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Review of biosecurity research on mechanical transmission of porcine pathogens by people

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The following is a brief review and critique of the biosecurity research done at Purdue University on mechanical transmission of swine pathogens by people.

Porcine reproductive and respiratory syndrome

Amass SF, Stevenson GW, Anderson C, Grote LA, Dowell C, Vyverberg B, Kanitz C, Ragland D. Investigation of people as mechanical vectors for porcine reproductive and respiratory syndrome virus. *Swine Health and Production.* 2000;8(4):161-166.
This research was funded by the National Pork Producers Council. The South Dakota State University, Animal Disease Research and Diagnostic Laboratory performed the PRRSV nRT-PCR.

Methods

In this study contamination of people was accomplished by having 10 people sit in a pen with viremic, PRRSV-inoculated pigs for one hour. People handled the pigs as the pigs chewed on the coveralls and rubber boots worn by the participants. Five of the ten participants then contacted sentinel pigs, housed in a different but identical room, in the same manner without employing biosecurity measures. The remaining five participants showered, donned clean coveralls and boots, and then contacted a second group of sentinel pigs, again housed in a different but identical room, in same manner. Ten pigs, housed in a different but identical room, served as negative controls and were never intentionally exposed to PRRSV.

Following the single-point exposure with potentially contaminated people, groups of sentinel pigs remained housed in their respective rooms and had separate caretakers. Sentinel pigs were monitored for clinical signs of PRRSV for 23 days after exposure to contaminated people at which time sentinel pigs were euthanized and samples collected for PRRSV isolation and serology. Samples were collected from human participants before and after exposure to pigs.

Results

Porcine reproductive and respiratory syndrome viral RNA was detected in saliva and fingernail rinse samples of two of 10 people immediately after exposure to PRRSV-inoculated pigs; a fingernail rinse sample of a third person at five hours after exposure to PRRSV-inoculated pigs; and a nasal swab sample of a fourth person at 48 hours after exposure to PRRSV-inoculated pigs. Most importantly, despite contamination, people did not act as mechanical vectors for PRRSV to sentinel pigs in this study.

Critique

- Only a single replication was performed.
- Virus isolation on human samples was not performed in this study; therefore, the viability, infectiousness, and amount of the virus contaminating participants remained unknown.
- Investigators could not prove that PRRSV-inoculated pigs in this study were shedding an infectious dose of PRRSV because uninoculated pigs were not housed in the same pen as inoculated pigs to act as sentinels for transmissibility.

Work done elsewhere on PRRSV

Otake S, Dee SA, Rossow KD, Deen J, Joo HS, Molitor TW, Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by fomites (boots and coveralls). *Journal of Swine Health and Production.* 2002;10(2):59-65.
In this study, contamination of personnel was extensive and accomplished by having the investigator don boots and coveralls and spend one hour in a room with PRRSV-inoculated pigs biting and licking their hands, coveralls, and boots. During the hour, the investigator picked up each of seven PRRSV-inoculated pigs and performed the following tasks: placed the PRRSV-inoculated pig's snout on the dorsal and ventral surface of each hand and rubbed the snout repeatedly across the boots and coveralls; placed each hand in the pig's mouth for five seconds; sprayed blood from the PRRSV-inoculated pig over the coveralls, boots, and dorsal and ventral surfaces of hands; and, picked up a handful of fecal material which was spread on the hands, boots and coveralls of the investigator. Thus, extraordinary measures not performed on a typical pork production unit were implemented to contaminate personnel. Investigators then moved to rooms of sentinel pigs after using no biosecurity procedures, washing hands and changing clothes and boots, or showering and changing clothes and boots with and without a 12 hour animal avoidance period. The investigator using no biosecurity procedures moved directly to sentinel pigs without changing

clothes, boots, or washing hands. The investigator contacted sentinel pigs for 30 minutes in a similar fashion as stated above but without exposure to blood or feces of sentinel pigs. Following exposure, the investigator doffed contaminated clothes and boots and left them in the pen with sentinel pigs for 24 hours. Four replications were performed. In this study, PRRSV was detected on the hands of one person in one of four replicates by PCR and swine bioassay. Infection of sentinel pigs by PRRSV was demonstrated in two of four replicates when biosecurity procedures were not used and contaminated coveralls and boots were left in the pen with sentinel pigs. Infection of sentinel pigs was not demonstrated in other treatment groups. One limitation of this study was that extensive procedures used to contaminate personnel with PRRSV did not reflect conditions on typical pork production units. Thus, isolation of PRRSV from the hands of personnel after such gross contamination was not surprising. The primary limitation of this study was that the investigator using no biosecurity procedures left contaminated outerwear in the pen of sentinel pigs for 24 hours following human exposure. This is not reflective of conditions on a typical pork production unit, and this action confounded the examination of human transmission. Specifically, one could not determine if the 30 minutes of human contact was sufficient to transmit PRRSV to sentinel pigs or if the source of PRRSV was the grossly contaminated coveralls and boots that the pigs presumably chewed on for up to 24 hours.

Summary for PRRSV

Although both studies found evidence of PRRSV contamination of people after exposure to PRRSV-infected pigs, neither study effectively examined whether people could indeed mechanically transmit PRRSV to susceptible pigs. Without this knowledge, the effectiveness of intervention strategies cannot be concluded because, if people cannot mechanically transmit PRRSV, then intervention strategies are not needed.

Transmissible gastroenteritis virus of swine

Alvarez RM, Amass SF, Stevenson GW, Spicer PM, Anderson C, Ragland D, Grote L, Dowell C, Clark LK. Evaluation of biosecurity protocols to prevent mechanical transmission of transmissible gastro-enteritis virus of swine by pork production unit personnel. *The Pig Journal*. 2001;48: 22-33.

This research was funded by the National Pork Producers Council. Dr. Ronald Wesley, USDA-ARS NADC provided the Miller strain of transmissible gastroenteritis virus (TGEV).

Methods

One hundred and twenty five, four-week-old pigs, serologically negative for TGEV were randomly allocated to five isolation rooms at Purdue University. Twenty pigs in one room were inoculated with TGEV. One caretaker moved from inoculated pigs to rooms of susceptible pigs either without using biosecurity procedures, or after hand washing and changing outerwear, or after showering and changing outerwear. The caretaker was in direct contact with pigs and their secretions and excretions for 10 minutes, twice daily, for 14 days. Negative controls were cared for by a separate caretaker.

Results

Inoculated pigs and pigs cared for without using biosecurity procedures developed clinical signs of TGEV infection. Pigs cared for after hand washing and changing outerwear or showering and changing outerwear and negative-control pigs all remained clinically normal and tested negative for TGEV. Under conditions of this study, a caretaker acted as a mechanical vector for the transmission of TGEV. Washing hands and changing into clean outerwear or showering and changing into clean outerwear, after being in contact with TGEV-infected pigs, prevented mechanical transmission of TGEV to susceptible pigs.

Critique

- Only a single replication was performed.
- The sentinel pigs in the TGEV study were seronegative and susceptible to TGEV but were > 4 weeks old when exposed. Thus, these pigs might have been less susceptible to a presumably smaller dose of TGEV transmitted after hand washing due to their age; whereas the presumably larger dose of virus transmitted by the investigator when biosecurity procedures were not used was sufficient to cause infection despite the age of the pigs. Thus, hand washing might not have been effective if younger sentinel pigs had been used in the study.

Work done elsewhere on TGEV

None

Escherichia coli

Amass SF, Halbur PG, Byrne BA, Schneider JL, Koons CW, Cornick N, Ragland, D. Mechanical transmission of enterotoxigenic *Escherichia coli* to weaned pigs by people, and biosecurity procedures that prevented such transmission. *Journal of Swine Health and Production.* 2003;11(2):61-68.

This research was funded by the National Pork Board. This project was a joint effort between Iowa State University and Purdue University. Dr. Harley Moon provided *E. coli* strain M1823B

Methods

One-hundred and twenty-five 19- to 21- day old weaned pigs, free of enterotoxigenic *E. coli* M1823B, were ran-

domly allocated to six treatment groups housed in five separate isolation rooms. Inoculated pigs (n = 20) were offered 1.36 x 1010 to 8.92 x 1010 *E. coli* mixed in strawberry gelatin on two occasions. Pen sentinels (n = 5) were housed with inoculated pigs. A caretaker fed pigs, checked waterers, and directly contacted each group of pigs for 10 minutes, once each day for 10 consecutive days. The caretaker contacted inoculated pigs and moved directly to direct sentinels (n = 25). The caretaker recontacted inoculated pigs, washed hands twice, changed outerwear, and then contacted hand wash sentinels (n = 25). The caretaker then recontacted inoculated pigs, showered, changed outerwear, and contacted shower sentinels (n = 25). A separate caretaker cared for non-exposed pigs.

Results

E. coli M1823B was isolated from 20 of 20 (100%) inoculated pigs, 5 of 5 (100%) pen sentinels, 20 of 25 (80%) direct sentinels, and 23 of 25 (92%) hand wash sentinels. Shower sentinels and non-exposed pigs remained negative.

Thus, hand washing was not sufficient to remove all *E. coli*-containing organic material from the hands of the caretaker. A pig could have contacted an infectious dose of *E. coli* from contaminated parts of the caretaker such as her face, mouth, neck, arms, hair, or under her fingernails because hand washing did not remove *E. coli* from these body parts. Although due care was taken, the caretaker could have inadvertently touched a contaminated body part after hand washing. In contrast, showering and donning clean outerwear was sufficient to prevent transmission of *E. coli* in this study. Presumably showering provided a whole-body decontamination procedure that was effective in removing organic material from other exposed areas in addition to the hands. Material carried under fingernails was possibly removed during hair washing. Time from day 0 to the day of detection of *E. coli* during set sampling periods was longer for hand wash sentinels compared to direct sentinels (P = .0021), suggesting that hand washing and donning clean outerwear decreased the number of organisms carried by the investigator such that it took longer to achieve an infectious dose in sentinel pigs. The infectious dose could have been achieved either by repeated contacts with the caretaker until an infectious dose was reached, contact with an infected pen mate in which the delay was the result of time needed for the *E. coli* to replicate within the infected pig and be shed to pen mates or, more likely, a combination of the two events. The results from this study suggest that hand washing and donning clean outerwear as performed in this study might not be a sufficient biosecurity measure to prevent transmission of *E. coli* in all cases. Thus, shower-in facilities might be considered on production units that are using some biosecurity measures (isolation and acclimatization facilities, all-in, all-out pig flow with cleaning and disinfection between groups, hand washing, boot changing, and coverall changing before entry, etc.) but are still experiencing uncontrollable losses due to *E. coli*.

Critique

- Only a single replication was performed.

Work done elsewhere on E. coli

None

Foot and mouth disease virus

Amass SF, Pacheco JM, Mason PW, Schneider JL, Alvarez RM, Clark LK, Ragland D. Procedures for preventing transmission of foot-and-mouth disease virus to pigs and sheep by personnel in contact with infected pigs. *The Veterinary Record.* 2003;153:137-140.

This research was funded by the Showalter Trust, National Research Initiative Competitive Grants program of USDA/CSREES (Grant #99-35204-7949) and the Agricultural Research Service of the USDA (CRIS Project #1940-32000-035-00D). This project was a joint effort between USDA and Purdue University.

Methods

Investigators inoculated susceptible pigs with foot and mouth disease virus (FMDV) (O/UK/35/2001). Two days after inoculation, four investigators had approximately 45 minutes of contact time with these clinically ill pigs. During contact, physical examinations were performed, temperatures taken, and blood and nasal swabs were collected from each pig. Immediately after exposure to these pigs, the people had similar contact with sentinel pigs and sheep in the direct human exposure group. The protocol was repeated for each treatment. Investigators contacted sick pigs and then washed hands and changed outerwear before contacting hand wash/change outerwear pigs and sheep. Investigators contacted sick pigs and then showered and changed outerwear before contacting shower/change outerwear pigs and sheep. In-pen contact sheep and pigs were placed with inoculated pigs for the period of time that the human exposure treatments took place. Individual, room-designated caretakers cared for each room of animals for the next 14 days. Clinical signs were recorded. Blood and nasal swabs were collected from each animal at the end of the experiment (or on the day of euthanasia, if FMD lesions were detected). Nasal swabs were collected from investigators prior to exposure to FMDV, immediately after exposure to FMDV-infected pigs, and then daily for four consecutive days.

Results

FMDV was detected in nasal secretions of one investigator immediately after necropsies of FMDV-inoculated pigs but was not detected in human samples collected from

12.75 to 84.5 hours after exposure. FMDV appeared to be mechanically transmitted by investigators when no hygienic measures were undertaken. Minimal hygienic measures appeared to interrupt transmission of FMDV (O/UK/35/2001) to pigs, but not to sheep (which are usually more susceptible to infection). We found that after contaminated personnel showered and changed into clean outerwear they did not transmit the UK outbreak strain of FMDV to susceptible pigs and sheep.

Critique

- Only a single replication was performed.
- For further discussion, please see Donaldson AI and Sellers RF. Transmission of FMD by people. *The Veterinary Record.* 2003;153:279-280.

Work done elsewhere on FMDV

Sellers RF, Donaldson AI, Herniman KAJ. Inhalation, persistence, and dispersal of foot-and-mouth disease virus by man. *Journal of Hygiene.* 1970;68:565-573

Sellers RF, Herniman KAJ, Mann JA. (1971) Transfer of foot-and-mouth disease virus in the nose of man from infected to non-infected animals. *The Veterinary Record.* 1971;89:447-449.

In these studies using FMDV strains O1 Swiss, A5, O2, and C Noville, human nasal carriage was reported to occur at 28 hours but not at 48 hours in one person. Additionally, showering did not prevent human transmission of O1 BFS 1860 or C Noville FMDV to one of four steers when people exhaled, coughed, and sneezed directly onto the muzzle of the steers for 2.5 minutes. One possibility for the varying results is that different viral strains were used. Alternatively, the nature of contact between personnel and animals in the latter study was unnaturally excessive.

Summary

Conflicting results in biosecurity trials are not surprising. I hypothesize that the effectiveness of biosecurity procedures needed to prevent mechanical transmission of pathogens by people is variable due to the vast differences among pathogens and host susceptibilities. For example, the nature (pathogen, commensal), type (Gram-negative bacterium, Gram-positive bacterium, enveloped virus, nonenveloped virus), infectiousness, and contagiousness of the organism must be considered. Moreover, host susceptibility will depend on many factors, including but not limited to age, immunocompetency, vaccination status, genetic predisposition, concurrent illness, stress, environment, management, and nutrition. The frequency of exposure and routes of transmission will also impact the efficacy of biosecurity protocols. In the field, large populations of swine, lack of compliance by personnel, large pathogen loads, and incorrectly performed or inadequate facility sanitation can all confound the efficacy of biosecurity procedures. Consequently, one would not expect a single biosecurity protocol to be efficacious in all cases.

Moreover, the effectiveness of biosecurity interventions tested under laboratory conditions may not reflect their efficacy under field conditions. The inherent variability in efficacy of biosecurity protocols exemplifies the need for further experimental and field studies to evaluate confounding factors on protocol efficacy. Thus, producers and veterinarians are encouraged to test biosecurity interventions on their farms to determine the most effective and appropriate biosecurity measures for their specific situation.