Biosecurity Imperatives and the Feed Supply Chain

Jordan Gebhardt, DVM, PhD

Assistant Professor

Diagnostic Medicine/Pathobiology

Kansas State University

Why biosecurity?

biosecurity noun

Save Word

bio·se·cu·ri·ty | \ ˌbī-(ˌ)ō-si-ˈkyůr-ə-tē \

Definition of *biosecurity*

: security from exposure to harmful biological agents

also : measures taken to ensure this security

Merriam-Webster

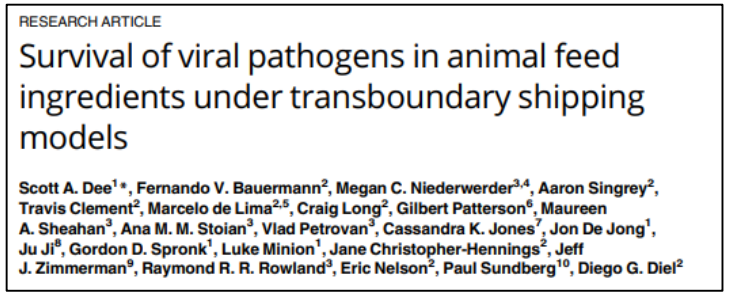
- Bi-directional:
  - Bio-exclusion – keeping pathogens out
  - Bio-containment – preventing pathogens from spreading

Biosecurity

- Practices of biosecurity have been widely implemented in the swine industry
  - Entry benches
  - Shoe covers
  - Downtime
  - Shower in/shower out
  - Disinfection of incoming supplies

Pathogens capable of surviving in feed and/or feed ingredients

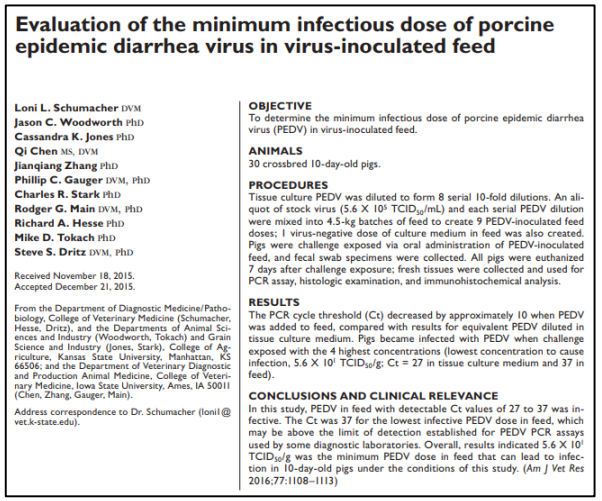
- Bacteria
  - *Salmonella* spp.
  - *Escherichia coli*
- Viruses
  - Porcine epidemic diarrhea virus (PEDV)
  - African swine fever virus (ASFV)
  - Senecavirus A (SVA)
  - Classical swine fever virus (CSF)
  - Pseudorabies virus (PRV)
  - Foot and mouth disease (FMD)
- Others?



RESEARCH ARTICLE

Survival of viral pathogens in animal feed ingredients under transboundary shipping models

Scott A. Dee[1]*, Fernando V. Bauermann[2], Megan C. Niederwerder[3,4], Aaron Singrey[2], Travis Clement[2], Marcelo de Lima[2,5], Craig Long[2], Gilbert Patterson[6], Maureen A. Sheahan[3], Ana M. M. Stoian[3], Vlad Petrovan[3], Cassandra K. Jones[7], Jon De Jong[1], Ju Ji[8], Gordon D. Spronk[1], Luke Minion[1], Jane Christopher-Hennings[2], Jeff J. Zimmerman[9], Raymond R. R. Rowland[3], Eric Nelson[2], Paul Sundberg[10], Diego G. Diel[2]



Evaluation of the minimum infectious dose of porcine epidemic diarrhea virus in virus-inoculated feed

Loni L. Schumacher DVM
Jason C. Woodworth PhD
Cassandra K. Jones PhD
Qi Chen MS, DVM
Jianqiang Zhang PhD
Phillip C. Gauger DVM, PhD
Charles R. Stark PhD
Rodger G. Main DVM, PhD
Richard A. Hesse PhD
Mike D. Tokach PhD
Steve S. Dritz DVM, PhD

Received November 18, 2015.
Accepted December 21, 2015.

From the Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine (Schumacher, Hesse, Dritz), and the Departments of Animal Sciences and Industry (Woodworth, Tokach) and Grain Science and Industry (Jones, Stark), College of Agriculture, Kansas State University, Manhattan, KS 66506; and the Department of Veterinary Diagnostic and Production Animal Medicine, College of Veterinary Medicine, Iowa State University, Ames, IA 50011 (Chen, Zhang, Gauger, Main).

Address correspondence to Dr. Schumacher (loni@vet.k-state.edu).

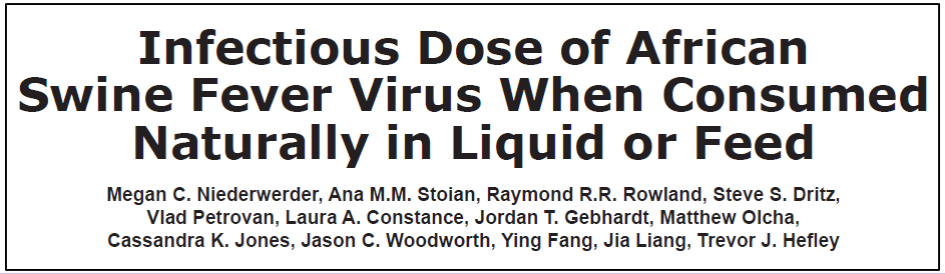
OBJECTIVE
To determine the minimum infectious dose of porcine epidemic diarrhea virus (PEDV) in virus-inoculated feed.

ANIMALS
30 crossbred 10-day-old pigs.

PROCEDURES
Tissue culture PEDV was diluted to form 8 serial 10-fold dilutions. An aliquot of stock virus (5.6 X 10^5 $TCID_{50}$/mL) and each serial PEDV dilution were mixed into 4.5-kg batches of feed to create 9 PEDV-inoculated feed doses; 1 virus-negative dose of culture medium in feed was also created. Pigs were challenge exposed via oral administration of PEDV-inoculated feed, and fecal swab specimens were collected. All pigs were euthanized 7 days after challenge exposure; fresh tissues were collected and used for PCR assay, histologic examination, and immunohistochemical analysis.

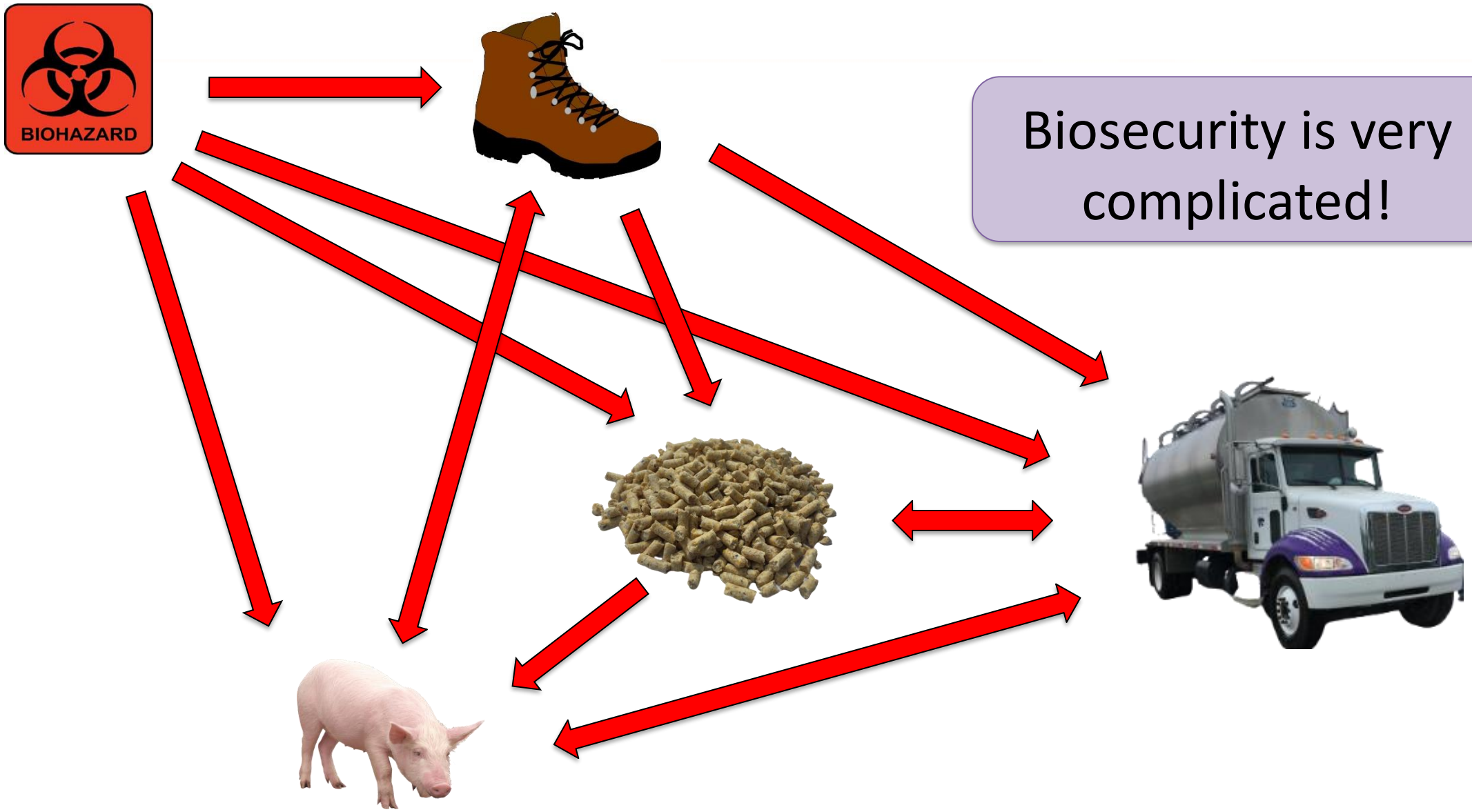
RESULTS
The PCR cycle threshold (Ct) decreased by approximately 10 when PEDV was added to feed, compared with results for equivalent PEDV diluted in tissue culture medium. Pigs became infected with PEDV when challenge exposed with the 4 highest concentrations (lowest concentration to cause infection, 5.6 X 10^1 $TCID_{50}$/g; Ct = 27 in tissue culture medium and 37 in feed).

CONCLUSIONS AND CLINICAL RELEVANCE
In this study, PEDV in feed with detectable Ct values of 27 to 37 was infective. The Ct was 37 for the lowest infective PEDV dose in feed, which may be above the limit of detection established for PEDV PCR assays used by some diagnostic laboratories. Overall, results indicated 5.6 X 10^1 $TCID_{50}$/g was the minimum PEDV dose in feed that can lead to infection in 10-day-old pigs under the conditions of this study. (*Am J Vet Res* 2016;77:1108–1113)

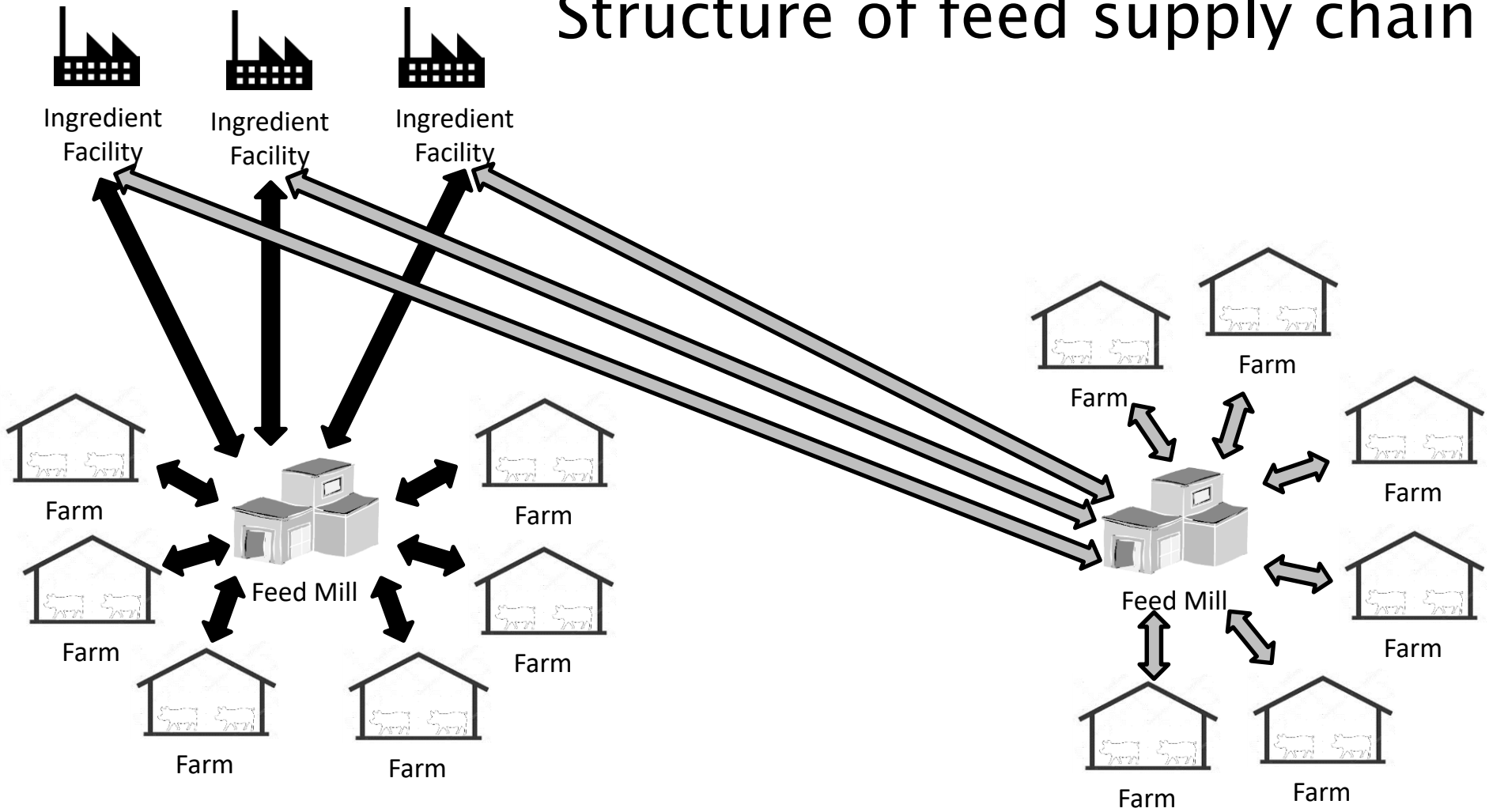


Infectious Dose of African Swine Fever Virus When Consumed Naturally in Liquid or Feed

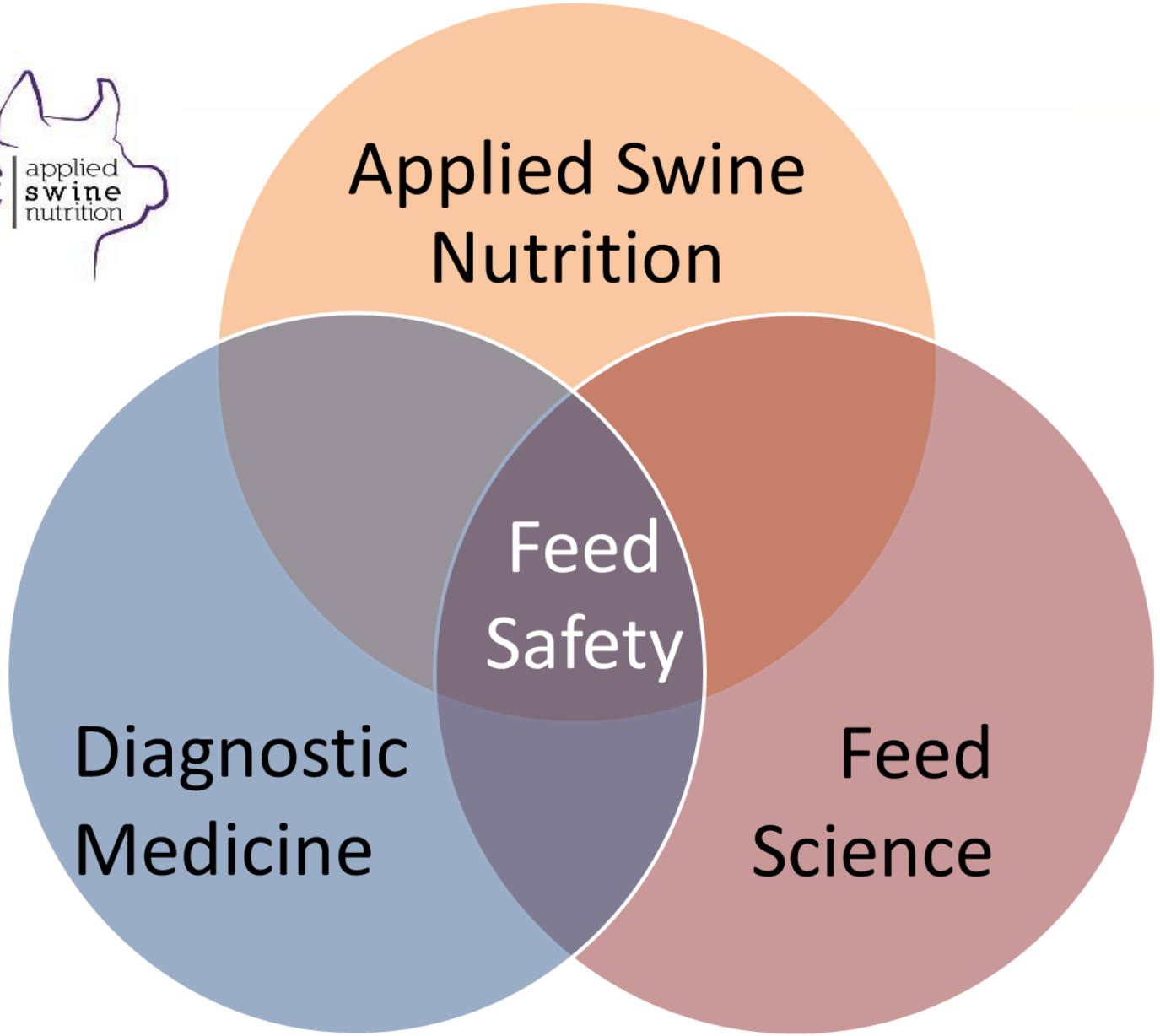
Megan C. Niederwerder, Ana M.M. Stoian, Raymond R.R. Rowland, Steve S. Dritz, Vlad Petrovan, Laura A. Constance, Jordan T. Gebhardt, Matthew Olcha, Cassandra K. Jones, Jason C. Woodworth, Ying Fang, Jia Liang, Trevor J. Hefley


BIOHAZARD
Biosecurity is very complicated!

Structure of feed supply chain



Kansas State University | applied swine nutrition



Diagnostic Medicine/Pathobiology
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GRAIN SCIENCE & INDUSTRY

Addressing Feed Safety

1. Is it likely to get contaminated?

2. Can it survive?

3. Is it infectious?

Prevention

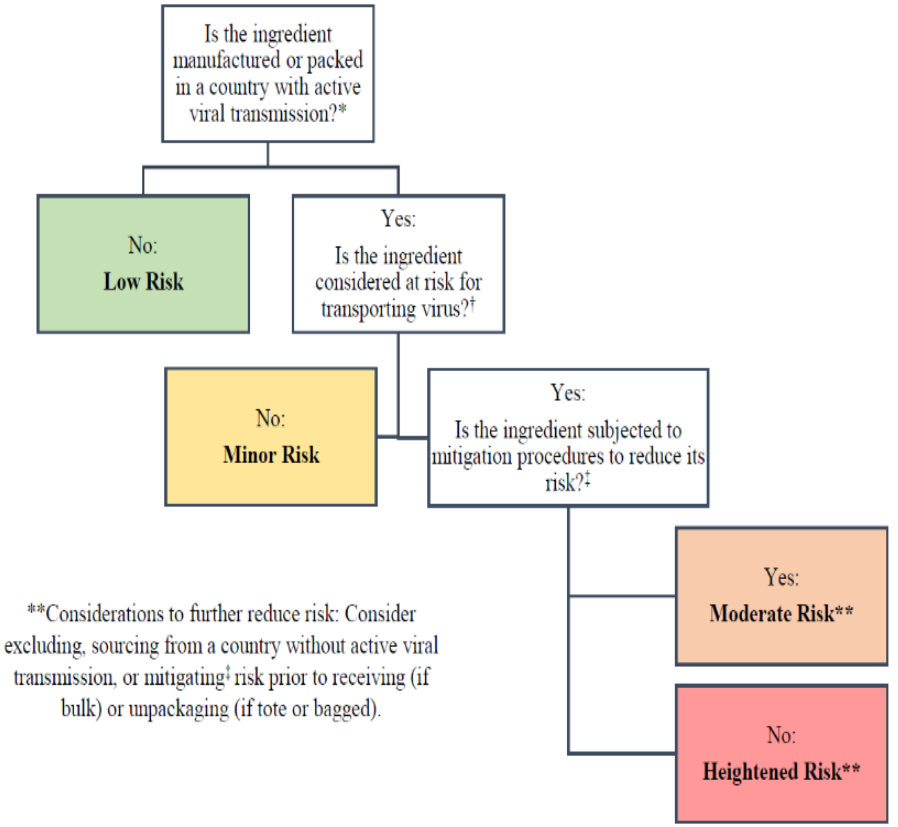
Intervention

1. Is it likely to get contaminated?

- Risk of contamination depends on:
  - Geographical considerations
    - Countries/regions with active disease outbreaks
    - Location of pigs with disease relative to location of ingredient production
  - Agricultural practices
  - Packaging
    - Single use bags or totes vs. re-used totes or bulk trailers

1. Is it likely to get contaminated?

- Understand where ingredients are coming from
- Are alternative sources available and cost effective?
- BIOSECURITY during manufacture, storage, and delivery



https://www.swinehealth.org/wp-content/uploads/2018/09/Feed-Ingredient-Safety.pdf

1. Is it likely to get contaminated?

Areas where improvement would be beneficial

1. Is it likely to get contaminated?

Research partnership

Production system located in Vietnam

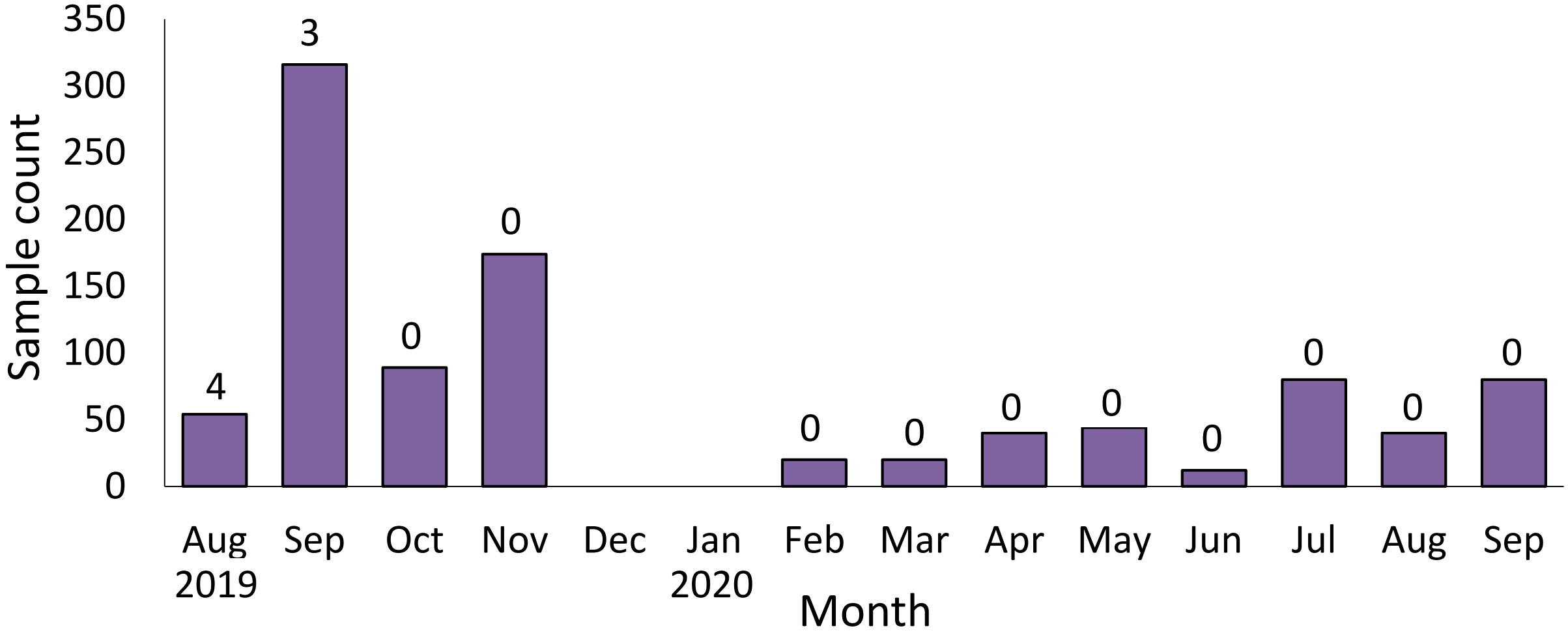
Goal: Use diagnostic testing capabilities to understand the risk of ASFV spread within their production system

1. Feed production system
    a. Feed mill
    b. Ingredients and finished feed
    c. Feed trucks
2. Live animal transport
3. Market animal transfer center

Gebhardt et al., 2021

1. Is it likely to get contaminated?

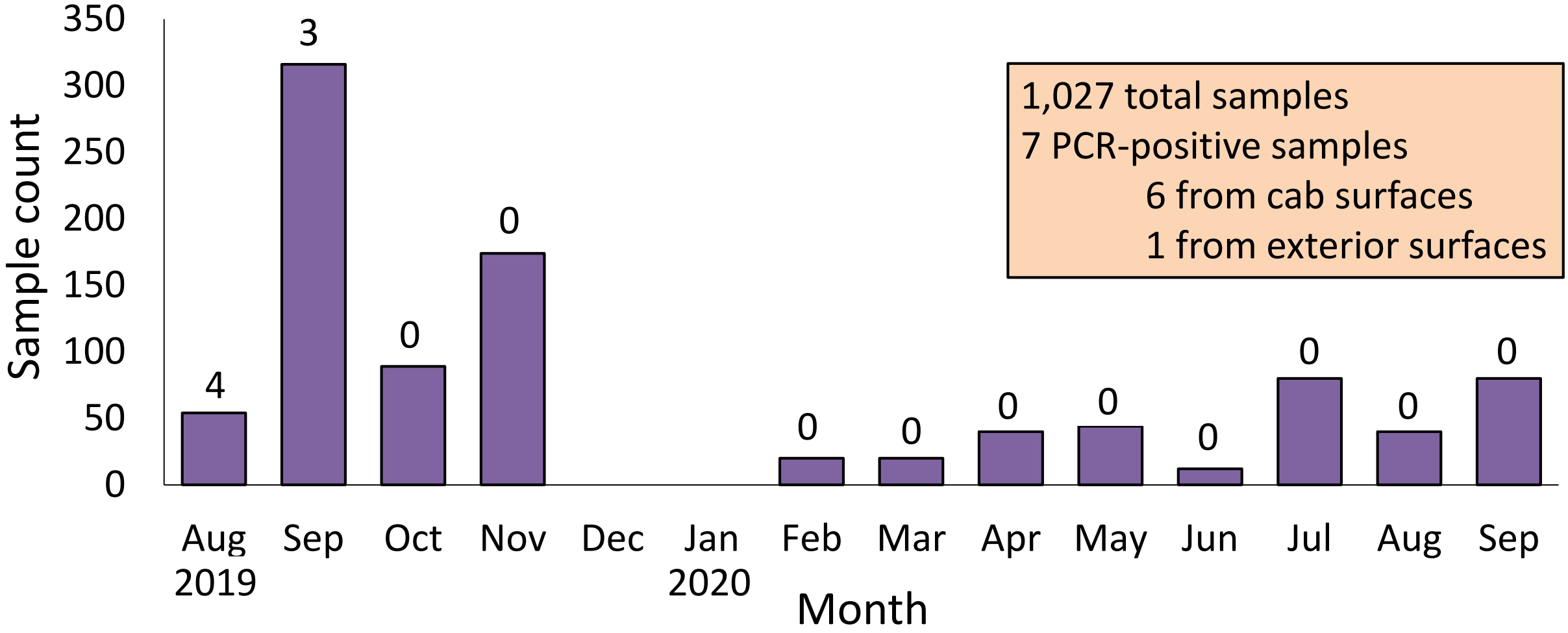
Feed delivery vehicles



Gebhardt et al., 2021

1. Is it likely to get contaminated?

Feed delivery vehicles



1,027 total samples
7 PCR-positive samples
6 from cab surfaces
1 from exterior surfaces

Gebhardt et al., 2021

How can this be accomplished?

Step 1:
Remove organic material

Step 2:
Dry

Step 3:
Apply disinfectant

Gebhardt et al., 2021

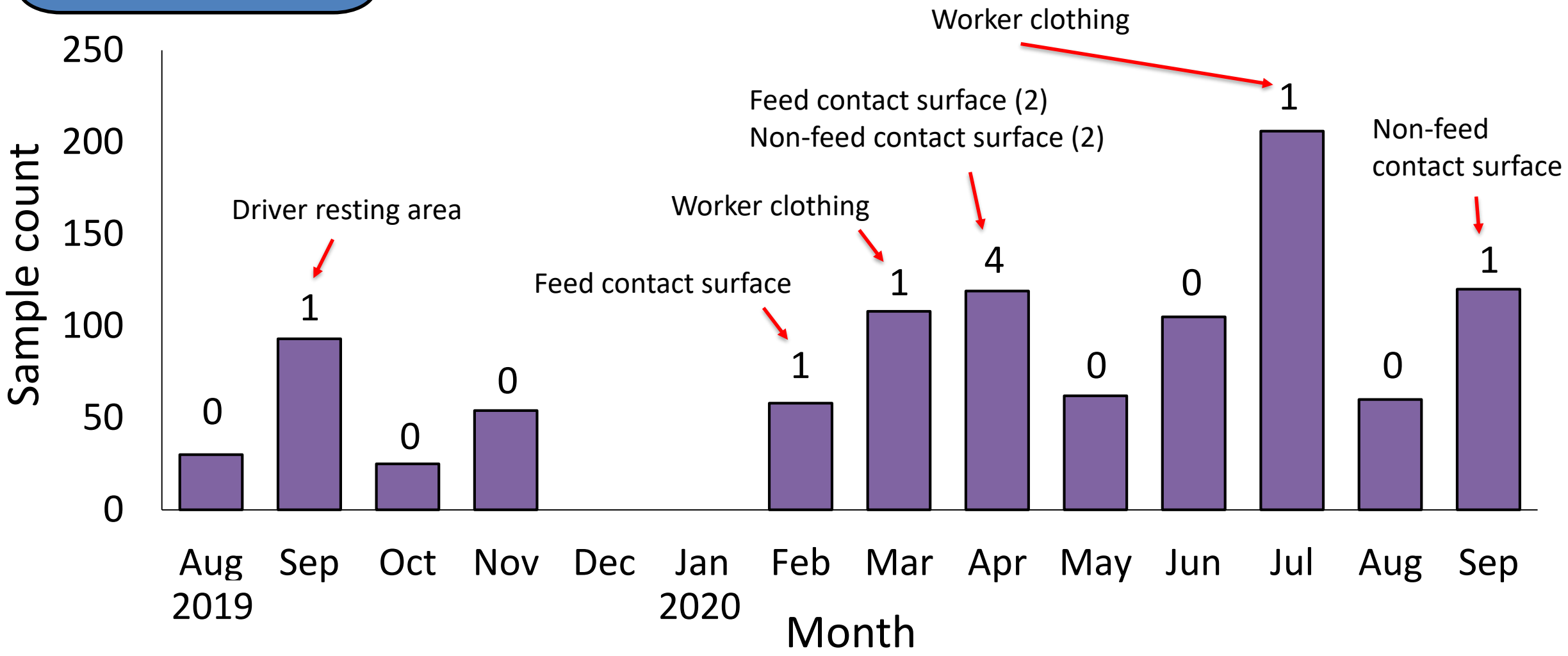
How can this be accomplished?

Avoid this

Gebhardt et al., 2021

1. Is it likely to get contaminated?

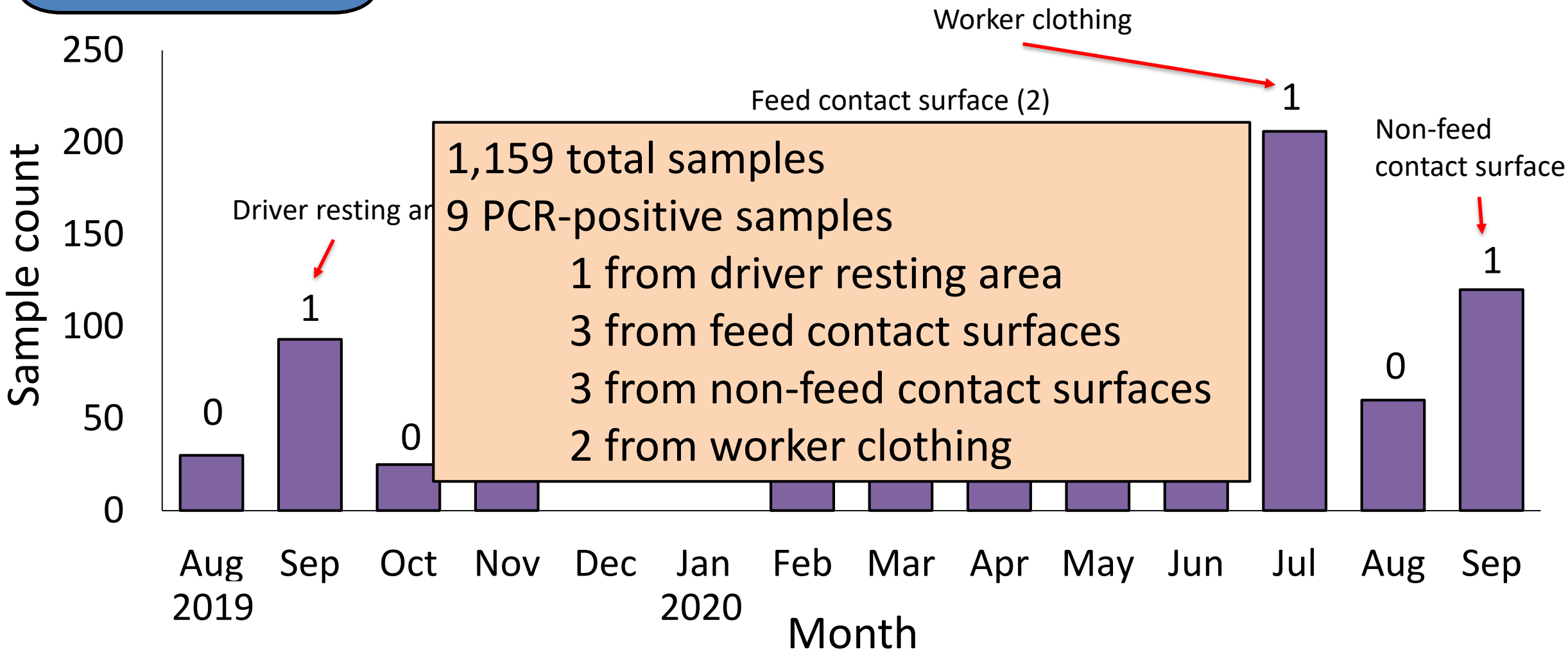
Feed mill surfaces



Gebhardt et al., 2021

1. Is it likely to get contaminated?

Feed mill surfaces



Gebhardt et al., 2021

1. Is it likely to get contaminated?

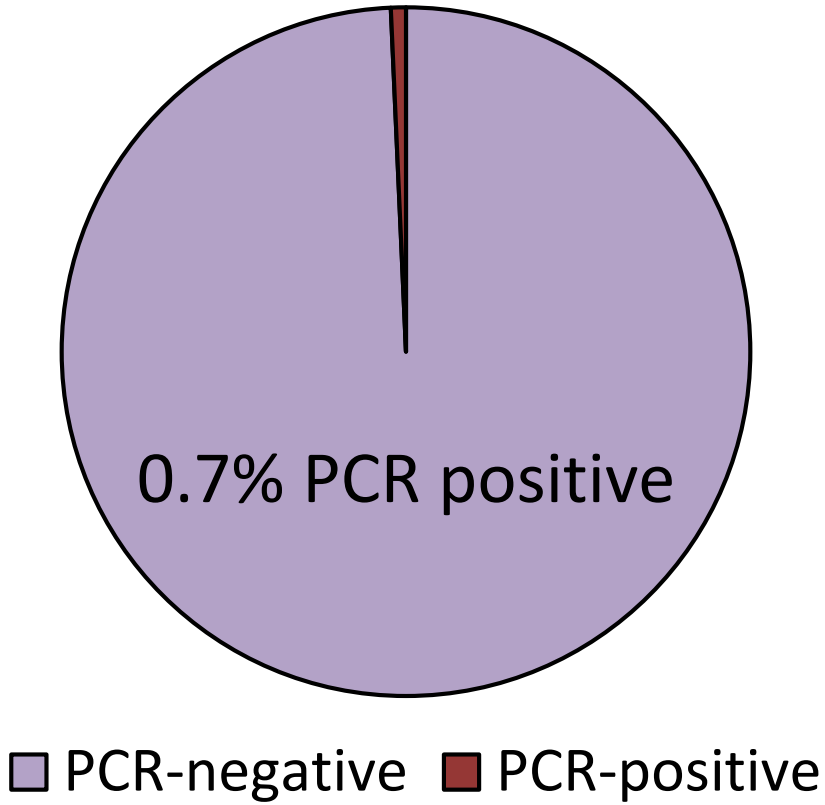
Feed and ingredients

142 total samples so far

40 ingredient and water samples
102 complete feed samples

1 complete feed sample PCR positive

- Batch of feed did not contain added formaldehyde-based product

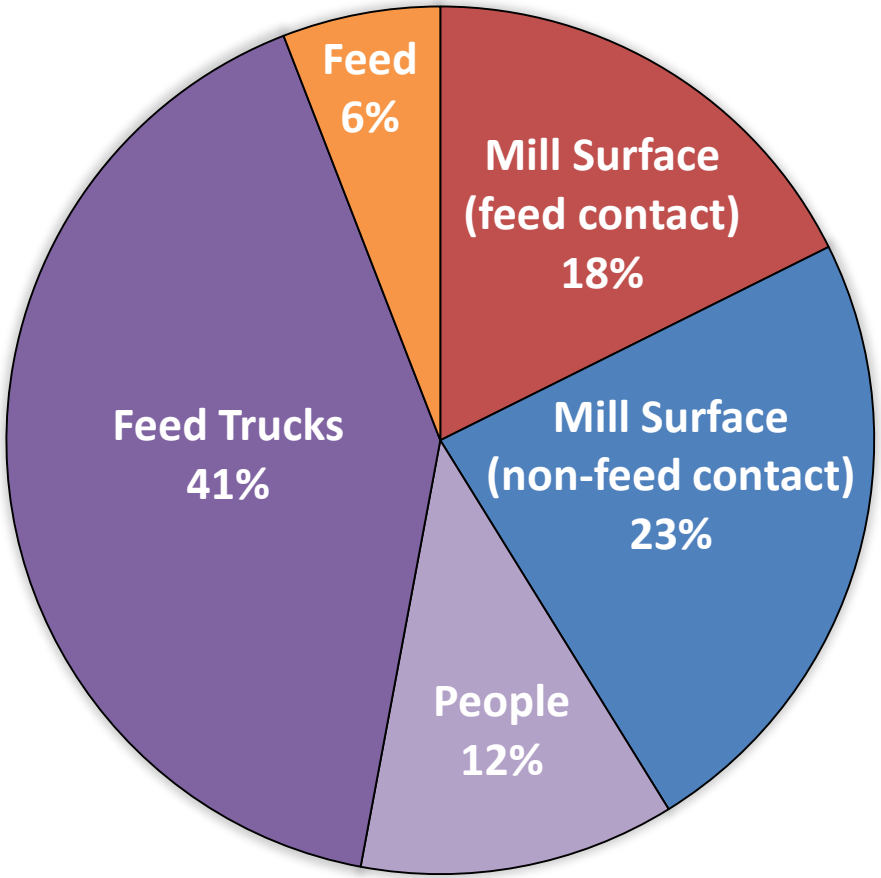


Gebhardt et al., 2021

1. Is it likely to get contaminated?

Where is the contamination at?

- 17 of 2,328 samples (0.7%) from the feed supply chain contain ASFV DNA as determined by PCR
  - 3 Feed-Contact Surfaces in Mill
  - 4 Non-Feed-Contact Surfaces in Mill
  - 2 Employee clothing in Mill
  - 1 Complete Feed
  - 7 Feed Trucks



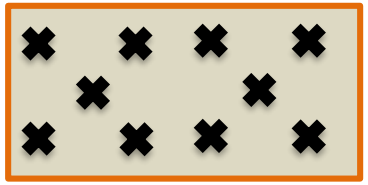
Key finding: People and fomites are incredibly important!

Gebhardt et al., 2021

1. Is it likely to get contaminated?

Risk of ASFV carryover if feed after contaminated batch

Batch	Ingredients
1	Negative
2	ASFV Inoculated
3	Negative
4	Negative
5	Negative
6	Negative



pork checkoff

Elijah et al., 2021

1. Is it likely to get contaminated?

Risk of ASFV carryover if feed after contaminated batch

Detection of African swine fever virus (ASFV) p72 DNA in feed samples	
	Batch of feed
	1
Batch	Negative
Non-detected	10
Suspect	0
ASFV detected	0

pork checkoff

K-STATE Research and Extension

Elijah et al., 2021

1. Is it likely to get contaminated?

Risk of ASFV carryover if feed after contaminated batch

Detection of African swine fever virus (ASFV) p72 DNA in feed samples		
	Batch of feed	
	1	2
Batch	Negative	Positive
Non-detected	10	0
Suspect	0	0
ASFV detected	0	10

pork checkoff

K-STATE Research and Extension

Elijah et al., 2021

1. Is it likely to get contaminated?

Risk of ASFV carryover if feed after contaminated batch

Detection of African swine fever virus (ASFV) p72 DNA in feed samples			
	Batch of feed		
	1	2	3
Batch	Negative	Positive	Negative
Non-detected	10	0	0
Suspect	0	0	0
ASFV detected	0	10	10

1. Is it likely to get contaminated?

Risk of ASFV carryover if feed after contaminated batch

Detection of African swine fever virus (ASFV) p72 DNA in feed samples				
	Batch of feed			
	1	2	3	4
Batch	Negative	Positive	Negative	Negative
Non-detected	10	0	0	0
Suspect	0	0	0	1
ASFV detected	0	10	10	9

1. Is it likely to get contaminated?

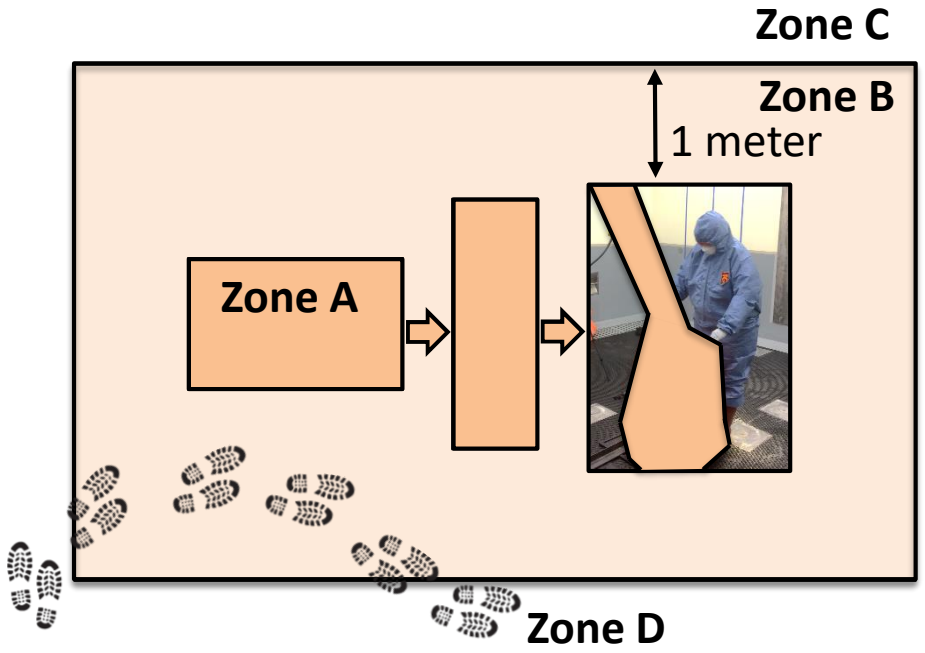
Risk of ASFV carryover if feed after contaminated batch

Detection of African swine fever virus (ASFV) p72 DNA in feed samples						
	Batch of feed					
	1	2	3	4	5	6
Batch	Negative	Positive	Negative	Negative	Negative	Negative
Non-detected	10	0	0	0	0	0
Suspect	0	0	0	1	1	3
ASFV detected	0	10	10	9	9	7

ASFV was still detected after 4 subsequent batches of feed

1. Is it likely to get contaminated?

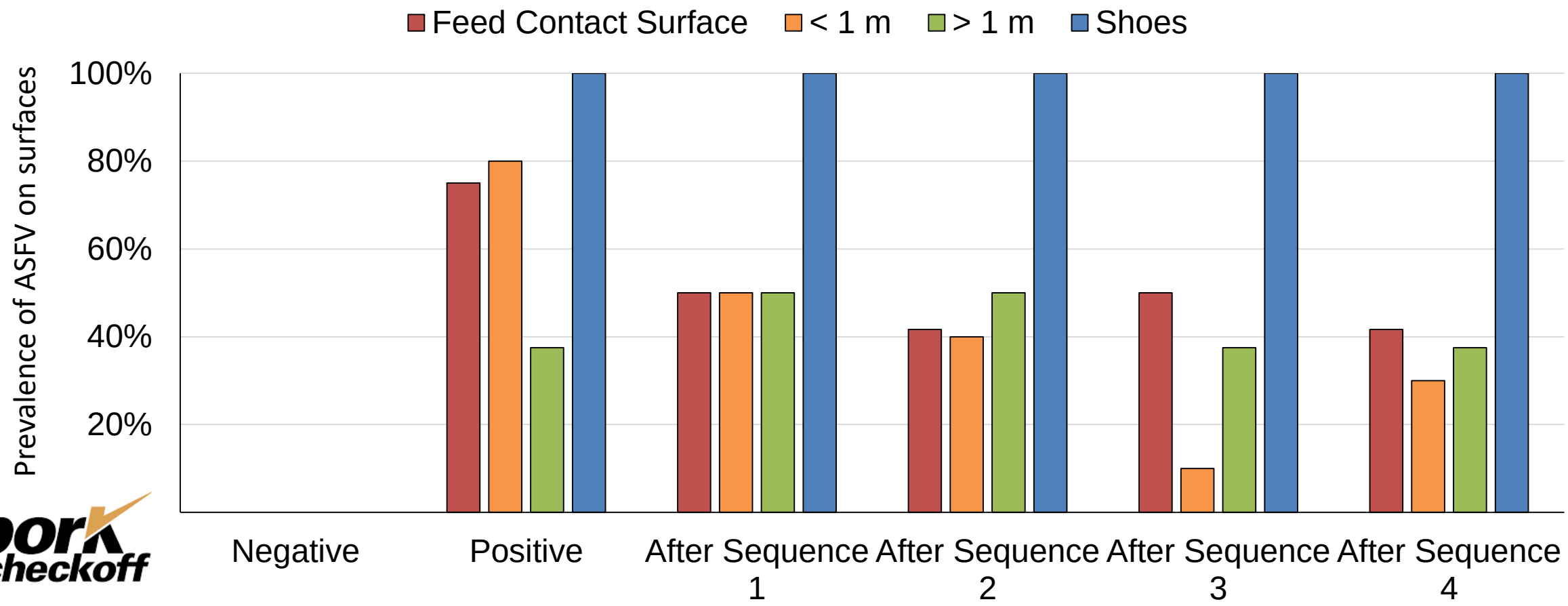
Risk of ASFV carryover on <u>feed surfaces</u> <u>and within environment</u> after contaminated batch



Elijah et al., 2021

1. Is it likely to get contaminated?

Risk of ASFV carryover on feed surfaces and within environment after contaminated batch



pork checkoff

Elijah et al., 2021

1. Is it likely to get contaminated?

Risk of ASFV carryover on feed surfaces and within environment after contaminated batch

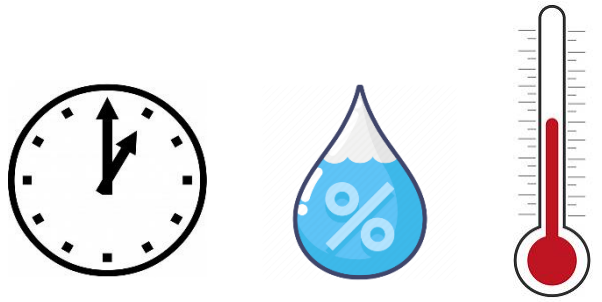
- Key findings:
  - ASFV has similar characteristics to PEDV within a feed mill
    - It goes everywhere!
  - Contamination of feed and surfaces can be detected after multiple batches of feed pass through the equipment
  - People are extremely important to consider!

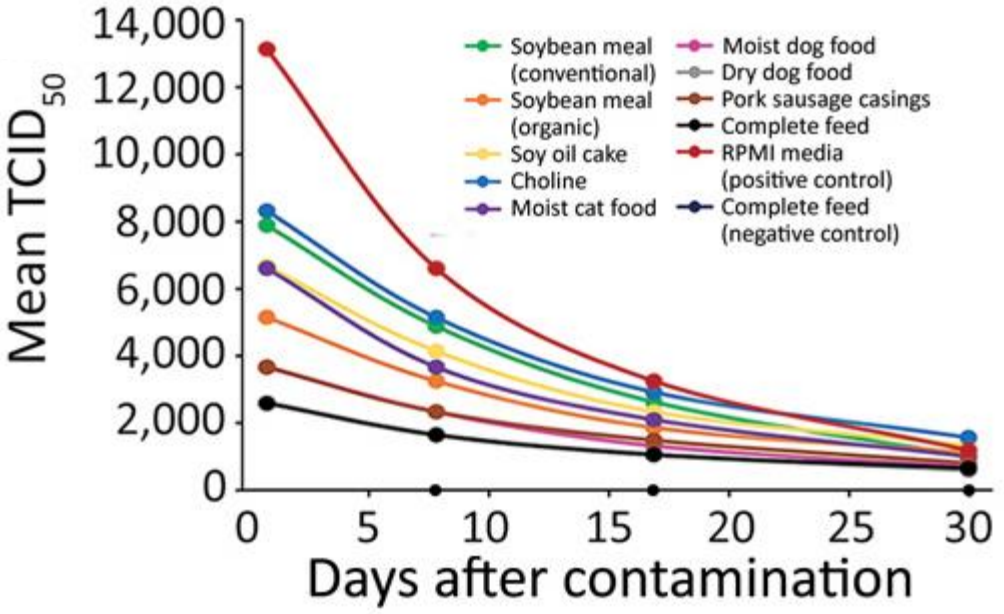




2. Can it survive

- Pathogen has to survive on surface to cause infection
  - Viruses do not replicate outside of host
  - Naturally decay over time (lose infectivity)
    - Time, temperature, humidity, environment
- Greatest survival in:
  - Choline
  - Soybean meal
  - Soy oil cake

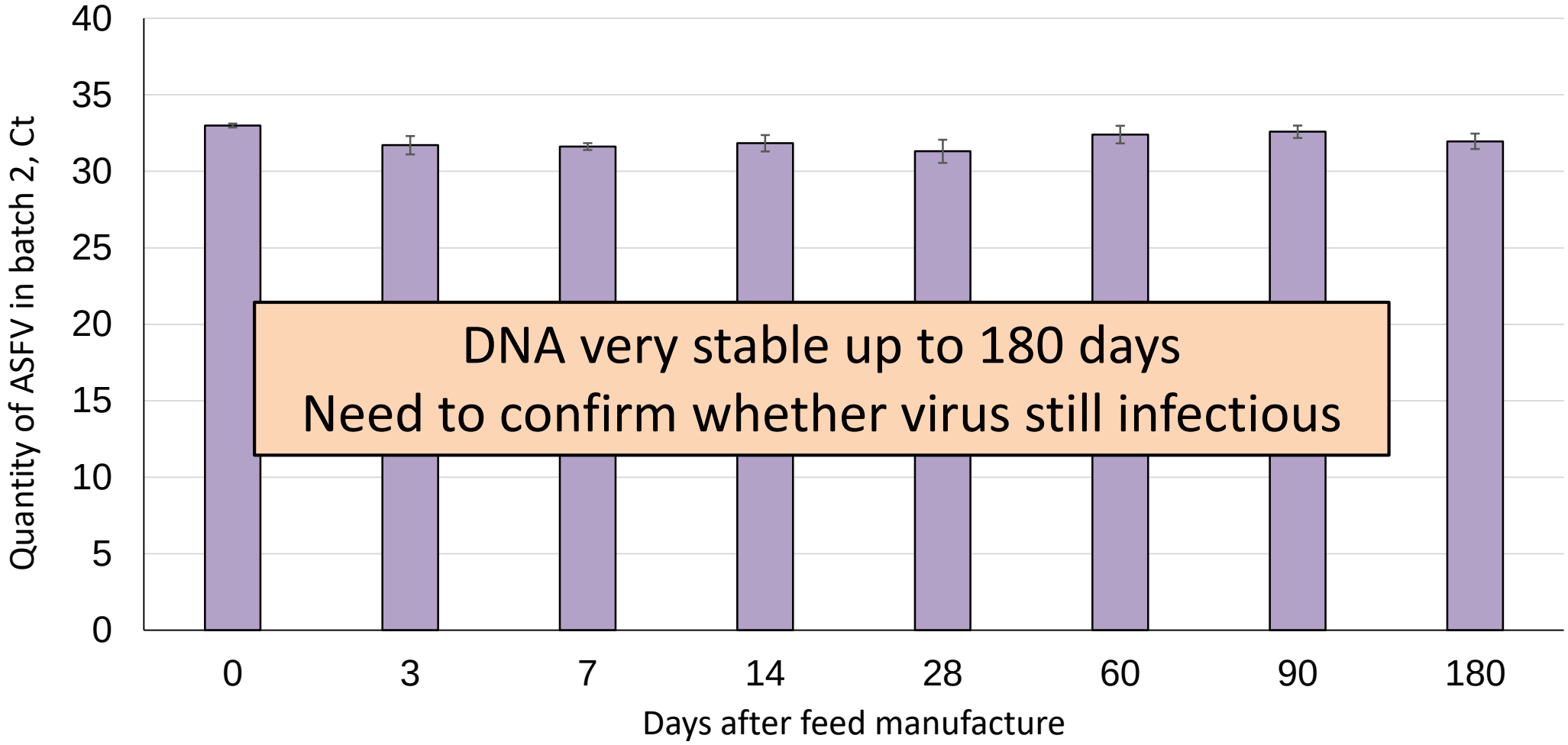




Stoian et al., 2019

2. Can it survive

Detection of African swine fever virus in contaminated feed over time



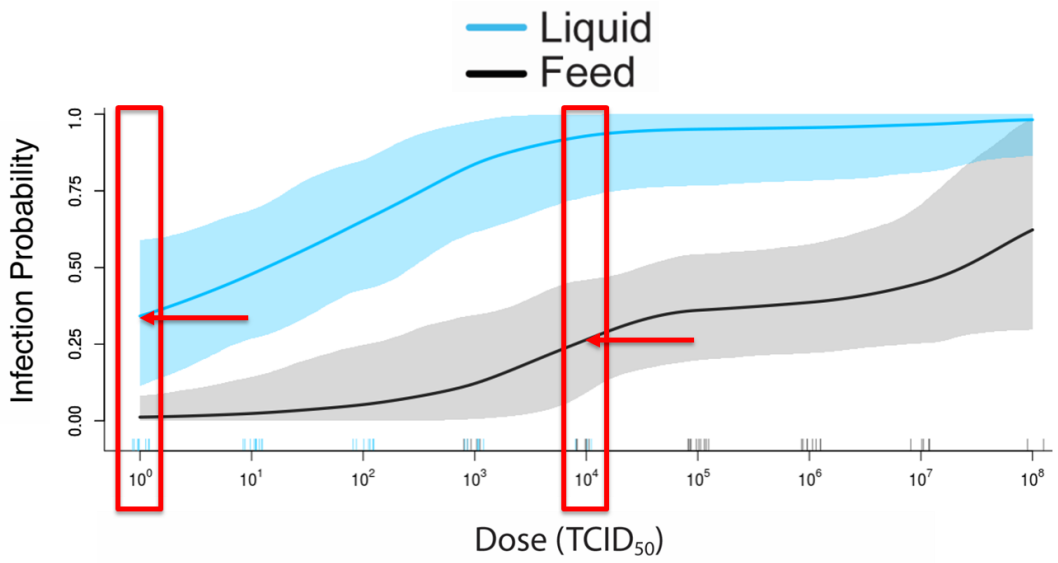
pork checkoff

Elijah et al., 2021

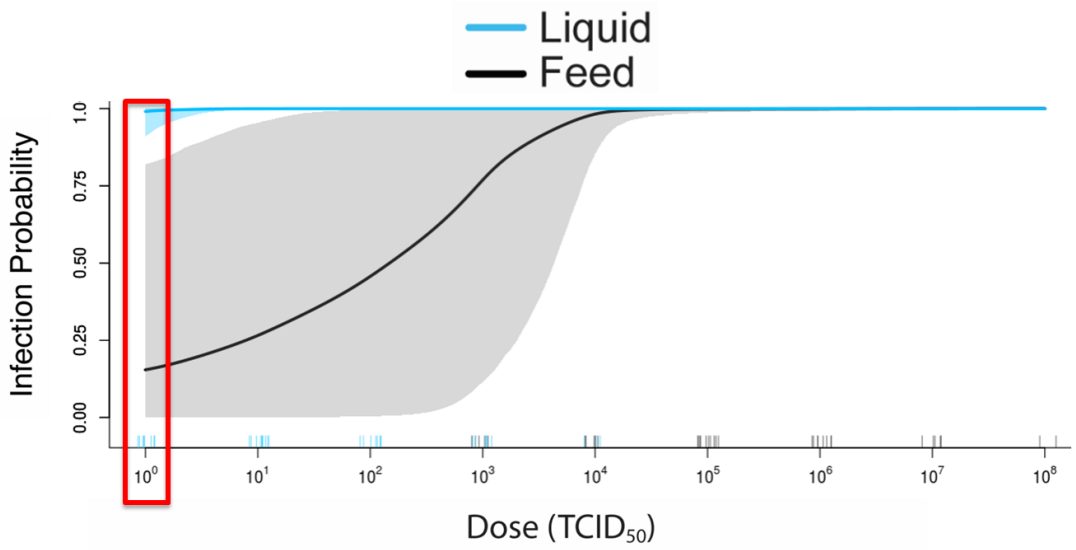
3. Is it infectious?

Feed as vector for disease

Single Exposure to a Single Animal
(100 g × 1 time)



Multiple Exposures to a Single Animal
(100 g × 20 times)



Multiple exposures increases risk of infection

Niederwerder et al., 2019

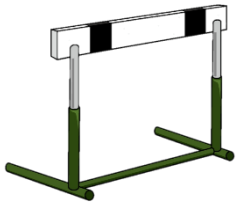
3. Is it infectious?

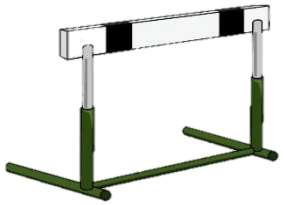
Feed as vector for disease

- For PEDV, 1 gram of feces from an acutely infected pig can contaminate 500 tonnes of feed – with EACH GRAM being infective

Schumacher et al., 2016

Feed Biosecurity:
Hurdles to Prevent Pathogen Transfer through feed supply chain





Prevention

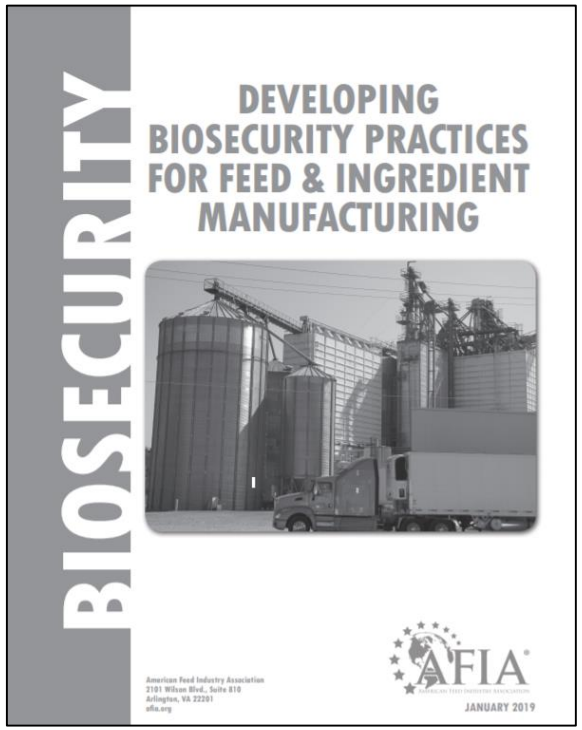
- Ingredient sourcing
- Biosecurity

Intervention

- Point-in-time
- Residual

Prevention

- Biosecurity at feed mills



Feed mill biosecurity plans: A systematic approach to prevent biological pathogens in swine feed

Roger A. Cochrane, MS; Steve S. Dritz, DVM, PhD; Jason C. Woodworth, MS, PhD; Charles R. Stark, MS, PhD; Anne R. Huss, MS, PhD; Jean Paul Cano, DVM, PhD; Robert W. Thompson, DVM, MS; Adam C. Fahrenholz, MS, PhD; Cassandra K. Jones, MS, PhD

KANSAS STATE UNIVERSITY

Swine Feed Mill Biosecurity Audit

This audit has not pass/fail score. Instead, the intent is for producers to use this audit as a method of engaging in discussion with feed manufacturers about potential methods that may be employed to maximize feed safety from biological hazards.

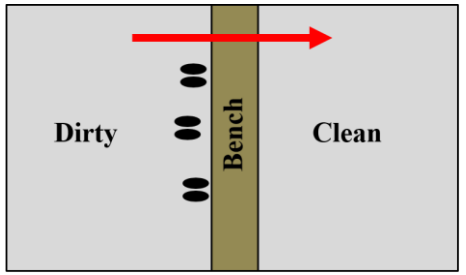
Feed Mill Name and Address: _____ Date: _____

GENERAL

- Distance of nearest pigs: ☐ < ½ mile ☐ ½ to 1 mile ☐ > 1 mile
- Is the mill in compliance with the Food Safety Modernization Act (FSMA)? ☐ Yes ☐ No
- Does the mill have any hazards requiring a preventive control? ☐ Yes ☐ No
  - If Yes, describe:

Prevention

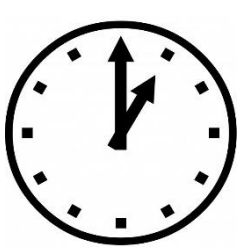
- Extend biosecurity to feed mills to limit contamination from trucks and people
  - Use receiving mats/funnels
  - When possible, don't let drivers out of trucks
    - Use your own employees to unload
    - Start treating your mill like your farm – physical barriers, foot baths, zoning
- Consider truck disinfection

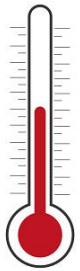


Intervention

Point-in-Time

- Susceptible to recontamination
  - Time
  - Irradiation
  - Thermal processing





Residual

- Have some level of residual activity to help combat possible recontamination
  - Acids and alkalis
  - Essential oils
  - Formaldehyde-based products
  - Medium chain fatty acids

Intervention

Point in time: Holding time

- Based on half-life estimates, recommended holding times have been established
  1. Temperature
  2. Humidity
  3. Ingredient matrix

Mean Holding Time for 99.99% SVA Degradation			
	Days at 4°C (39.6°F)	Days at 15°C (59°F)	Days at 30°C (86°F)
Conventional SBM	143 days	52 days	26 days
DDGS	494 days	182 days	26 days
Vitamin D	39 days	26 days	26 days
Lysine	78 days	13 days	13 days

Mean Holding Time for 99.99% ASF Degradation at 54°F Avg.[3]			
	Average	95% Confidence Interval - Lower	95% Confidence Interval – Higher
Conventional SBM	125 days	113 days	135 days
Organic SBM	168 days	150 days	186 days
Choline	155 days	142 days	168 days

https://www.swinehealth.org/wp-content/uploads/2020/02/Holding-Time-Calculations-for-Feed-Ingredients-to-Mitigate-Virus-Transmission-Print-02.04.20.pdf

Intervention

Point in time: Thermal processing

	Feed	0 dpi	2 dpi	4 dpi	6 dpi	7 dpi	7 dpi Cecum
No PEDV	0	0	0	0	0	0	0
38°C	9/9	0	1/9	3/9	3/9	3/9	3/9
46°C	9/9	0	3/9	3/9	3/9	3/9	3/9
54°C	9/9	0	0	0	0	0	0
63°C	8/9	0	0	0	0	0	0
71°C	8/9	0	0	0	0	0	0

No infectivity in diets pelleted ≥ 54°C (129°F)

Cochrane et al., 2017

Addressing Feed Safety

1. Is it likely to get contaminated?

2. Can it survive?

3. Is it infectious?

Prevention

Intervention

Keys to a successful biosecurity program

Culture

Training

Biosecurity

Infrastructure

Continuous improvement

Culture

- Any biosecurity program cannot be successful without the proper culture
  - Support and feedback from management
  - Financial support
- Consistent expectations and accountability at all levels of organization

Training

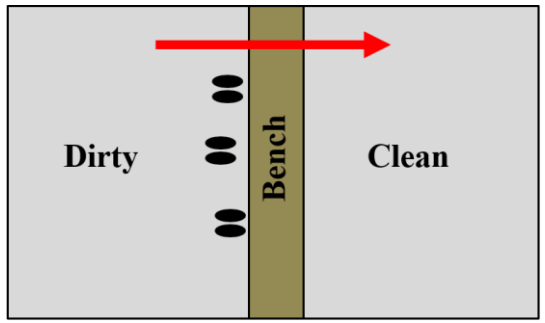
- SOP's are worthless if employees don't know how to implement
- Routine reinforcement
- Focus on the WHY
- Glo-Germ fluorescent powder




Infrastructure

- Facility designs must accommodate biosecurity practices
  - Minimize inconvenience = more consistent implementation

Entry benches -
Can we include in mills?

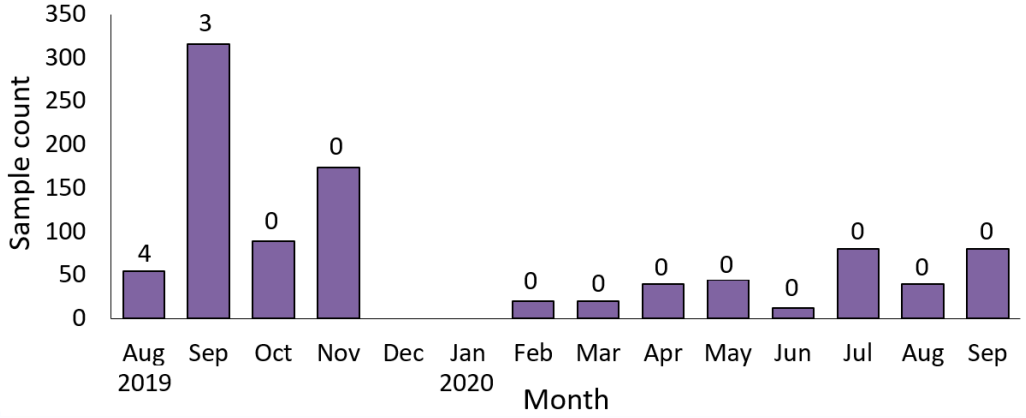


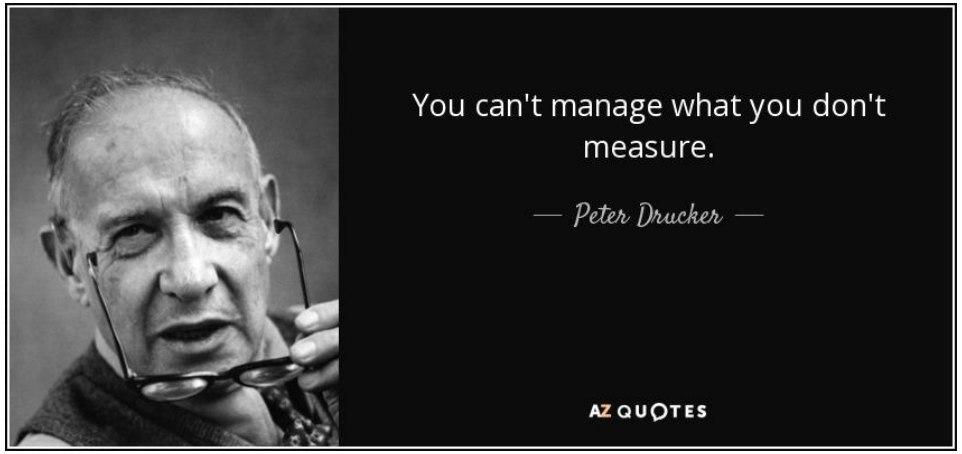
Too convenient to sweep dust into mixer

Perimeter barriers – control traffic flow

Continuous improvement

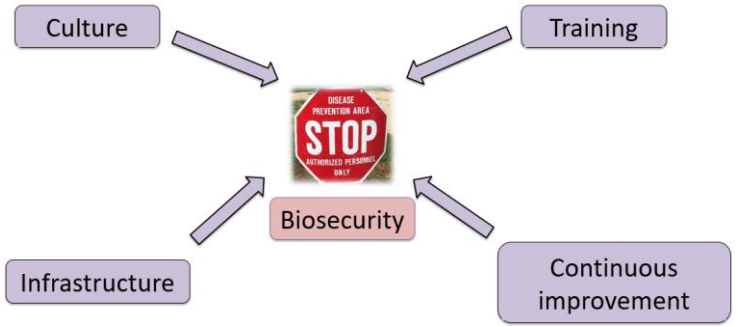
- Routine biosecurity audits of mills and mills
  - Change the paradigm and negative perception
  - Getting better helps everybody
- Sampling and diagnostic testing





What have we learned

- Biosecurity is:
  - Inconvenient
  - Expensive



- Modern swine production is continuously moving towards high health
- Biosecurity as a whole is critical to long-term success of swine businesses
  - Feed biosecurity is becoming a critical component

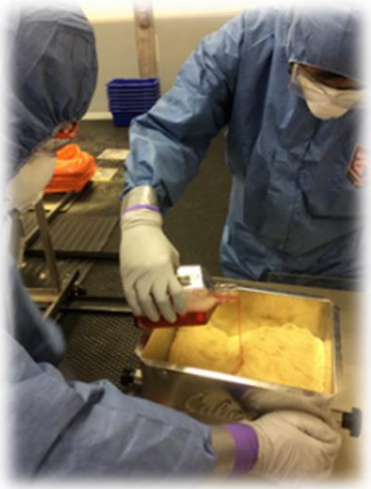
Kansas State University Feed Safety Team

Dr. Jordan Gebhardt – Diagnostic Medicine/Pathobiology

Dr. Cassie Jones – Animal Sciences & Industry

Dr. Chad Paulk – Feed Science

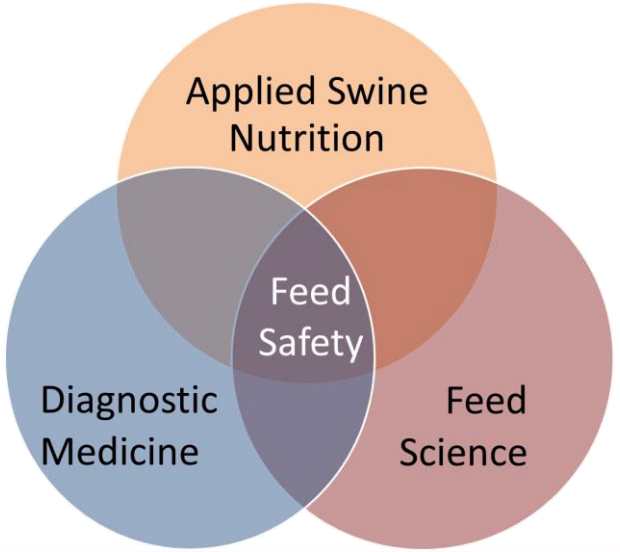
Dr. Jason Woodworth – Animal Sciences & Industry



www.ksuswine.org → Feed Safety Resources

Kansas State University | applied swine nutrition

Diagnostic Medicine/Pathobiology — Kansas State University



Kansas State University
Animal Sciences and Industry

Kansas State University
Grain Science & Industry