Modeling between-farm transmission dynamics of porcine epidemic diarrhea virus: characterizing the dominant transmission routes

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Background: The role of transportation vehicles, pig movement between farms, proximity to infected premises, and feed deliveries has not been fully considered in the dissemination dynamics of porcine epidemic diarrhea virus (PEDV).

Objective: To develop a stochastic mathematical model of PEDV transmission to mimic how PEDV is known to spread between farms. The model considered between-farm propagation such as between farm transmission due to proximity (distance between farms), animal and vehicle movements (feed, personnel, shipment of live pigs between farms and to slaughterhouses), quantity of pig feed related animal by-products restricted (e.g. fat, meat and bone meal) in pig feed ingredients, and PEDV break history (previous outbreaks occurrence).

Materials and methods: Data for three U.S. non-related pig production systems were obtained directly from producers and the Morrison Swine Health Monitoring Project (MSHMP). Data for each farm included their national premises identification number, production type, pig spaces per farm, geographic coordinates, between-farm movement data and PEDV outbreak data. The model developed was a stochastic model in discrete-time with a weekly time step. The model accounted for (1) contact network of discrete pig movements; (2) the local transmission events between neighboring farms driven by distances between farms; indirect contact by vehicles coming into farms, including for (3) feed, animal delivery to (4) farms and (5) market, and (6) vehicles used by personnel (crew) involved in the loading and unloading of pigs; amount of (7) fat and (8) meat and bone meal in feed formulation delivered to farms; and (9) re-break by a previous exposure to PEDV.

Results

1. Our results demonstrate that vehicles transporting feed to farms were the most important route infecting sow farms, with a 42.7% contribution in the transmission dynamic (Figure 1). Vehicles transporting pigs to farms were the most important for nursery farms, with a 34.5% while local transmission was the most important for finisher farms with a 31.4% contribution. In addition, for finisher and nurseries, pig movement contact networks or local transmission were the next most relevant routes of PEDV dissemination.
2. As expected, vehicles transporting pigs to market showed a higher contribution for PEDV dissemination into finisher farms (with 6% of the farm infections) than for sow and nursery farms (contributing with 1.7% and 1.3% of the farm infections, respectively).
3. Vehicles transporting farm crews had limited contribution in the propagation of the virus regardless of farm type contributing overall between 1.8% and 3.1% in the farm infections.
4. The volume of animal fat and meat and bone meals in the dynamics of PEDV did not significantly improve model calibration metrics, sensitivity, or specificity; therefore, between-farm dissemination seems to be independent from the evaluated by-products in the studied period of time.

Conclusions and implications: This study provides a better understanding of the role of several transmission routes that have not yet been considered while modeling PEDV dissemination. Collectively, these results reinforce the hypothesis that PEDV dissemination is also driven by vehicle movements that interconnect large numbers of farms. The volume of animal by-products delivered to farms via feed did not contribute to explaining the spatial distribution of PEDV outbreaks. Nevertheless, more studies are necessary before more conclusions can be drawn about PEDV transmission in feed deliveries.

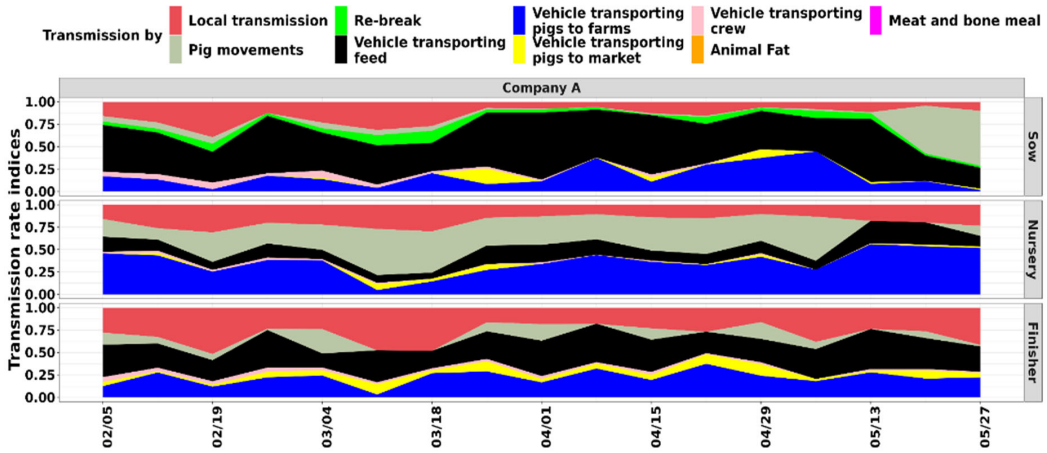

Figure 1. Farm infection contribution for each transmission route of each farm types (rows). The y-axis represents the proportion of transmission by each transmission route, while the x-axis shows each week in the simulation.

For more details, please read the full available paper here (https://doi.org/10.48550/arXiv.2201.04983).