Salmonella's Impact on Human Health (SIHH): A food chain perspective on pork production

Course project by:

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Introduction

Salmonella and other microbial hazards have long been considered threats for food safety in many countries. The problems regarding salmonella in pork production have been dealt with in various ways. Some measures have been done at the farm level, others at the slaughter houses. The purpose of the present analysis is to outline a method to view the problem in a holistic perspective, by modelling the food chain from farmer to consumer. Main sources of inspiration from the literature are Roberts et al. (????) and Unnevehr and Jensen (2001). The method employed is the Bayesian Network (BN) approach (Jensen, 2001). BN allows for explicit expressions of probabilities of salmonella evolvement through the food chain. In addition, BN facilitates modelling of the effects of precautious actions taken at various steps in the chain. In the following, the model, called SIHH, is outlined.

1 The SIHH model

The following subsections describe the different parts of the model, starting with the feed inputs to the farms. Then follows modelling of the farm, transportation from the farm to the slaughter house, modelling of the slaughter house and finally processes in the consumers' kitchen and effects on human health are modelled. The software package Hugin has been used. The network is illustrated in figure 1.

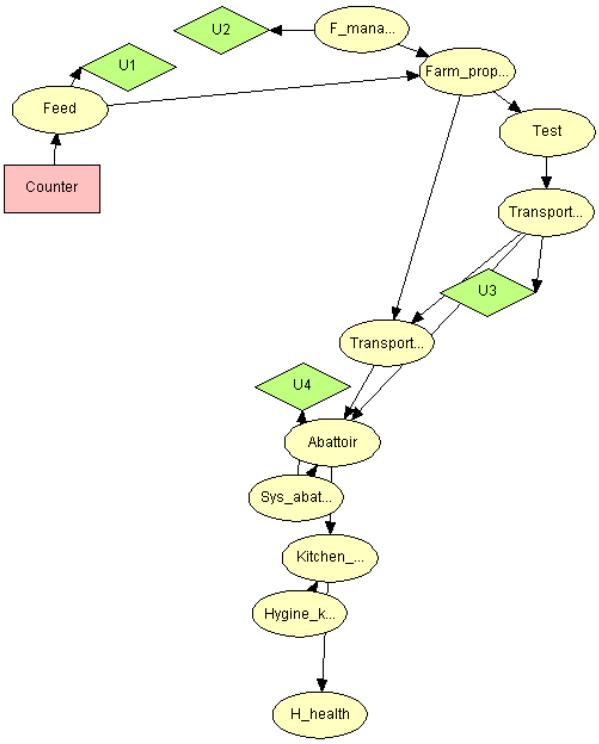

Figure 1: Graphical presentation of the food chain as modelled in Hugin.

1.1 Feed inputs

Nørgaard (1999) has found, that different sources of food has an influence on the prevalence of salmonella in pig production. To model this in SIHH, feed inputs are categorized as either $Feed \in \{Homegrown, Commercial\}$.

1.2 Farm management and transportation

For simplicity farms are modelled as farrowing to finishing units. Therefore, SIHH does not explicitly model how salmonella infection in farrowing/piglet units affects the prevalence ion the finishing herds. However findings by Kranker et al. (2001) do indicate some relevance of the more detailed model.

Management decisions on the level of hygiene and cleaning have an impact on the spreading of salmonella. The way sheds are designed and the way manure is handled also has an impact on the prevalence of salmonella (Nørgaard, 1998). In SIHH all these effects are encompassed in a single variable called management. The variable is binary: $Management \in \{Good, Excellent\}$. The proportion of pigs infected by salmonella is conditioned on management and the type of feed inputs. The proportion of contaminated pigs is given by a distribution on the 3 intervals $0 - 0.1, 0.1 - 0.2$ and $0.2 - 1$.

During transportation pigs can potentially be cross contaminated (Erdman et al., 2003). The farmer can perform a salmonella test on his pigs before they are shipped for slaughtering, to determine the appropriate type of transportation. Non-infected pigs are transported isolated from pigs from other herds, to avoid cross-contamination from other pigs. Severely infected pigs are also isolated from pigs from other herds, to avoid cross-contamination of the other pigs.

1.3 The abattoir

Different production systems exist between slaughter houses. Alban et al. (2002) have developed a tool to decide when infected meat is suitable for human consumption. Some infected meat can safely be used for sausage production. In SIHH, production systems can either be *Ordinary* or *Advanced*.

1.4 Kitchen hygiene

Kitchen hygiene in the home of the consumer is widely recognized as an important factor regarding cross contamination of salmonella. Consumers are a heterogenous group of people. Some keep their kitchen clean and hygiene standards high, others don't mind a little dirt now and then, and finally some consumers are messy and hardly ever worry about kitchen hygiene. The 3 groups are modelled in SIHH, and referred to as $Hysterical$, $Decent$ and $Bachelor$.

1.5 Consumption

The final part of the food chain is the human body. Contaminated food can affect human health in various ways. In SIHH 3 different effects are modelled: $No\ effect$, $Illness$ and $Death$.

2 Data

Due to the lack of data which are apparently applicable, parameters in SIHH are assessed by an spt-analysis.[1]

[1]Spt is a Danish abbreviation for an old saying: "slag på tasken", in English: "hit on the bag", meaning use your intuition to make some sophisticated guesses.

3 Results

The results from the model indicate that the expected number of deaths is insignificant, irrespective under which conditions the model is run. Therefore results given focus on illness cases only. As described above, in the production chain there are different factors affecting the prevalence of salmonella. Each of these factors is associated with costs, illustrated by the diamond shaped nodes in the food chain in figure 1. Farmers can use either homegrown H or commercially C purchased feed. Furthermore, farmers can achieve good G or excellent E management skills. At the abattoir production can be performed with an ordinary O technology or an advanced A technology. The model has been run with the factual distribution of the factors. It was found that the number of expected illnesses caused by salmonella infection from pork is around 16, which is considered the baseline case for comparison with counterfactual cases. Figure 2 illustrates the baseline case as being associated with zero-costs. Running the model with counterfactual "evidence", results are obtained regarding the additional costs or savings and the counterfactual number of expected illnesses is given. The extreme counterfactual cases where all farmers are as-

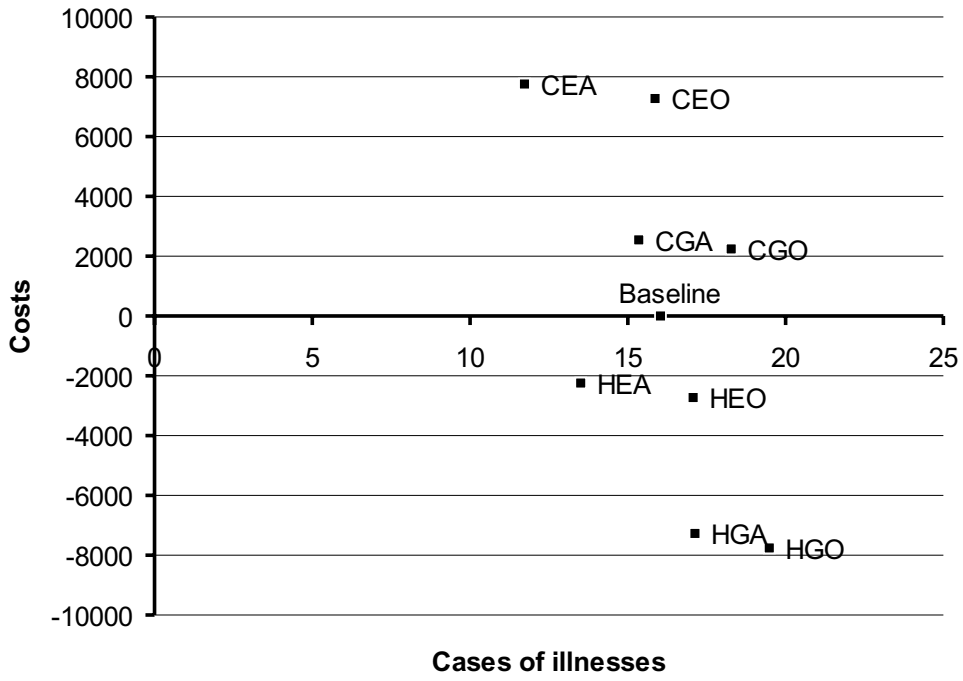

Figure 2: Trade-off between costs and cases of salmonella related cases of illness.

sumed to use homegrown feed and commercially purchased feed respectively are done with the model, as well as the cases with all farmers having good and excellent management

skills respectively and the cases where abattoirs employ ordinary and advanced production technologies respectively, giving a total of $2^3 = 8$ counterfactual cases. Results of the counterfactual simulations done with Hugin are given in figure 2, where the first letter indicates the type of feed, the second letter indicates management skills and the third letter indicates the production technology at abattoir.

Due to the method of data collection described in section 2, some caution should be taken as to interpretation of the findings illustrated by figure 2. The HEA case where all farmers use home grown feed and have excellent management skills and all abattoirs have advanced production technology turns out to be a double-dividend situation, where costs are reduced at the same time as the number of illness cases also is reduced.

A sensitivity analysis as suggested by Coupe and van der Gaag (1998) and Gaag (van der) and Renooij (????) has been done to see how various proportions of farmer performing good and excellent management skills respectively affect expected number of illness cases. The number of illness cases $n_{illness}$ is expressed as a function of the proportion of farmers having good management skills x:

$$n_{illness}(x) = \frac{-257.4x - 1323.825}{x - 91}$$

The function is nearly linear in the interval $[0; 1]$, and increasing from 14.5 illness cases to 17.5 illness cases. Therefore, the more farmers having good management skills (less with excellent skills) the more cases of illness from salmonella are expected. Intuitively this result is appealing.

4 Use of SIHH

An alternative method of data collection needs to be employed to enable accurate analyzes of what impact changes in farming and abattoir practices have on the prevalence of salmonella and the expected result on human health.

5 Discussion

It would very nice if Hugin could do sensitivity analyzes as elegant as the system Linda is using for her work at Utrecht University. Calculating the sensitivity function mentioned above manually is unnecessarily cumbersome, and therefore only a single example is given.

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