Modelling *Salmonella* spread in a pig farm under three biosecurity strategies

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INTRODUCTION

The *Salmonella* contamination level of pigs at slaughter age is a critical point in the contamination of the human food chain. Our aim was to estimate by simulation the influence of within farm biosecurity strategies on the prevalence of shedder and carrier pigs at slaughter age.

METHODS AND MATERIALS

We developed a stochastic mathematical model to simulate the pig population dynamics (Fig.1) and the *Salmonella* transmission within a farrow-to-finish herd. In this herd, the farrowing batch system was set. To model the infection of *Salmonella* in sows and pigs, three states were distinguished: susceptible state, shedder state, and carrier state. *Salmonella* transmission between pigs depended on contamination of pen floor which was influenced by the prevalence of shedders in the pen. Input parameter values for *Salmonella* transmission were estimations from literature (1,2,4,5). We modelled variability of pig reproduction and growth and of producers' management that can influence the size of batches. Groups of slaughtered pigs were issued from several batches depending on their weight. For an effective control of *Salmonella* transmission within a farrow-to-finish herd, biosecurity interventions simulated here were prevention of batch mixing while raising pigs and implementation of cleaning and drying period between consecutive batches. We tested three biosecurity strategies: (i) strict all-in/all-out (AI/AO), (ii) all-in/all-out with suppression of the drying period between batches (NDP), and (iii) possible batch mixing and suppression of the drying period between batches (BM). We calculated the frequency of batch mixing, that was the number of batch mixed per total number of batches produced, during finishing under the BM strategy. We assumed a herd marketing 210 pigs every four weeks on average. We needed to reach an equilibrium for the prevalence of the shedder and the carrier pigs in the herd to compare different biosecurity strategies. For that, we chosen to begin the simulation with the introduction of a shedder gilt and ran until we obtained a realistic prevalence of *Salmonella* within the herd. Afterwards, we estimated the influence of the three biosecurity strategies on two model outputs: (a) the average number of batches in a slaughtered group, (b) the prevalence of shedder and carrier pigs at slaughter age. One hundred simulations were performed for each biosecurity strategy over a 300-week period.

RESULTS

The frequency of batch mixing at finishing was 40% (±SD=3.2) for the BM strategy. The number of batches in a group at slaughter differed significantly under the three biosecurity strategies (P<0.01) (Tab.1).

Table 1. *Distribution of proportion of groups of pigs at slaughter per number of batches under the three biosecurity strategies.*

Biosecurity strategy	Number of batches 1	2	3	>3
AI/AO	0.18	0.34	0.30	0.18
NDP	0.21	0.35	0.27	0.17
BM	0.25	0.20	0.31	0.24

The introduction of a shedder gilt at the beginning of the simulation led to an average prevalence of 20% of shedder and carrier sows in the herd under the AI/AO strategy after around 50 weeks. When we change the biosecurity strategy at 130 weeks, the prevalence of shedder and carrier pigs at slaughter varied between the three strategies tested around 20 weeks later (Fig. 1). Prevalence of shedders and carriers at slaughter differed significantly (0.53±0.01. 0.45±0.02 and 0.27±0.04 for BM, NDP and AI/AO, respectively) (prevalence ± SD, p<0.001).

DISCUSSION

Allowing contact between batches and reducing drying period increased the *Salmonella* transmission within the herd. When pigs from two batches were mixed, the number of shedders and carriers at slaughter age was almost twice higher than under AI/AO strategy.

Our modelling approach allowed to investigate the magnitude of the effects of biosecurity strategies. We used a simple epidemiological model. Transmission parameters must be precised. Indeed, published parameters were obtained from experiments which were not always performed in realistic herd conditions and varied highly depending on authors. Moreover, environmental transmission parameters are not documented. Sensitivity analysis on parameter values has to be done.

Previously published models described *Salmonella* transmission assuming homogeneous pig populations and considered only the growing and the finishing periods (3,6). Our model studied the influence of both biological variability (such as growth heterogeneity) and producers' decisions on the population dynamics and structure. The contact structure plays a major role in pathogen transmission in a farrow-to-finish herd.

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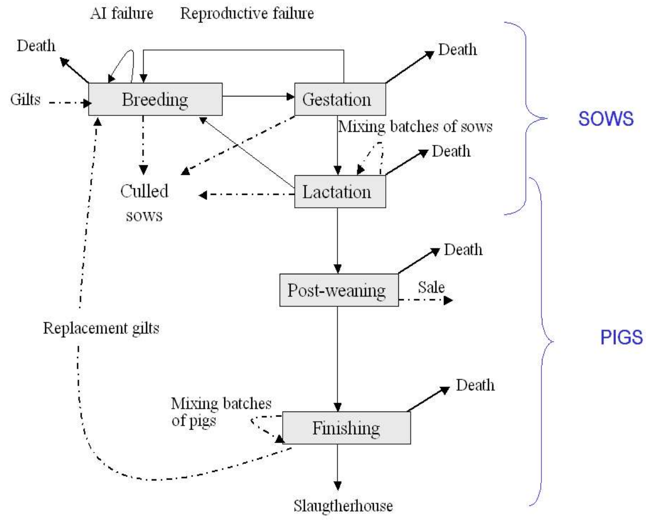

Figure 1. *Simplified flow diagram of the farrow-to-finish herd production system. flows linked to demographic processes --> flows controlled by producer,* **).**

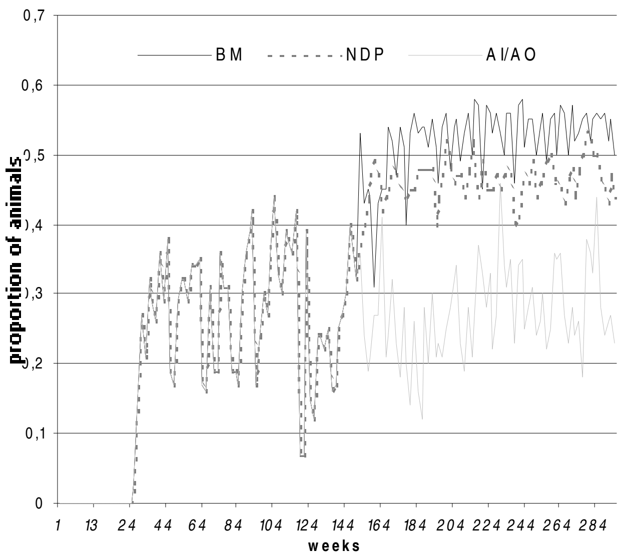

Figure 2. *Prevalence of shedder and carrier pigs at slaughter over 300 weeks under AI/AO, NDP and BM biosecurity strategies (average over 100 simulations).*