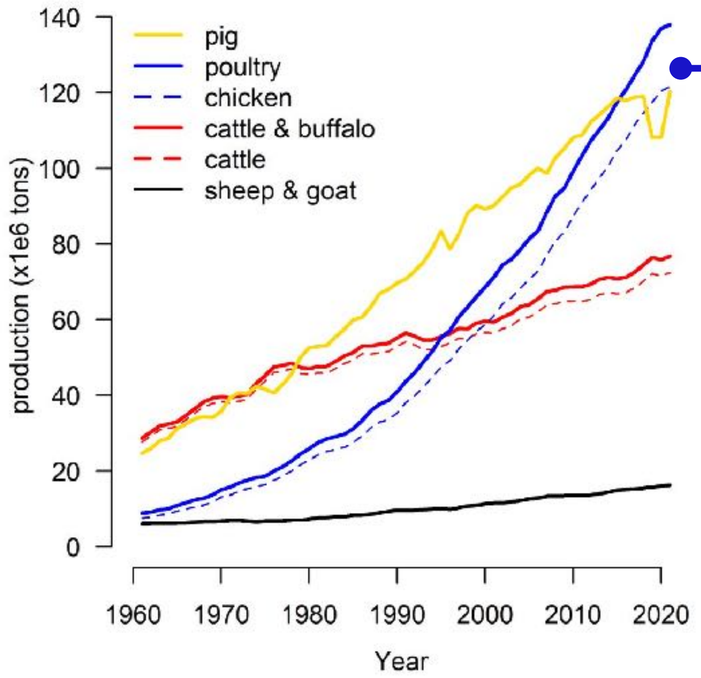
# Modelling avian influenza transmission in poultry production and distribution networks in Bangladesh

Francesco Pinotti, *ModStatSAP*, 16/05/2024


# Livestock production is increasing globally

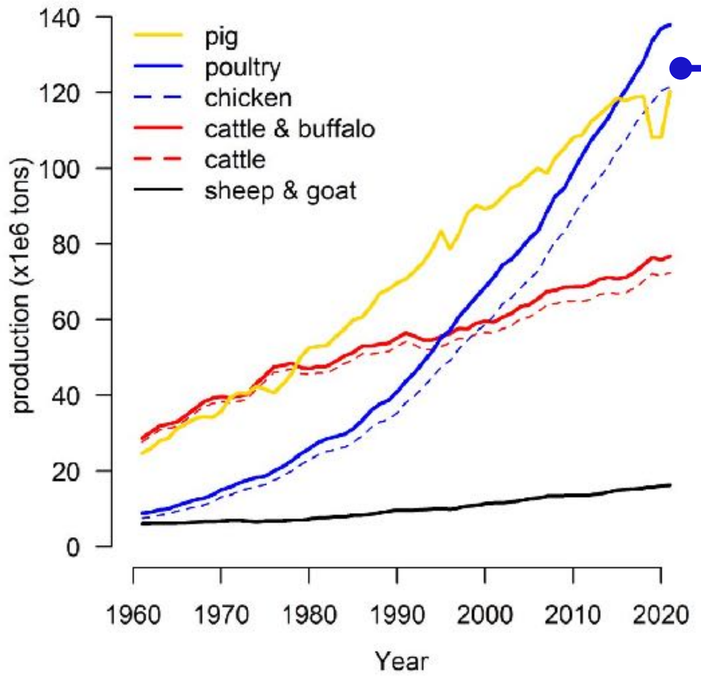



**poultry is the fastest growing sector**

**Increasing volumes and intensification of production raise concerns about pathogen transmission**

ONE HEALTH POULTRY HUB

# Livestock production is increasing globally




**poultry is the fastest growing sector**

**Increasing volumes and intensification of production raise concerns about pathogen transmission**

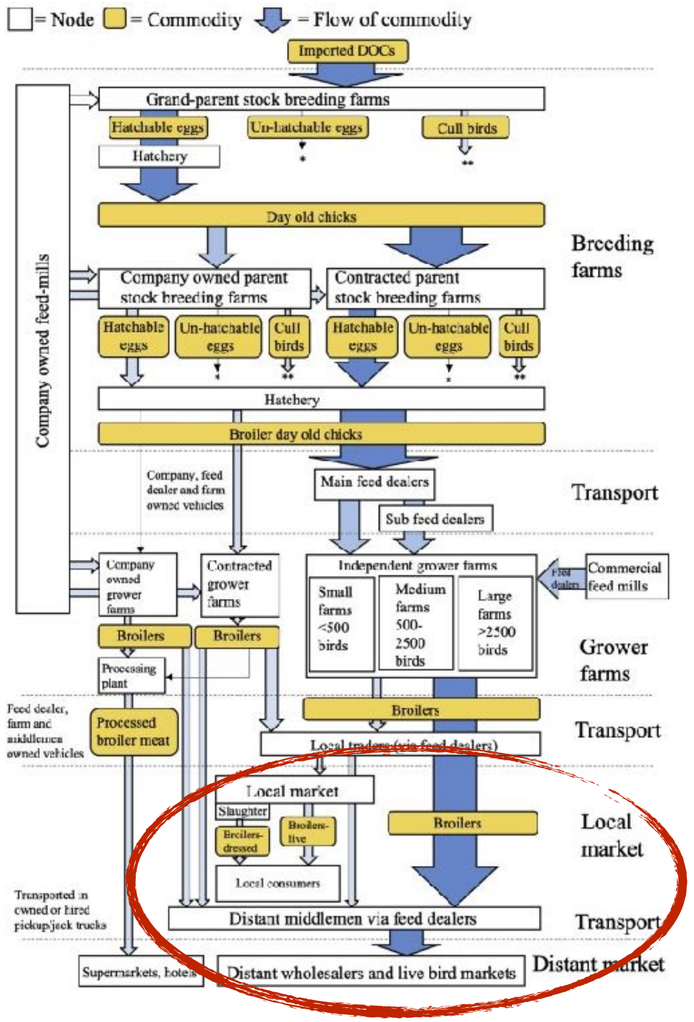
**Characterise the networks through which chickens are produced and distributed (PDNs)**

ONE HEALTH POULTRY HUB

# Poultry production and distribution in Bangladesh

Poultry moves along complex and heterogeneous networks before reaching consumers

Flow of birds




**Live-bird markets (LBMs)**

Hennessey et al, Prev Vet Med, 2021

# Live Bird Markets in Bangladesh

## LBMs sustain AIV transmission

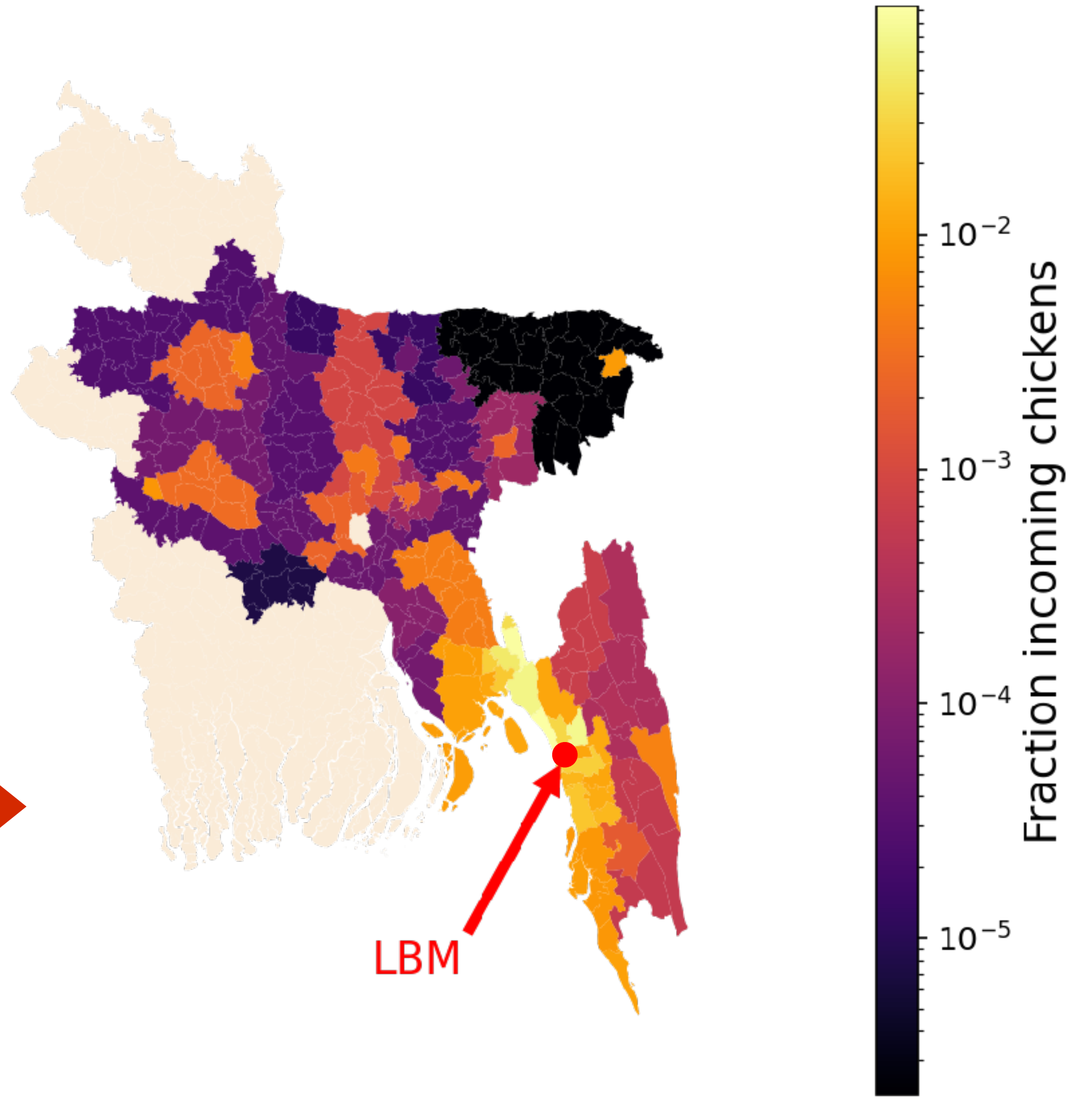
- **High (H9N2 AIV) viral prevalence**

  Negovetich et al, *PLOS ONE*, 2011; Kim et al, *Emerging Infect Dis*, 2018

- **High mixing of birds and viruses**

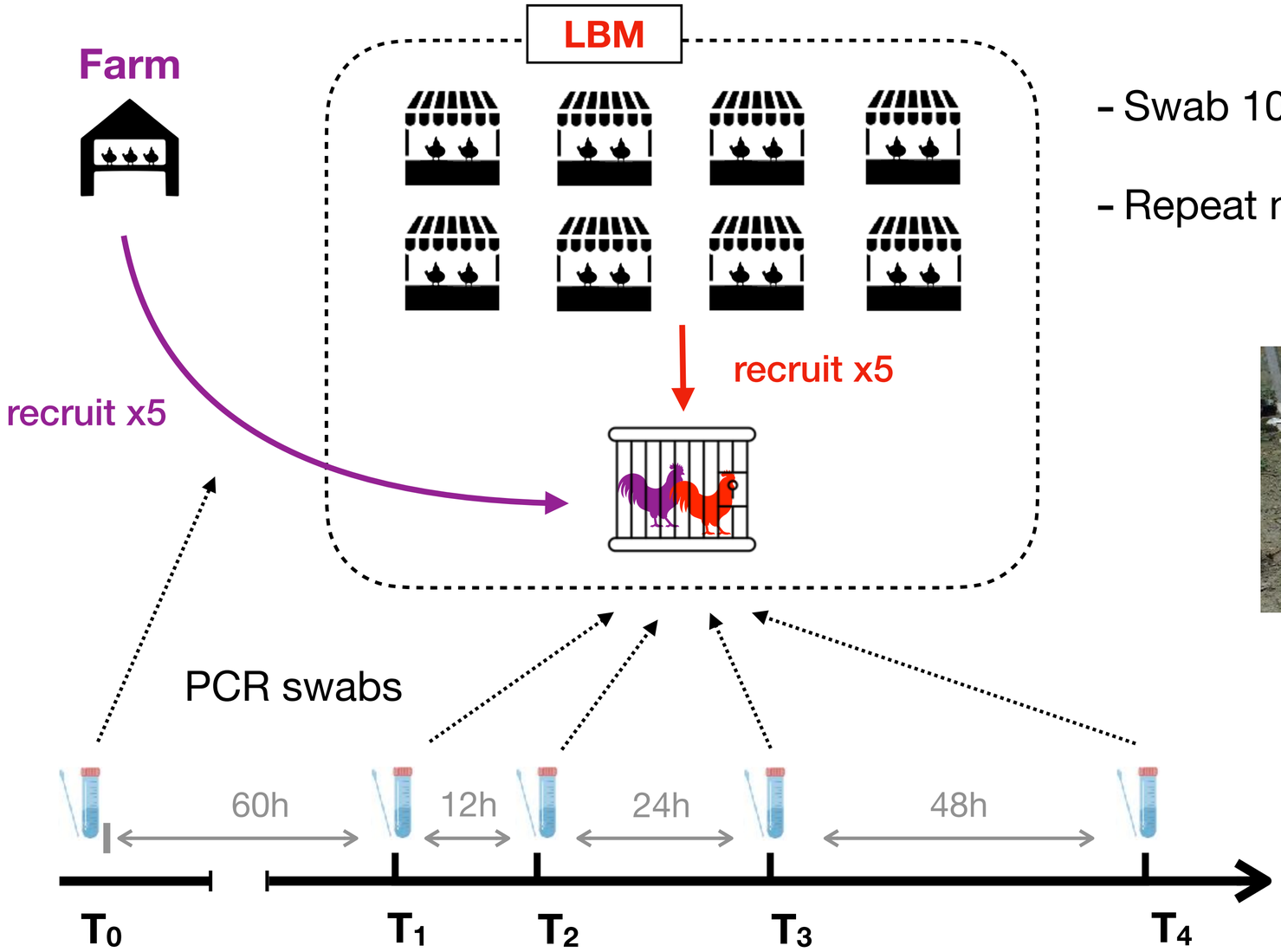
  Moyen et al, *Sci Rep*, 2021

**Catchment area for a single LBM**
(where do chickens come from?)



# H9N2 AIV transmission in an LBM - a field experiment

Credits: Lisa Kohnle




- Swab 10 chickens caged in an LBM for 3.5 days
- Repeat many times with different chicken types

**Exotic broiler chicken**

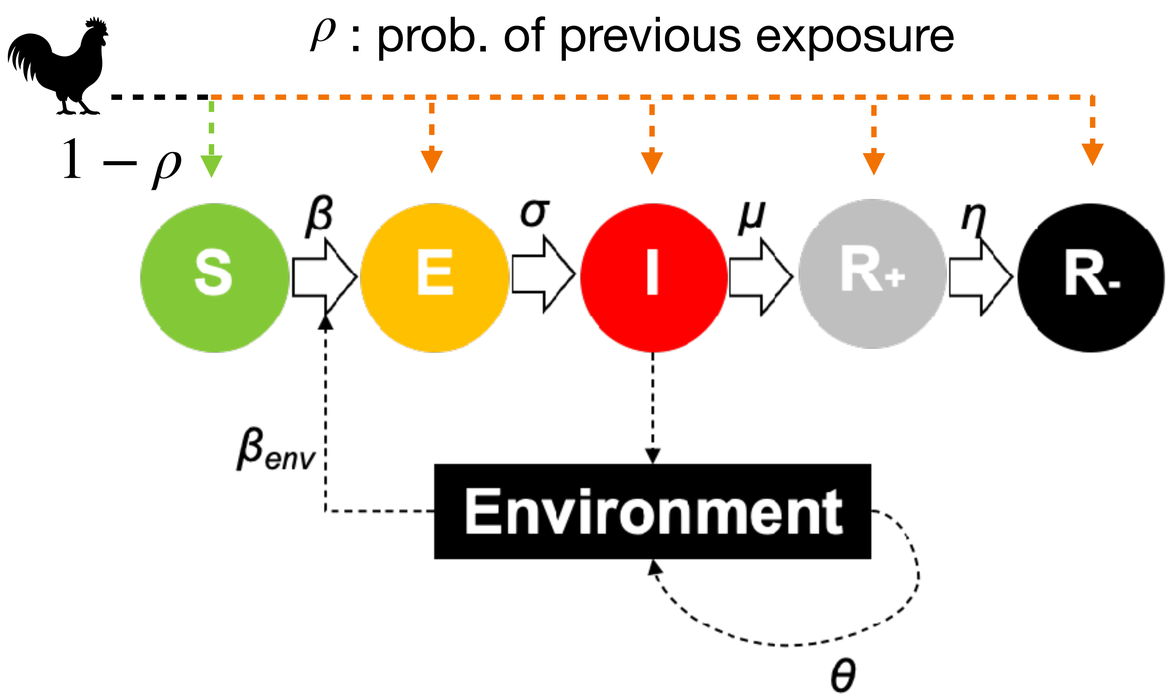
**Backyard chicken**

*Kohnle et Al., Under Review*

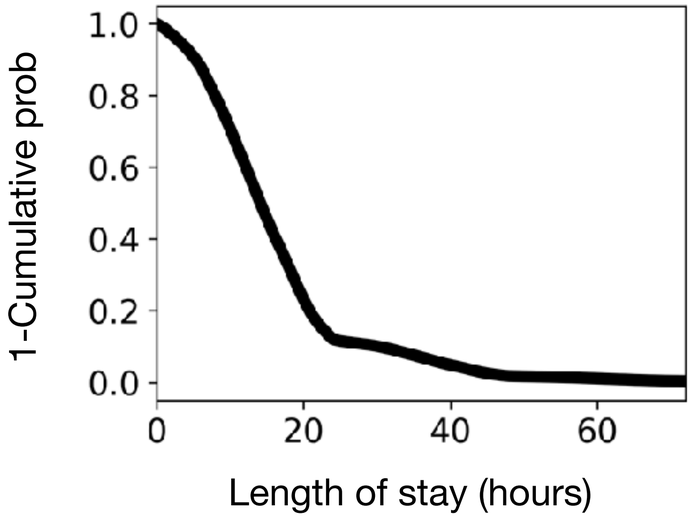
# Fitting a mechanistic model

Pinotti et Al, Nat Commun, 2024

SEEIRR compartmental model for H9N2 AIV




Simulate poultry trade

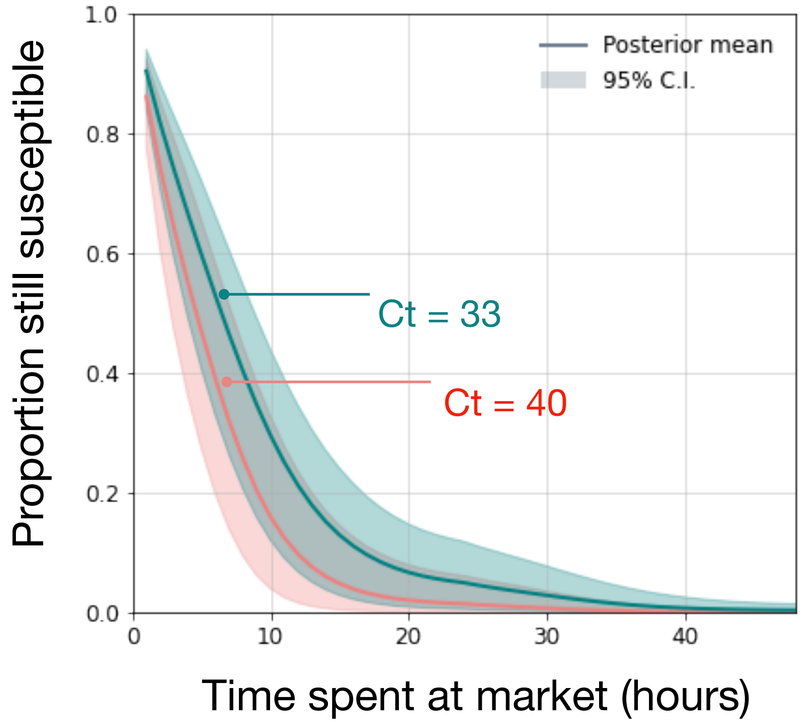



Infer parameters about **transmission**, **disease progression**, **viral introduction**

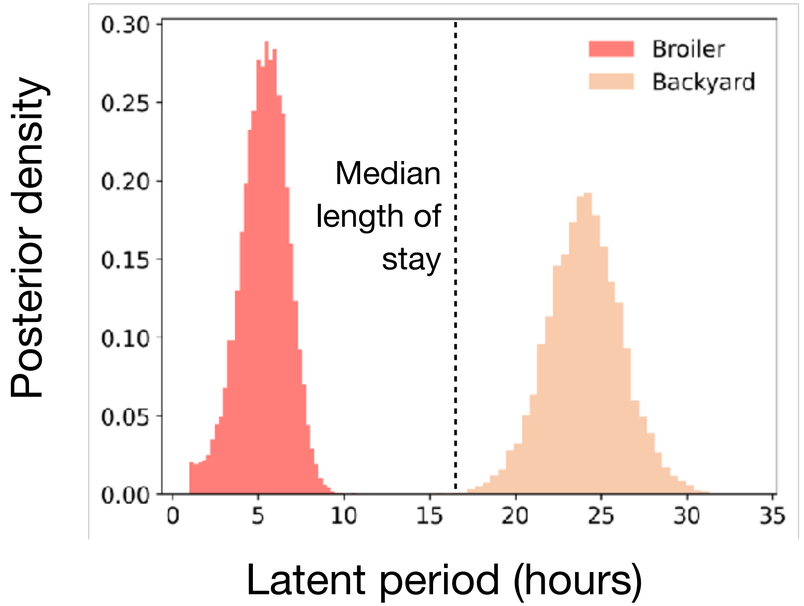
# High H9N2 AIV transmission within LBM

Pinotti et Al, Nat Commun, 2024

**(1) More than 80% of chickens become infected within 24 hours in the LBM**



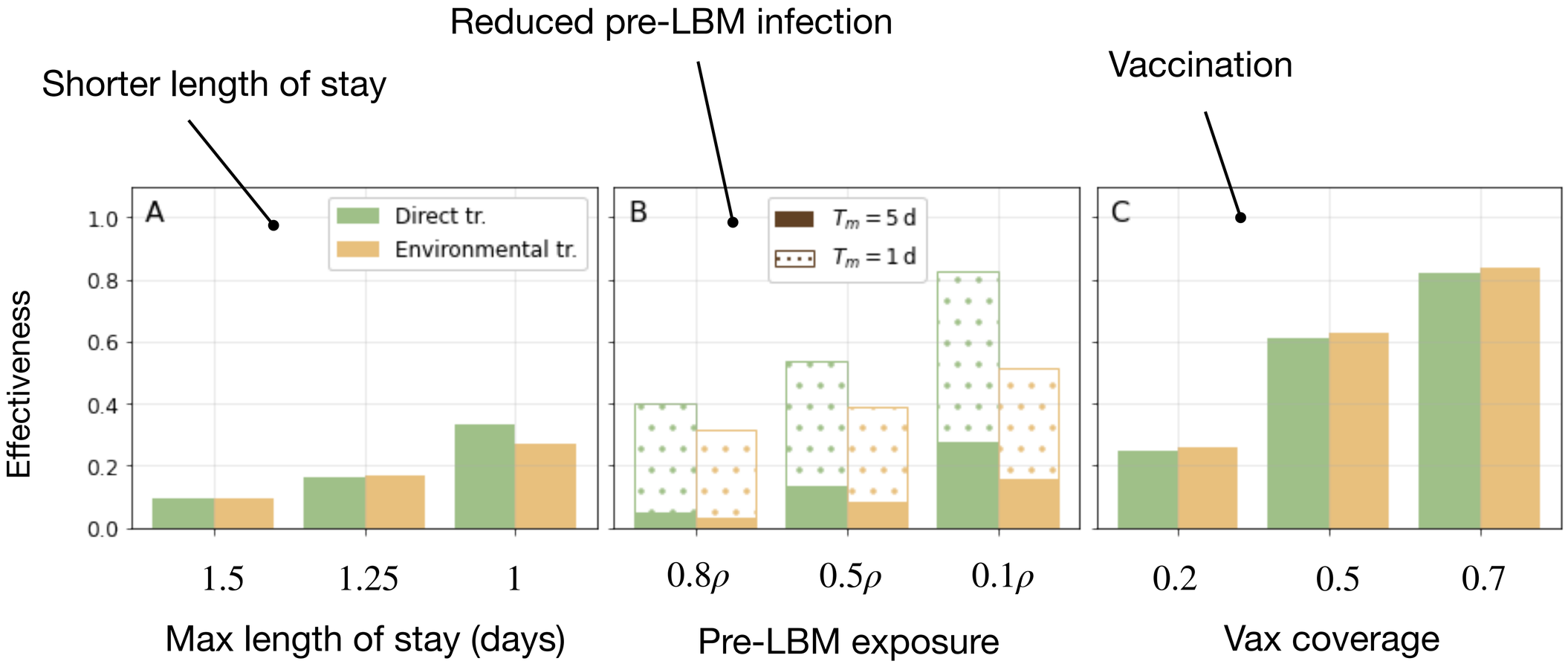

**(2) broilers become infectious in ~6 hours**




**(3) ~10% of broilers enter the LBM as latent/infectious**

# Interventions

Pinotti et Al, Nat Commun, 2024



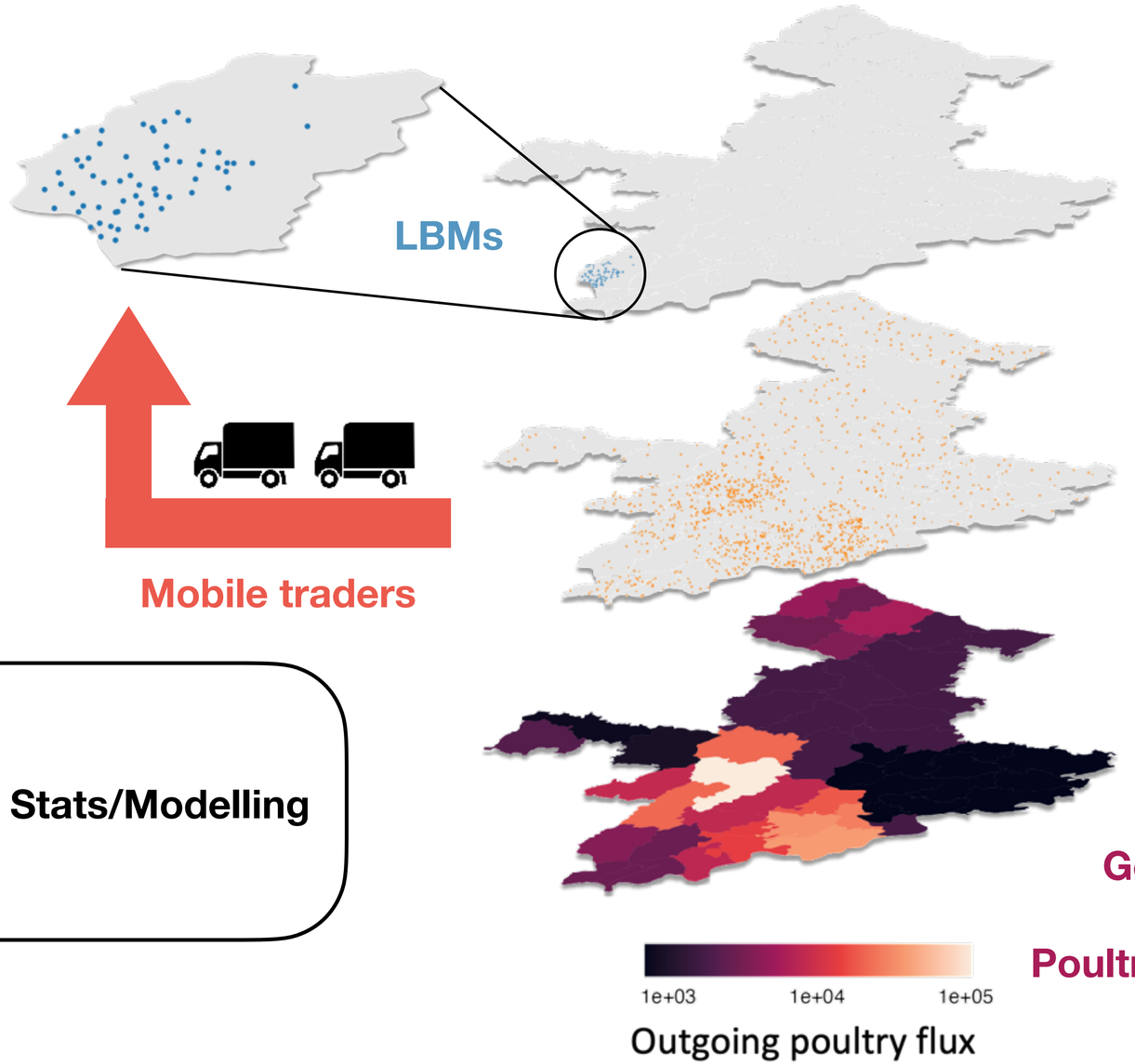

**We should consider not only markets but the entire production & distribution system**

# EPINEST (EPIdemic NEtwork Simulation in poultry Transportation systems)

- Generate synthetic PDNs

- Data-driven

- Modular & customisable




**Available data**

**Questionnaires**

**Stats/Modelling**

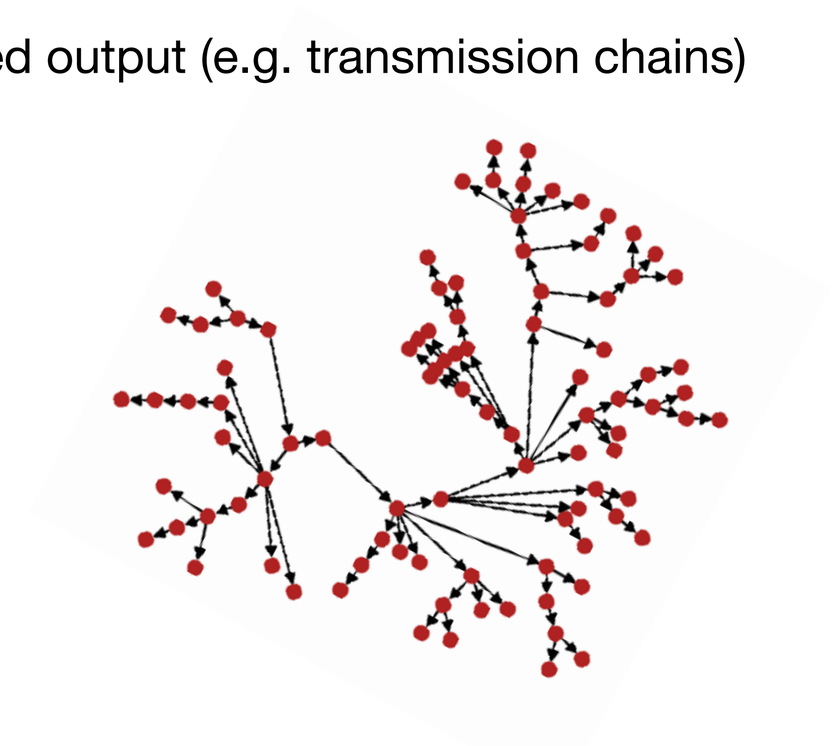
Pinotti et Al, PLOS Comp Biol, 2024

# Epidemic simulations

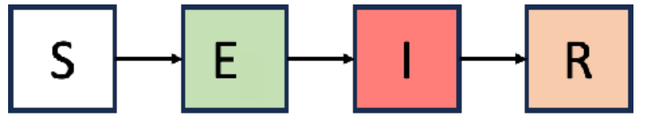
- Explore different modelling assumptions

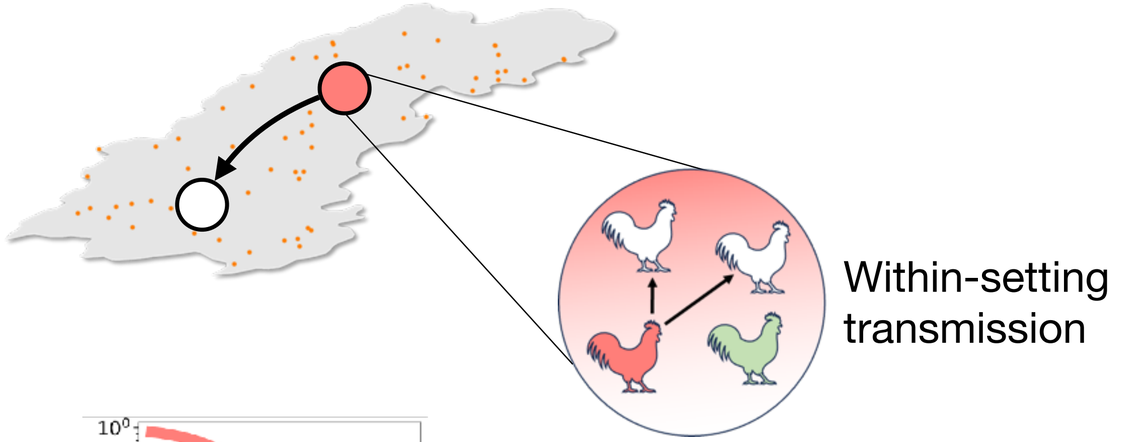
- Single/Multi strain simulations

- Detailed output (e.g. transmission chains)

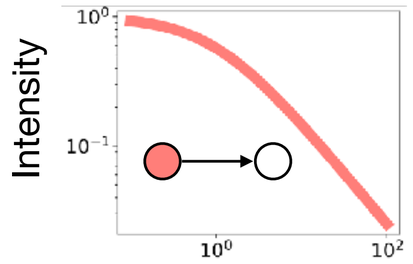


Pinotti et Al, PLOS Comp Biol, 2024



Within-setting transmission

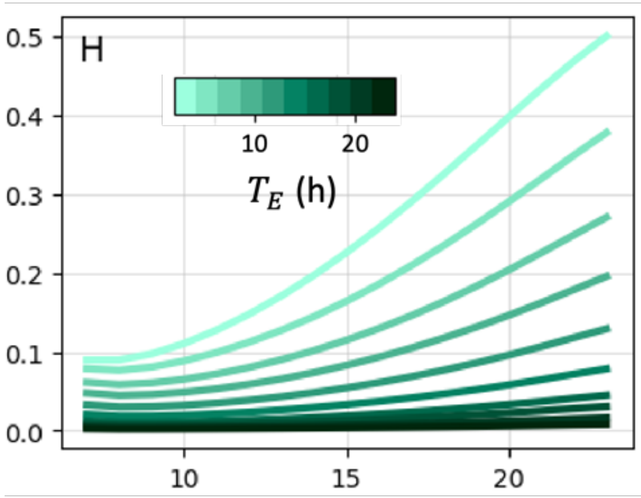



Between-farm transmission

# Example: characterise AIV persistence in LBMs

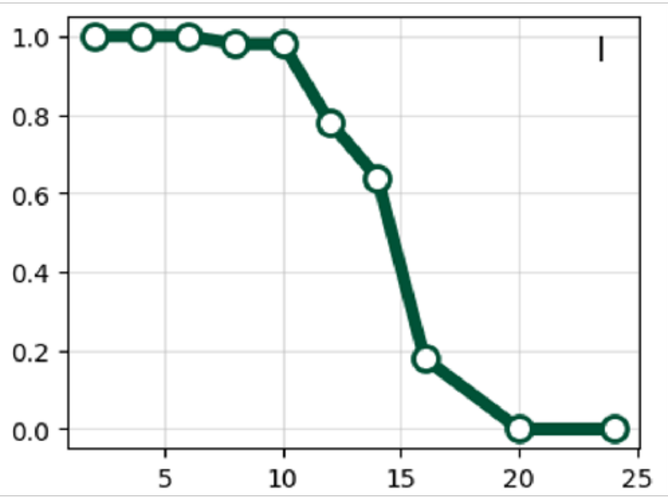
We vary the duration of latency $T_E$ (infection to infectiousness)

LBM prevalence




Time of day

Persistence



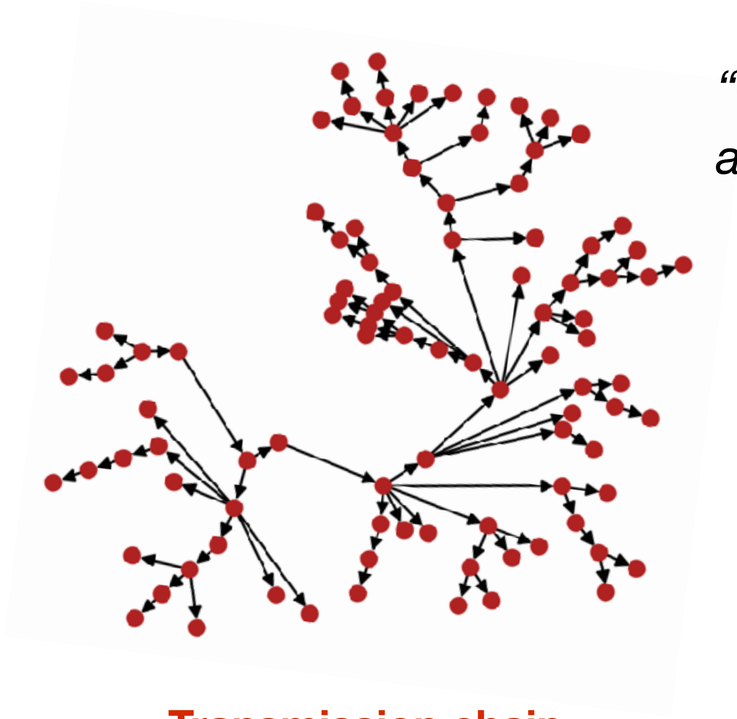

Latency (hours)

**Persistence** = Probability of a long-lived transmission chain

Pinotti et Al, PLOS Comp Biol, 2024

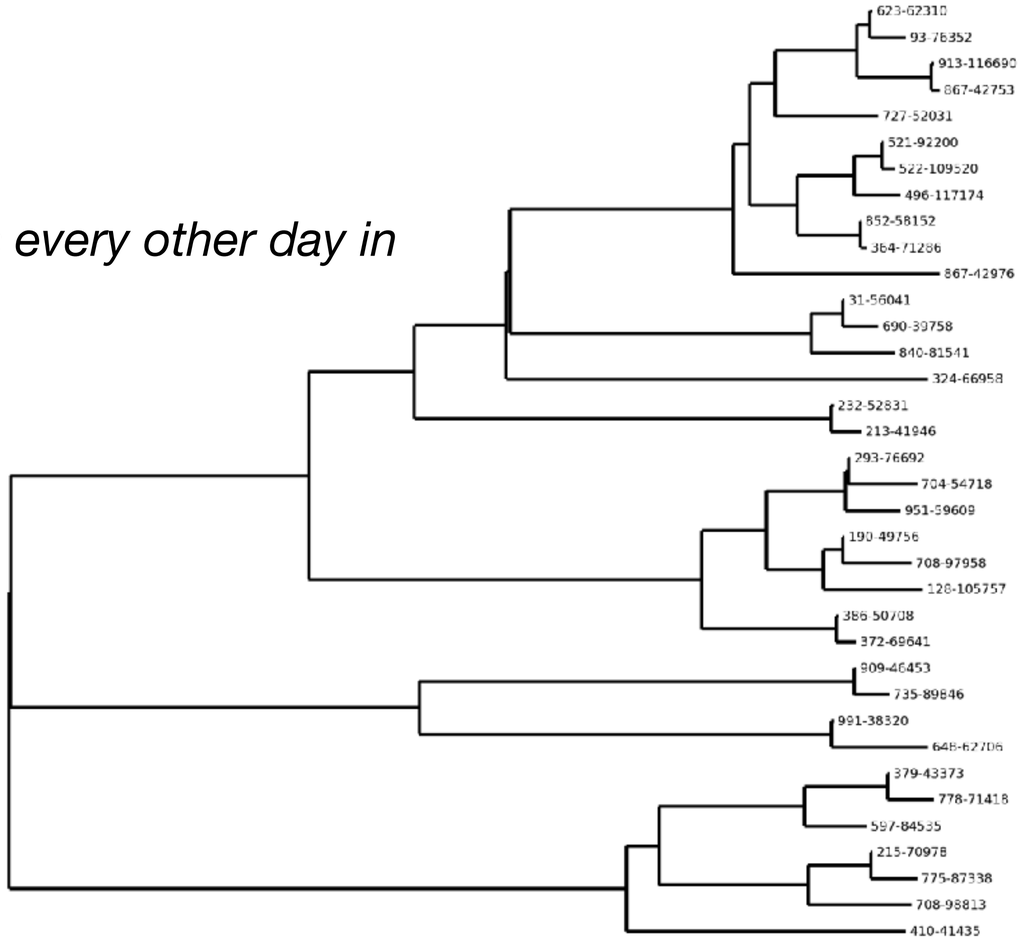
# Outlook: making sense of genetic data

Simulate viral transmission and sampling



**Transmission chain**

*“Get 2 samples every other day in a given LBM"*




**Ancestry of sampled lineages**

Pinotti et Al, PLOS Comp Biol, 2024

# Conclusions

- Useful epidemiological insights from field experiments.

- LBMs support high transmission of H9N2 AIV.

- Veterinary public health interventions should consider the entire PDN.

- Implemented an ABM to simulate realistic poultry movements and pathogen transmission in PDNs.

## Collaborators:

Lisa Kohnle

José Lourenço

Sunetra Gupta

Dirk Pfeiffer

Md. Ahasanul Hoque

Paritosh Biswas

Guillaume Fournié

Suman Das Gupta

Joerg Henning

Damer Blake

Fiona Tomley

Tony Barnett

Md. Ahasanul Hoque

**One Health Poultry Hub**

[onehealthpoultry.org](onehealthpoultry.org)