Veterinary Medicine

Transmission models of ESBL-producing *E. coli* in the broiler production chain

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INTRODUCTION

ESBL-producing *E. coli* in the broiler production chain inactivates antimicrobials, acts as a reservoir of antimicrobial resistance genes and contributes to the emergence of new resistant bacteria.

AIM

To develop a transmission model of ESBL-producing *E.coli* in broiler production chain and evaluate interventions.

METHODS

Model overview

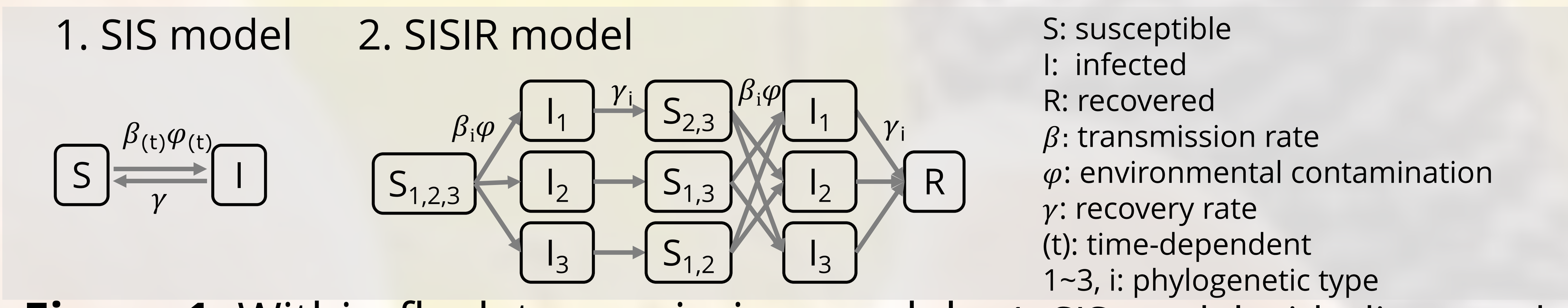

Figure 1. Within-flock transmission models. 1. SIS model with direct and indirect transmission, which are reduced as a bird ages. Only one phylotype is included. 2. SISIR model with three phylotypes with cross-immunity after two infections. Only indirect transmission without transmission reduction.

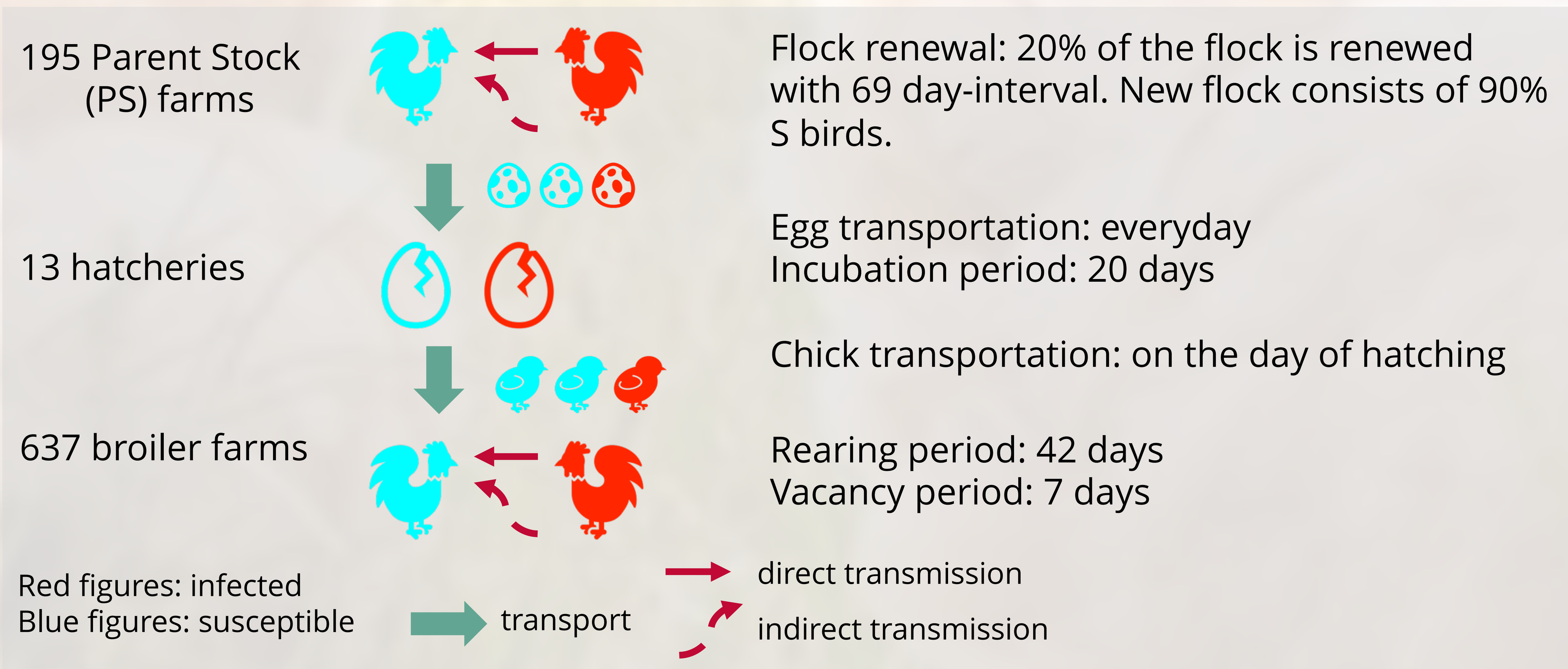

Figure 2. Within-flock and between-stage transmission dynamics.

Parameter estimation

- Within-flock: Approximate Bayesian computation (ABC)[1] on longitudinal data from a Dutch organic broiler farm[2]
- Between-production stage: literature[3]

Evaluation of interventions

Intervention in practice	Parameter adjustment
1 Competitive exclusion (CE), vaccine, hygiene management	Transmission reduced to 1/3 of the baseline value (PS and broiler)
2 CE, vaccine	Shedding reduced to $1/10^5$ of the baseline value (PS and broiler)
3 Cleaning and disinfection	Bacteria survival reduced to 0 during vacancy period (broiler)

Table 1. Interventions and parameter adjustment.

Quantitative microbiological risk assessment

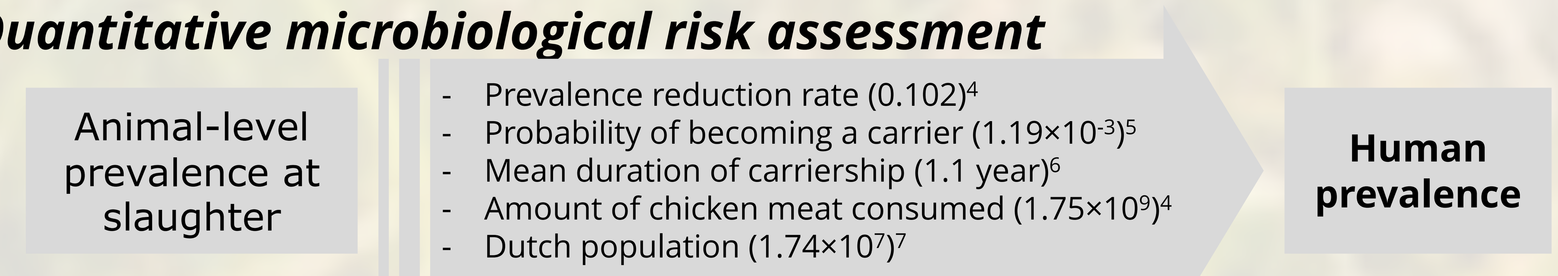

Figure 3. Assessment of human prevalence due to consumption of chicken meat.

Simulation method

- SimInf package[8] (version 8.2.0.9000) in R (version 4.0.4)

RESULTS

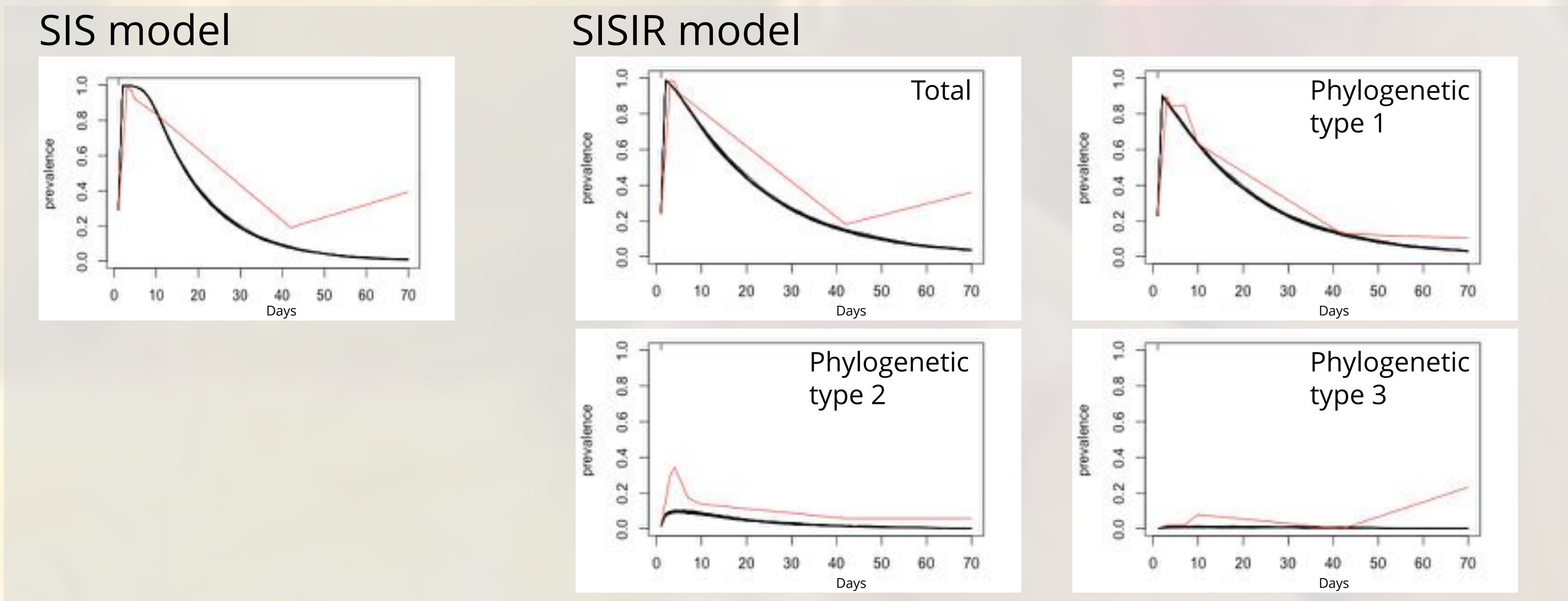

Figure 4. Observed (red) and ABC fitted (black) animal-level prevalence in a broiler farm without demography or between-production stage transmission.

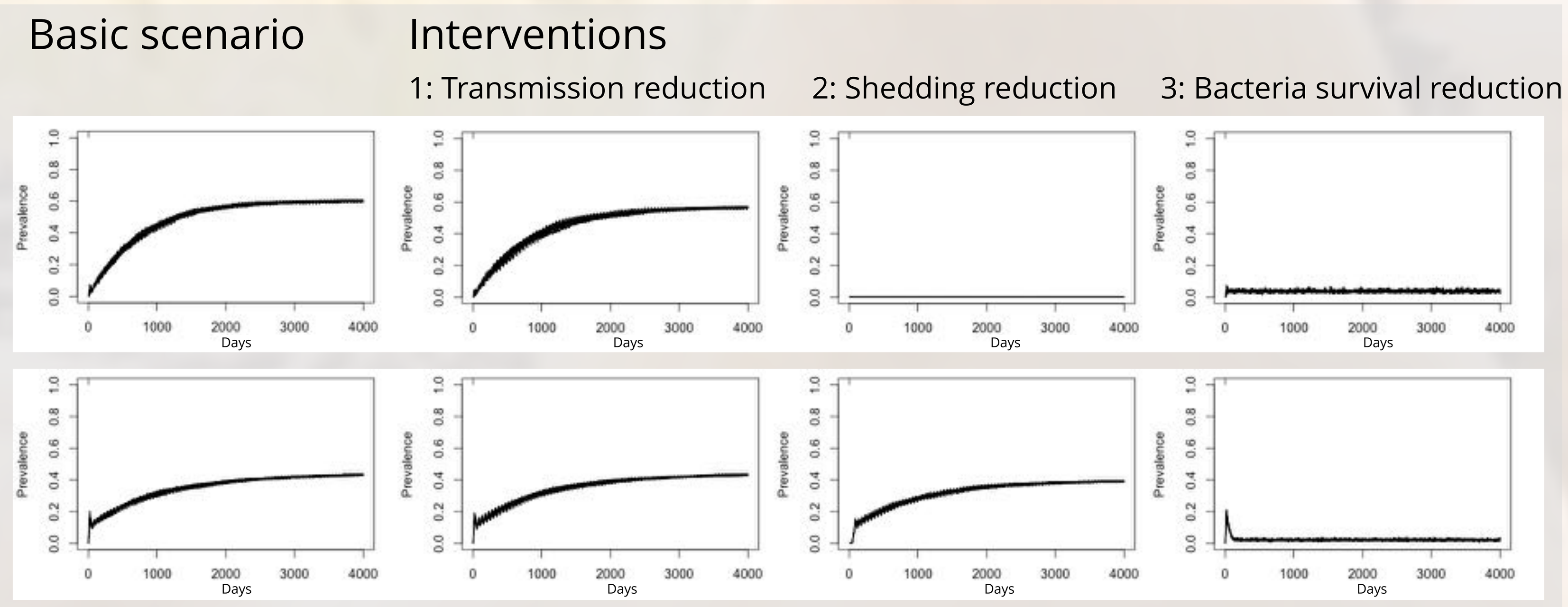

Figure 5. Simulated animal-level prevalence in broiler farms with demography and between-stage transmission with and without interventions (top row: SIS model, bottom row: SISIR model).

Model		Basic scenario	Interventions		
			1	2	3
SIS	Broiler	10.6%	9.2%	0.0%	0.0%
	Human	0.1%	0.1%	0.0%	0.0%
SISIR	Broiler	14.1%	14.3%	22.2%	1.1%
	Human	0.2%	0.2%	0.3%	0.0%

Table 2. Simulated animal-level prevalence at slaughter in broiler farms with and without interventions and human prevalence due to consumption.

DISCUSSION

- Intervention 3 (complete clearance of bacteria between production rounds) was the most effective for both models. However, a minor environmental contamination from the previous round can initiate an outbreak in the next round.
- Intervention 2 (reduced shedding) did not reduce the prevalence in SISIR model because the transmissibility is constant and reduction was not enough, while it was effective in SIS model where the transmissibility decreases exponentially during a round.
- Consumption of chicken meat had minor estimated contribution of 0.1 to 0.2% of human prevalence (overall prevalence 4.68%[9]).

CONCLUSIONS

To implement effective interventions, it is important to know the mechanism of transmission. Thorough cleaning and disinfection between production rounds in broiler farms can reduce ESBL-producing *E. coli* but may be difficult in practice.

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