

Evaluating the Role of Distance in the 2015 HPAI Outbreak in Minnesota via a Spatial Transmission Kernel

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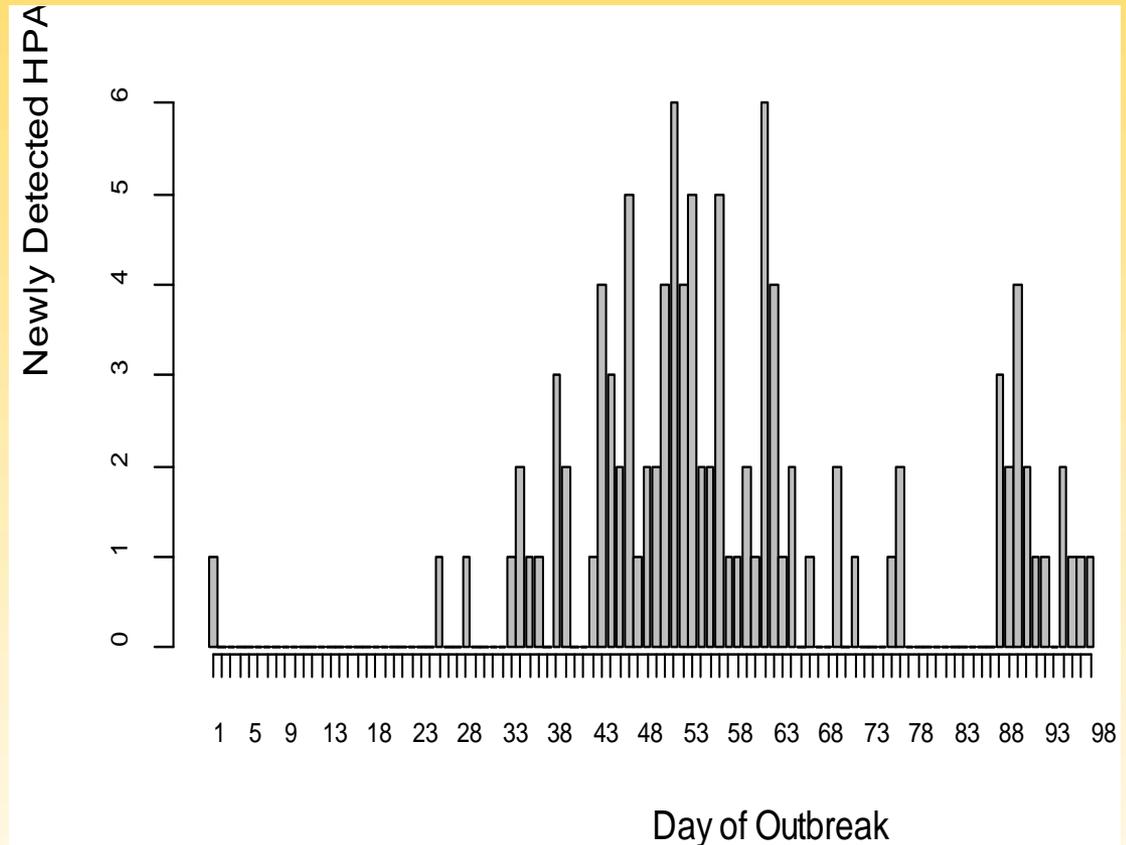
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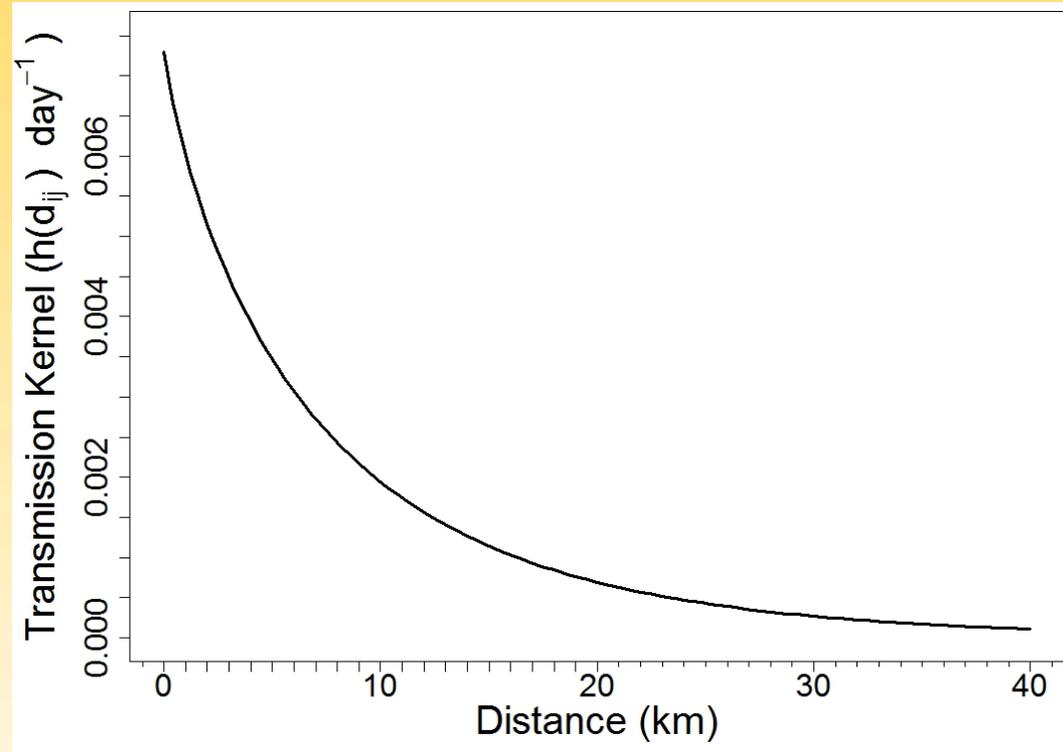
Minnesota HPAI H5N2 Outbreak

- First case detected February 26th, 2015
last case detected June 3rd, 2015
- Total of 110 infected premises across 23 counties



Spatial Transmission Kernels

- Estimates the rate of infection for a susceptible premises a given distance from an infected premises
- Depends only on infection status and distance
- Has applications in
 - predicting the probability of infection
 - assessing outbreak control strategies such as early marketing
 - understanding the role of distance dependent transmission



Spatial Transmission Kernel Parameterization

- Model given by the rate of infection as a function of distance between susceptible premises i and infectious premises j :

$$h(d_{ij}) = h_0 \exp\left(-\left(\frac{d_{ij}}{r_0}\right)^\alpha\right)$$

- h_0 , r_0 , and α are unknown constants to be estimated from outbreak data
 - h_0 is the maximum daily infection rate
 - r_0 and α control the rate and distance over which the infection rate declines



Parameter Estimates

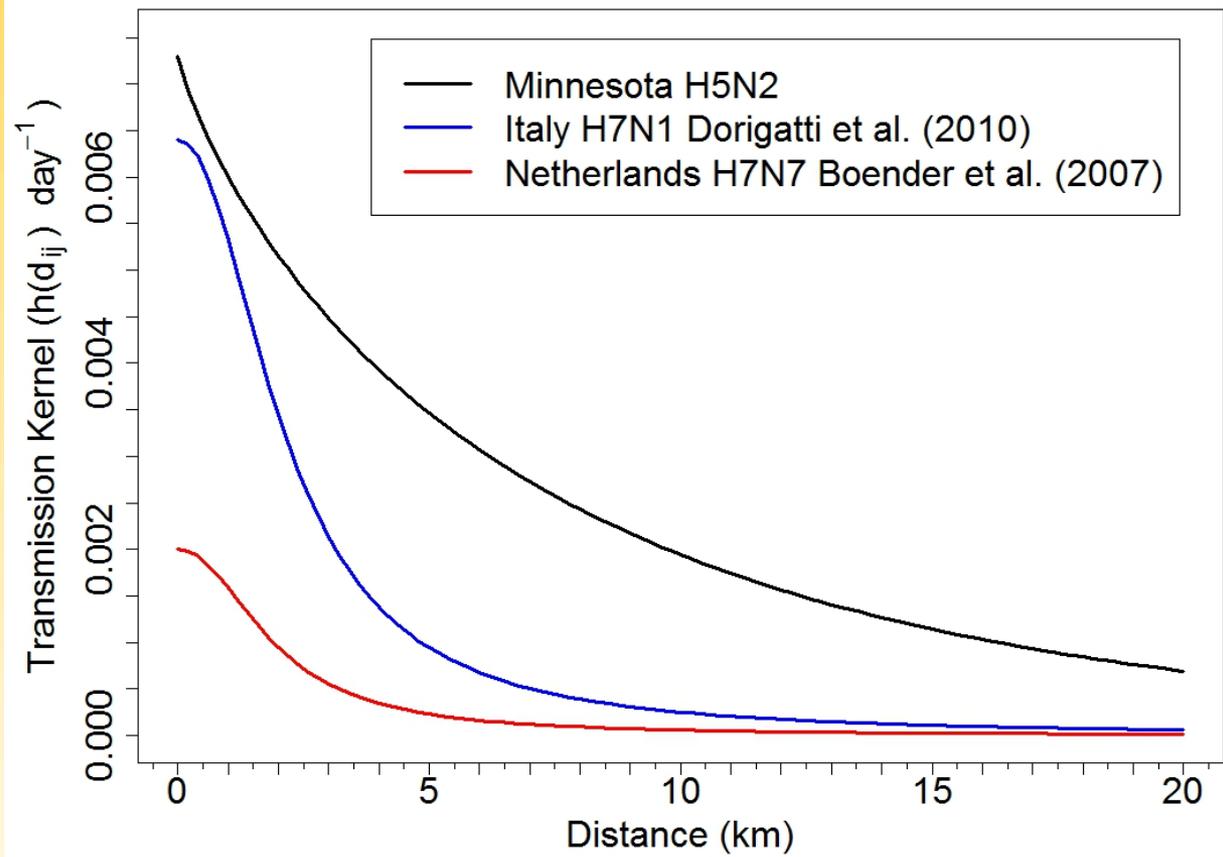
Parameters estimated using a maximum likelihood method

Parameter	Mean Estimates with 95% CI
h_0	0.0073 (0.0017-0.0881)
r_0	7.13 (0.06-26.77)
α	0.83 (0.28-9.37)



Outbreak Comparison

Similar to Netherlands and Italy outbreaks, HPAI transmission risk in Minnesota was primarily from distance dependent pathways (e.g., local contacts such as equipment sharing)



Distance Independent Transmission: MN Outbreak

- The force of infection (cumulative rate of infection faced by a susceptible premises) previously dependent solely on the number of infected premises
- Additional parameter, “ k ”, added to the force of infection to allow for infection from a source other than an infected premises (e.g. wild birds)
 - Phylogenetic evidence of multiple primary introductions (Sep. USDA Epidemiology Report)
- “ k ” represents a constant infection risk posed by distance independent exposures such as wild birds or long distance movements of people and equipment



Results for “*k*”

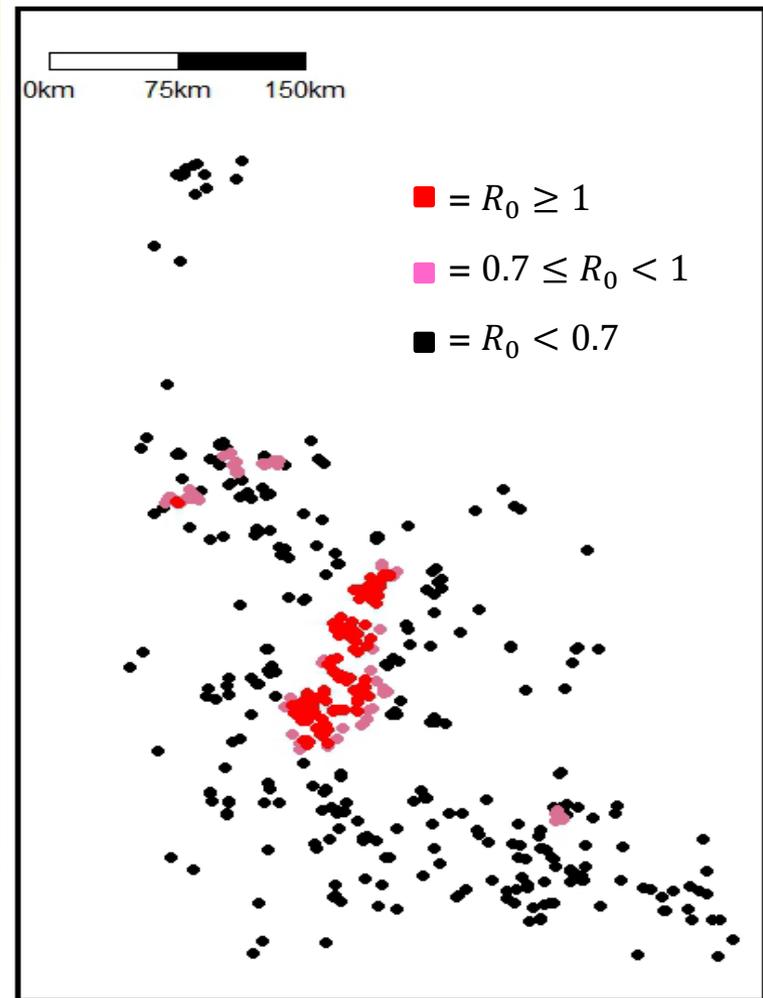
“*k*” estimated to have mean 0.00038 (95% CI: 0.00023-0.00056)

- Based on parameter estimate, 33 (95% CI: 21-73) premises could have been infected by a distance independent pathway during the Minnesota outbreak
- “*k*” identified as improving model fit via AIC



Minnesota Risk Map

- Transmission kernel used to estimate the expected number of premises infected by each premises if it was infectious, called R_0
- 61% of cases occurred in the central risk area during Minnesota outbreak



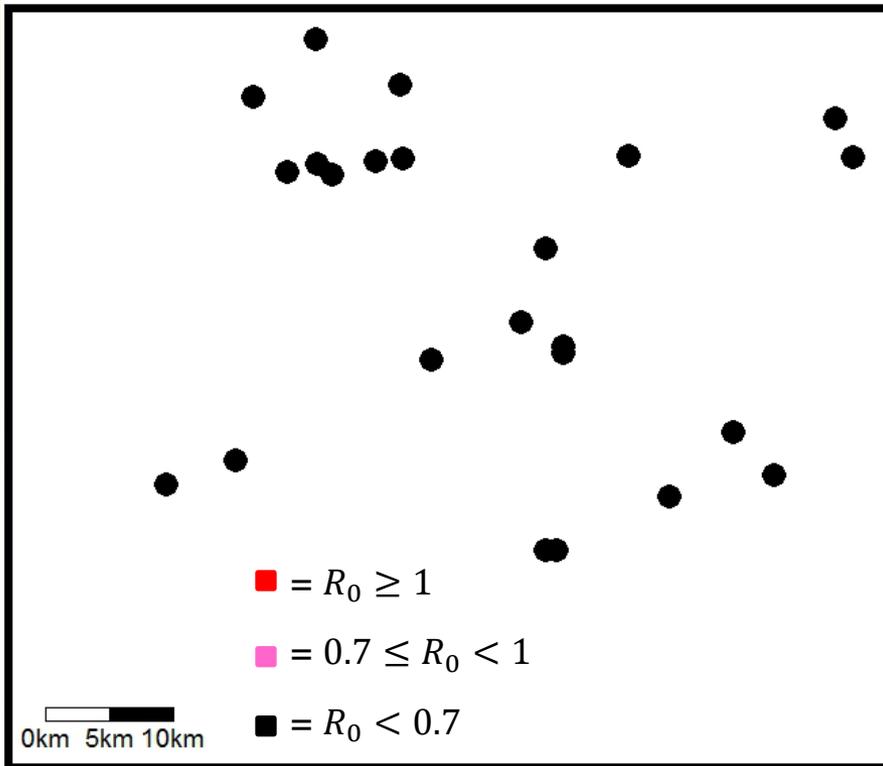
Early Marketing Outbreak Control Strategy

- A county in Minnesota sent turkey flocks to processing prior to the regular market date
- Risk maps made for 04/14/15 considering the susceptible population with and without the strategy having been implemented
- Premises were considered not susceptible if:
 - housing broilers
 - had been infected
 - housing turkeys < 9 weeks old (age predilection USDA Sep. Epi Report)

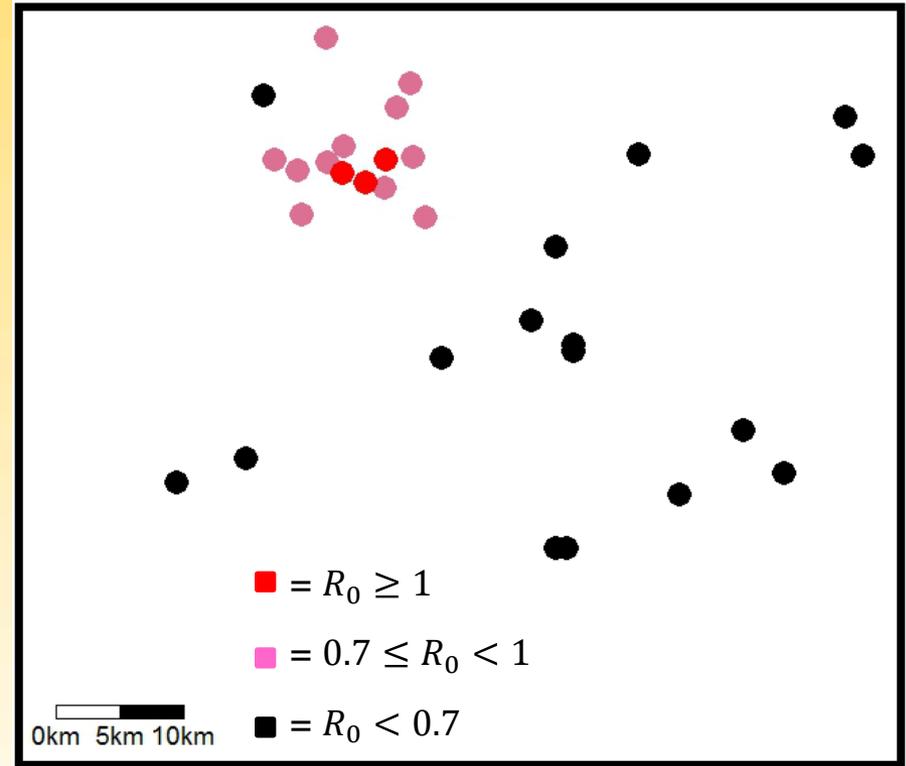


Early Market Comparison

Early Marketing (4/14/15)

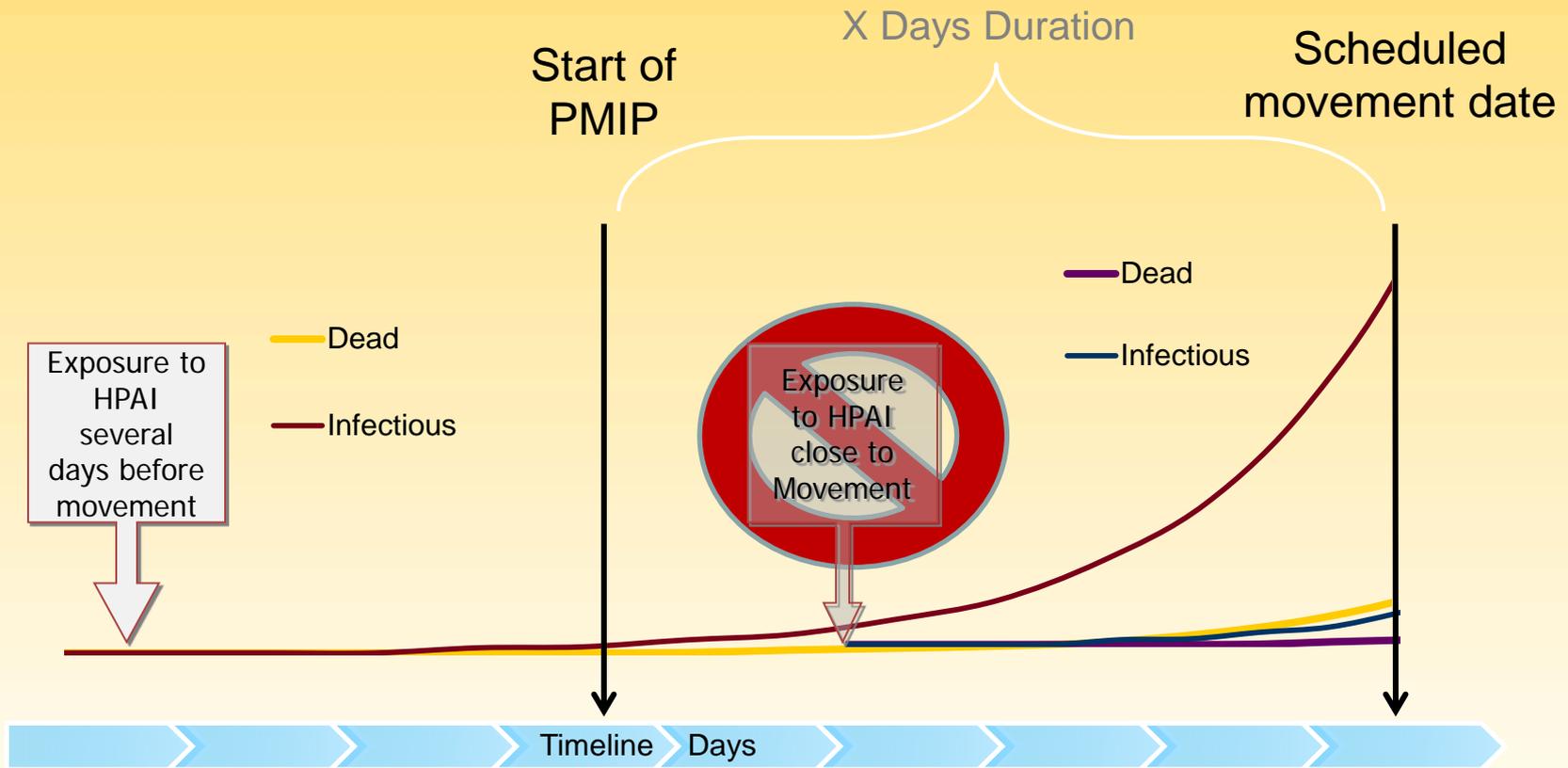


No Early Marketing (4/14/15)



Pre-movement Isolation Period (PMIP) Strategy

Exposure risk close to the time of movement is reduced by **PMIP biosecurity**



Overall Probability of Moving Infected Undetected Birds

- Combined probability of a premises first becoming infected and then moving undetected birds under active surveillance protocol
 - Transmission kernel estimates probability of infection
- PMIP greatly reduces risk of moving infected undetected birds
- Risk higher under MN kernel due to higher infection rate

Distance from infected premises (km)	MN HPAI H5N2 kernel ; no PMIP	MN HPAI H5N2 kernel ; 8-day effective PMIP	Netherlands HPAI H7N7 kernel ; no PMIP
1.5	2.63%	0.0064%	0.56%
2	2.47%	0.0060%	0.42%
3	2.19%	0.0053%	0.25%
5	1.76%	0.0043%	0.10%



Conclusions

- Distance dependent pathways contributed substantially to outbreak spread, though there is evidence of some distance independent exposures as well
- Results provide a basis for further evaluation of early marketing as a possible outbreak management strategy
- Overall probability of moving infected undetected birds considerably reduced via PMIP



Bibliography

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