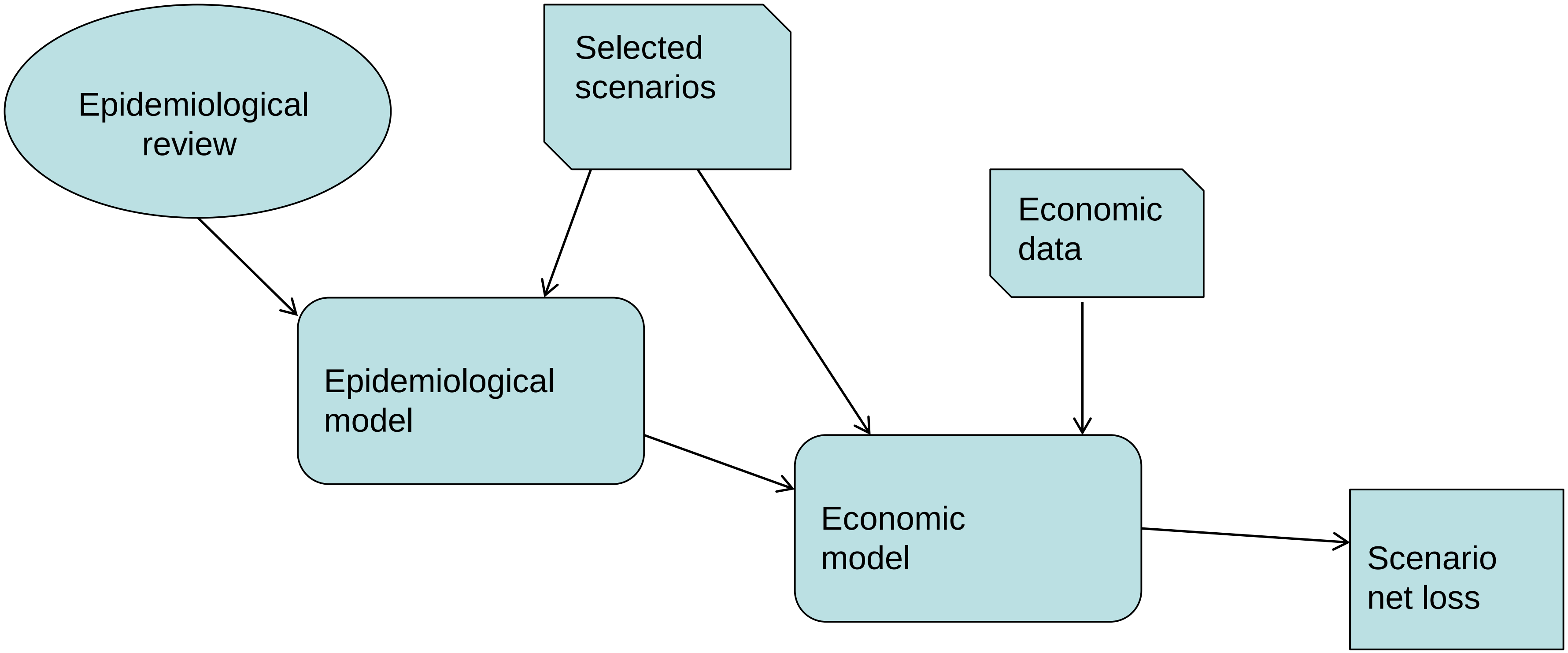

An application to Bacterial Kidney Disease

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Number of expected cases taken from epidemiological model

Costs of surveillance from MSS Fish Health Inspectors

inspectors time

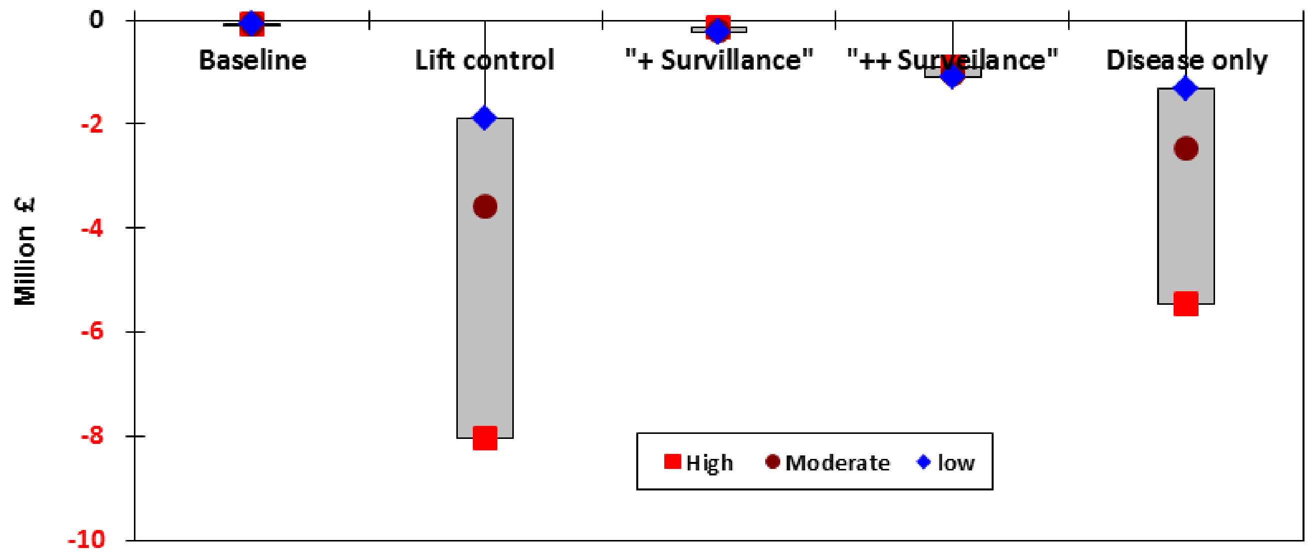
diagnostic testing

Losses of fish per case obtained from industry database

Losses and costs multiplied up by number of cases from epidemiological model

Net cost of alternative scenarios to support decision making

Decision analysis – Evaluating alternative policies



Examples of scenarios

1 baseline (controls until infection cleared)

2 no controls

3 small improvement in surveillance (+)

4 strong improvement in surveillance (++)

5 controls on clinical disease only

EBIT a simplified assessment of the value of losses

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Price had fish reached harvest is variable

We do not need to know the factors that drive this variability

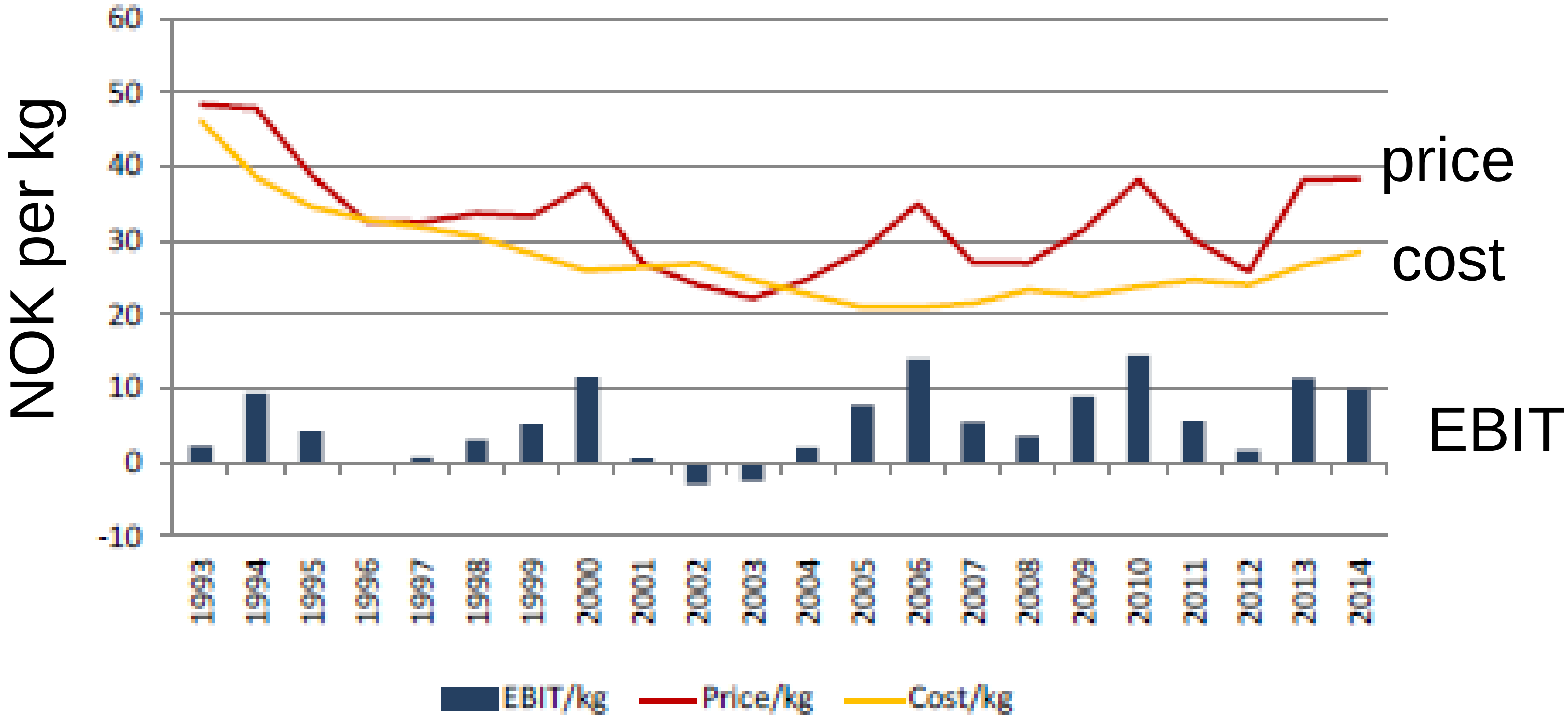
Industry publishes EBIT (Earnings before Interest and Taxes)

This is price minus cost of production

Using EBIT we do not have to assess cost of production, losses are simply losses of potential production

There are complications, e.g. reduced cost of production, surveillance costs that do have to be included

Cost relatively stable, price very variable



Pancreas Disease

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Widespread, but variable, infection in salmon
Caused by salmonid alphavirus (SAV)
Wild reservoir
Not notifiable in UK and eradication not believed possible
Not case in Norway, where PD free zone is maintained

Epidemiological study of cases in UK carried out
Data from Norway obtained from literature

Model developed of the impact of PD in salmon

Used to assess benefits of alternative farm-level management scenarios

Outline of intervention timing

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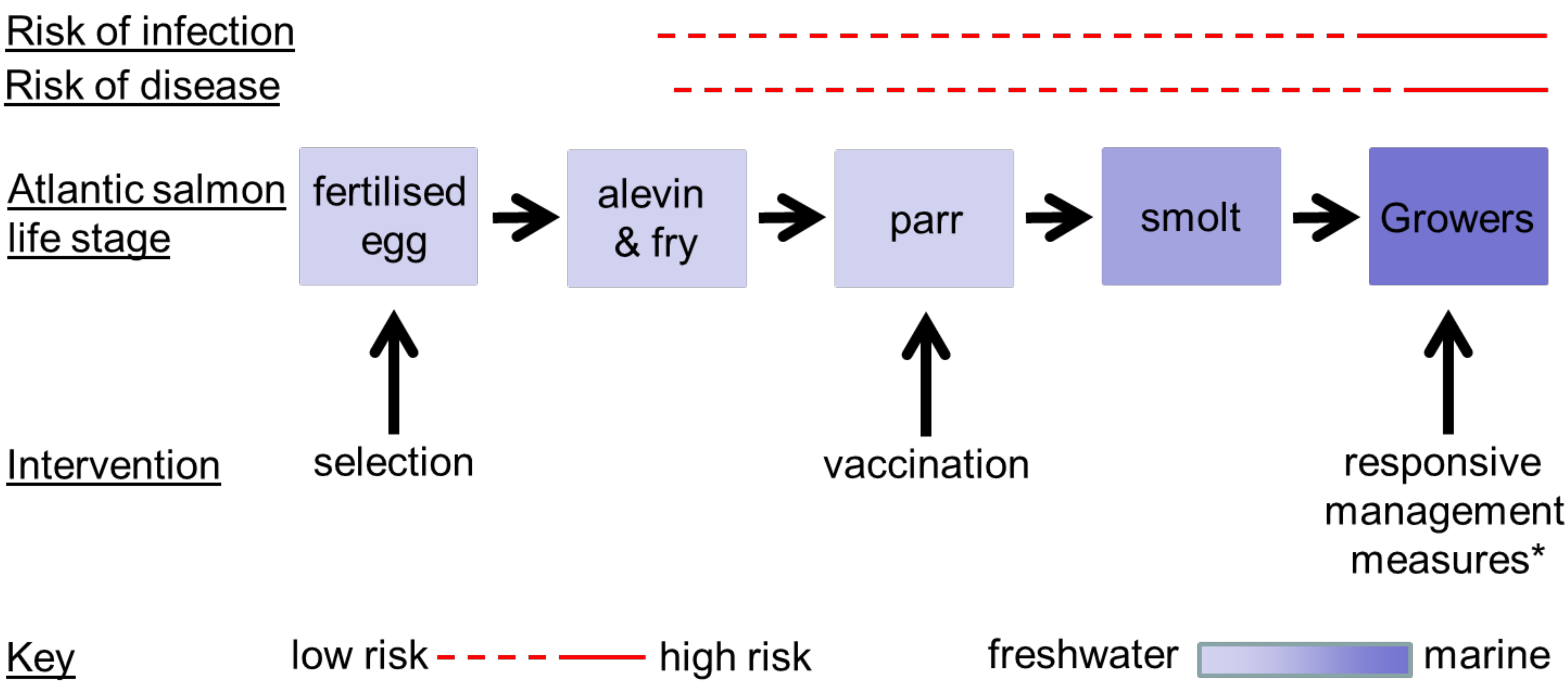
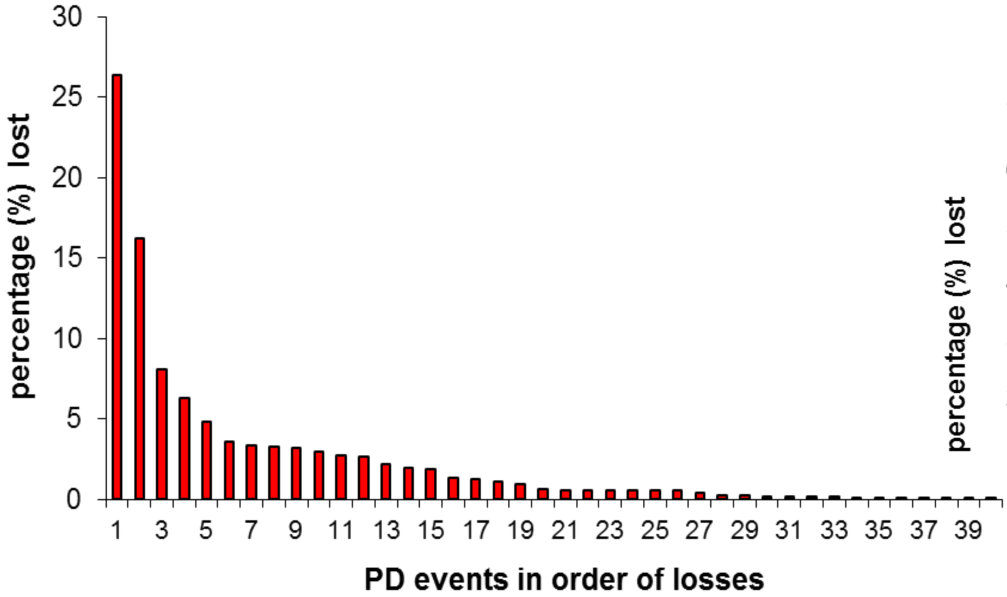
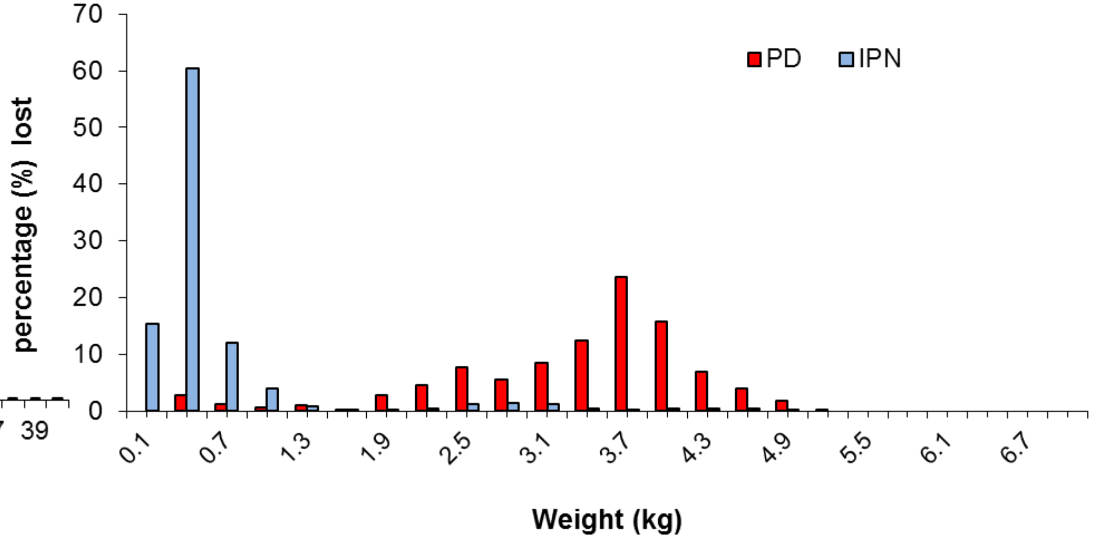


* responsive management measures: include inclusion of functional feed, cessation of handling, and/or increased removal of dead and moribund fish as a consequence of disease signs.

Pancreas Disease





Highly aggregated, 7.5% of events account for 50% of losses

Losses biased to large, expensive, fish

Compared with Infectious Pancreatic Necrosis (IPN) which generally kills small fish shortly after put to sea

Detailed model for loss of value of a production cycle due to PD

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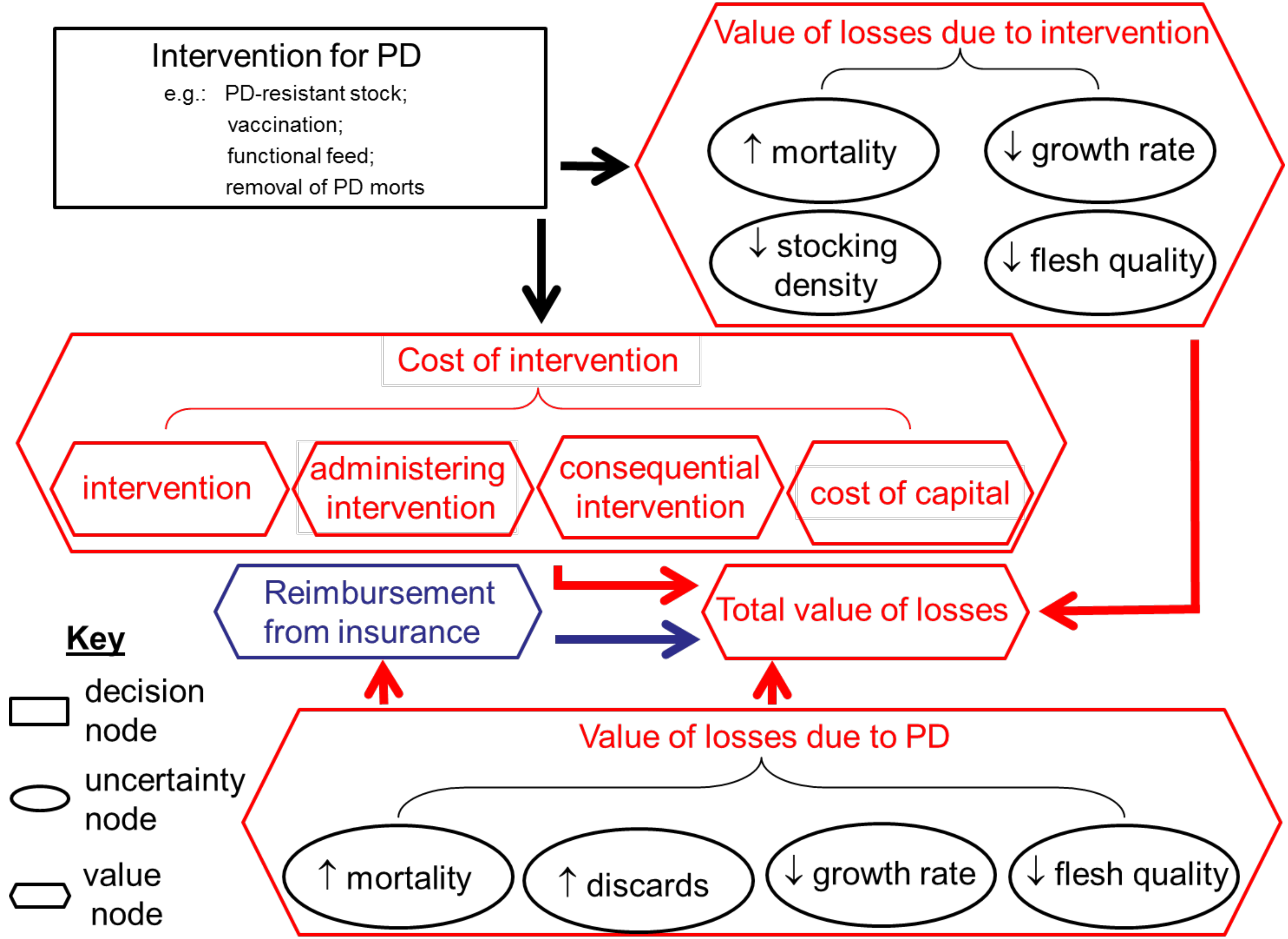

Developing a simplified model

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Losses are modelled from literature data with mean values and confidence ranges

literature mean and standard deviations used to create a beta distribution from which parameter values are sampled

We simplify the intervention costs into a simple constant. In case presented we are assuming 1% of production cost (can be varied)

Value of losses modelled by variation in EBIT. Assumption is cost of production constant, but price varied as shown in EBIT data and this variation affects the value of losses

Quantifying losses to PD

Losses increase with prevalence of PD and parameter values as selected from beta distribution

Cost of losses sampled from EBIT distribution

Cost of intervention is applied to all sites if a pre-emptive treatment, e.g. vaccination

If intervention is re-active, e.g. functional feed, then can target only infected sites (or at least the true and false positive sites)

Different diagnostic methods for different purposes

Insurance

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Insurance is assumed to cap maximum losses a site experiences

Insurance is assumed not PD specific, so not affected by PD prevalence

Risk neutral behaviour assumed

Mean and standard deviation used to derive beta distribution
Mortality >15% intervention for insurance (from industry)
75% of cases mortality caped at this level
Truncated beta distribution converted back to new mean and SD

Thus big losses generally covered by insurance
Long term low grumbling losses may not trigger payout threshold
hence 75% covered

Simplified model for loss-of-value of a production cycle due to PD

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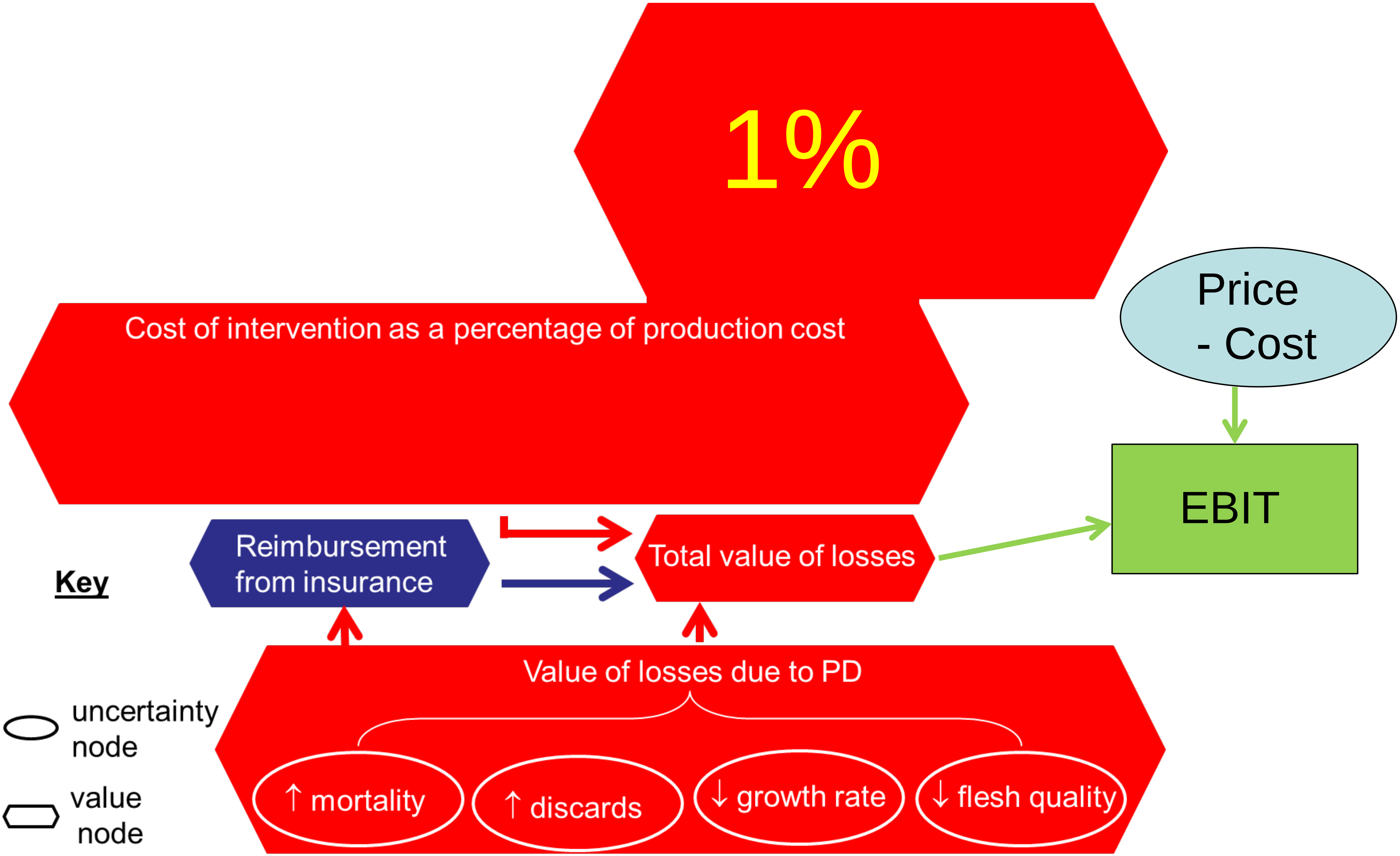

Illustrative Model Scenarios

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Illustrative model scenarios for generalised interventions:

- Intervention equivalent to effectiveness of vaccination on a strain similar to PD type III as reported by Bang Jensen et al. (2012)
- Intervention equivalent to effectiveness of vaccination on a strain with half the virulence of PD type III
- Intervention equivalent to half the effectiveness of vaccination on a strain similar to PD type III
- Intervention for equivalent to reduced effectiveness of vaccination on a strain with half the virulence of PD type III

All presented scenarios assume a total intervention cost of 1% of cost of production

Model output example

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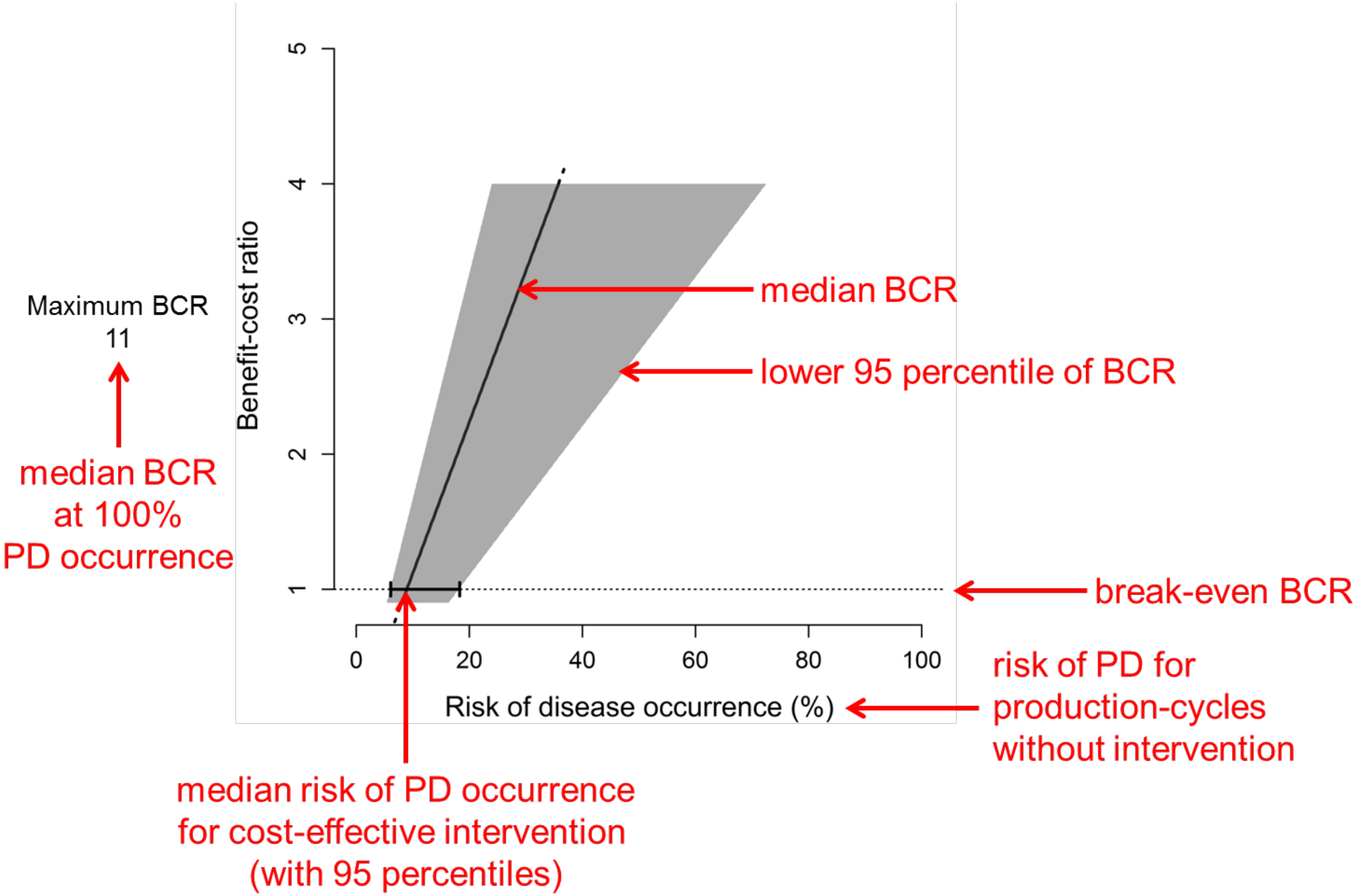
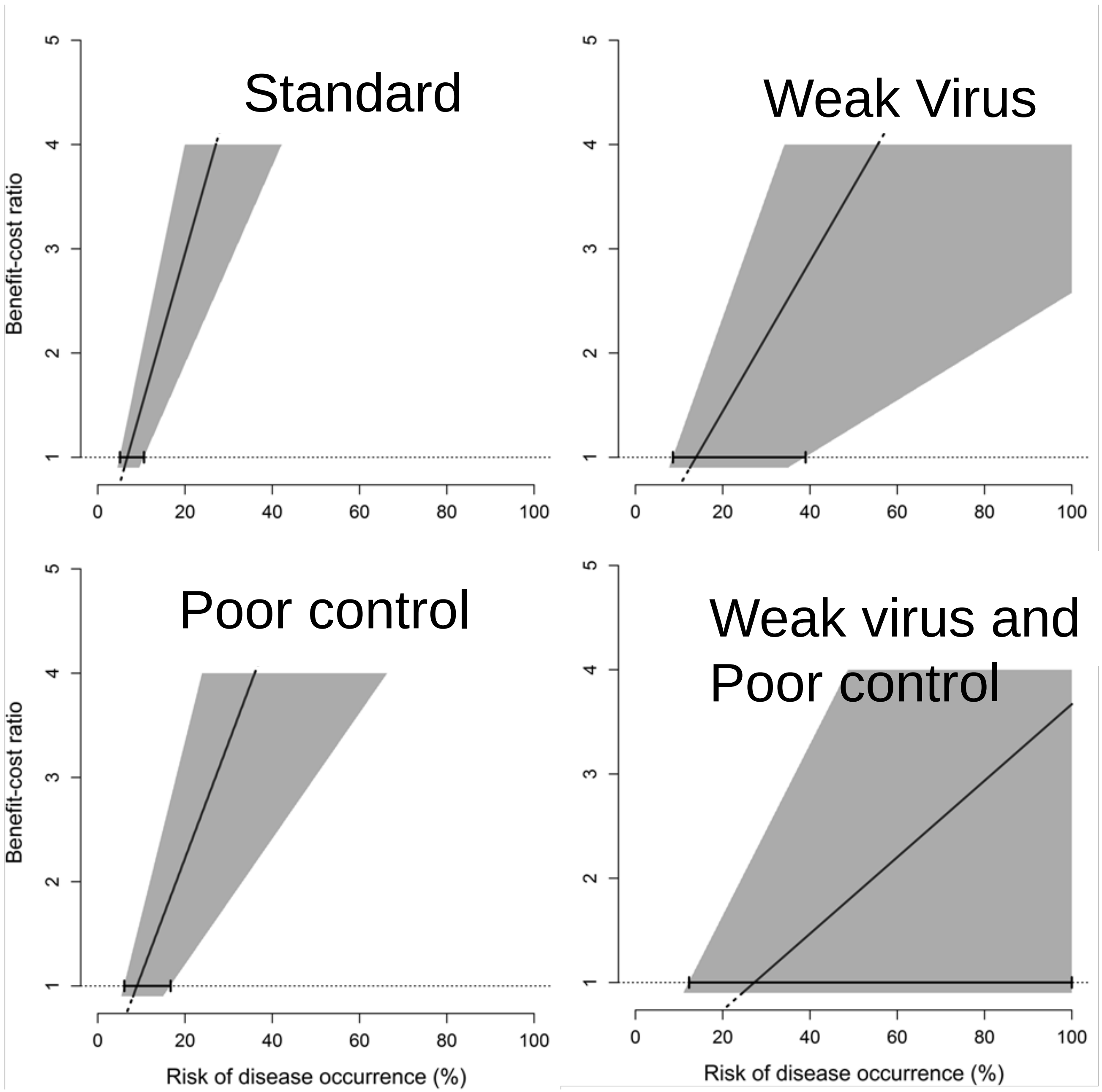


Illustrative model scenario results

Maximum BCR
15



Maximum BCR
7

Maximum BCR
11

Maximum BCR
4

Conclusions

Intervention benefits depend on virulence of strain and efficacy of control

Benefit of prophylactic intervention depends on underlying risk of infection

Benefit of intervention associated with the price of salmon

Controls suggest where PD risk is high prophylactic vaccination should be carried out
When risk is low, interventions such as functional feed are likely to be more cost effective, even if less effective, if targeted following detection of infection

Simple model can be easily run with managers assessment of cost of intervention, reduction in impact from intervention, and risk of infection