

# Quantitative assessment of Salmonella risk in pig feed chain

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## Introduction

Pig meat and products thereof have been among the most frequently reported sources of food-borne human salmonellosis (EFSA and ECDC, 2015). Therefore, it is of interest to examine the potential sources of infections for pigs, as these zoonotic bacteria are known capable of transmitting from production animals to the produced food items.

Besides from environmental routes, pigs can get Salmonella infection from contaminated feeds (EFSA BIOHAZ, 2008). It has been suggested that especially in countries with low Salmonella prevalence, significant share of animal infections could be feed-borne. In Finland not only food but also animal feed chain is monitored for Salmonella - from the production of feed ingredients to the feed consumption. Chemical and heat treatments are used to control the pathogens in imported feed ingredients and manufactured feeds.

The aim of the study was to quantify the risk of feed-borne infections for Finnish pigs and sows (Fig. 1). Feed chain has been modeled (Sauli et al., 2005; Binter et al., 2011), but no overall estimation attempts to quantify the resulting risk for animals have been presented yet, to our knowledge. Bayesian methodologies have advantages in the context of microbiological risk assessment (Greiner et al., 2013), and have been used to model production chains (Ranta et al., 2005).

## Materials and methods

A Bayesian model (Fig. 2) was built based on the data gained from reports, registries, questionnaires, literature, legislation and statistics about feed production, pig farming and their Salmonella surveillance. Uncertainties were quantified probabilistically by making an evidence synthesis of the available information over a categorically structured conceptual chain from feed ingredients to served feeding mixtures (feeds).

The model consists of sub-models for Salmonella contamination levels in feed chain, for the dose-response, and, for comparison of feeds and environmental sources of infection. In Fig. 2, surrounding boxes represent loops over the categories (named with orange texts). Dose-response module is used to provide uncertainty distribution independently from the full Bayesian model. The overall probability of infection from feed for pigs ( $P_i$ ) was calculated from the Salmonella prevalence in feeds and the probability of infection in the case of positive feed.

Prevalence ( $p$ ) of Salmonella in materials at three presented stages ( $i, j, k$ ) of feed chain was binomially modeled from the number of surveillance samples ( $N$ ) and positives ( $x$ ). Log-normal model was used for the concentration in positive feed (measurement data =  $c$ , mean =  $\mu$  and variance =  $1/\tau$ ) at corresponding stages. The relationship between the stages was defined by weighted mixing. Prior to mixing, prevalence was converted to overall concentration based on the relationship between sample prevalence and concentration in a Poisson process. Moreover, relative prevalences were used as weights when evaluating the expected concentration in positive materials ( $\mu$ ) in the next stage. Concentration is also linked to apparent prevalence of the same stage, via test sensitivity (not all dependencies shown in the Fig. 2). Factors ( $D$ ) for decontaminating treatments were included in the model too.

In the end, the proportion of feed-borne infections ( $r_i$ ) for pig types was inferred jointly from (1) the model-based predicted Salmonella prevalence ( $P$ : feeds & other) in pig types, and (2) slaughter samples ( $N_p$  = lymph node samples,  $x$  = positives) and (3) Salmonella types detected in specific samples informative of the source of infection ( $z_e$  = typings indicating environmental route of infection in  $N_s$  cases).

## Discussion

Proportion of feed-borne cases of all infections was estimated higher for sows using both yearly surveillance datasets, and a clear variation between the years can be identified. However, the uncertainty is notable due to limitations of data. Because of the very low Salmonella prevalence in both feeds and animals in Finland, the results from the model are sensitive for any slight changes of observed positives in data. Nevertheless, the results are directional, and the presented approach provides platform for the future development considering the research of the Salmonella risk from feed.

## Results

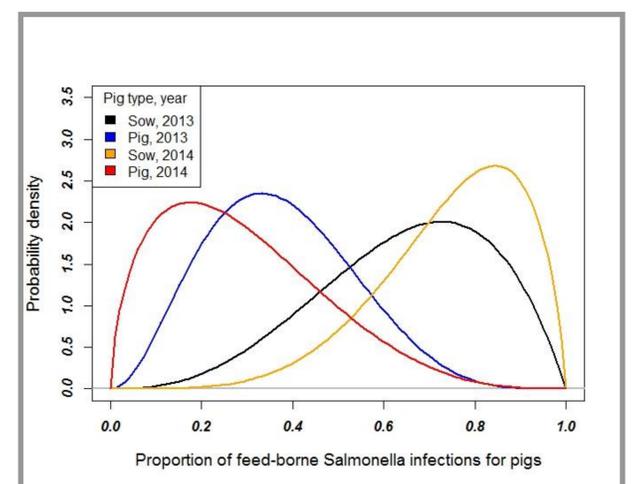


Fig. 1. Salmonella risk from feed for Finnish pigs. Posterior densities for the proportion of feed-borne infections, for two pig types, using surveillance data of two years. Data on Salmonella types in specific samples informative of the source of infection was from the years 2010-2015 in both calculations.

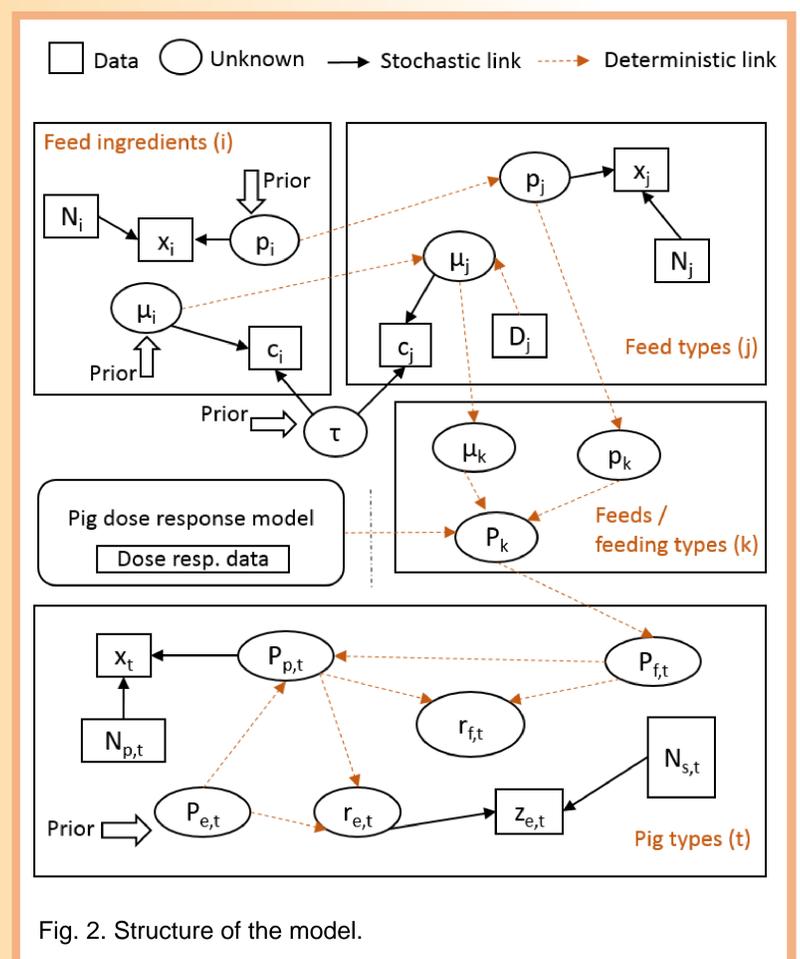


Fig. 2. Structure of the model.

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