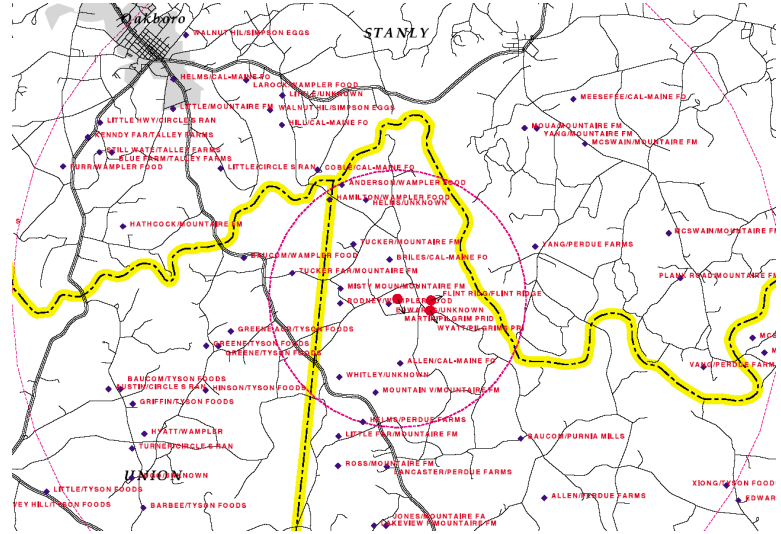
The neglected components of biosecurity programs

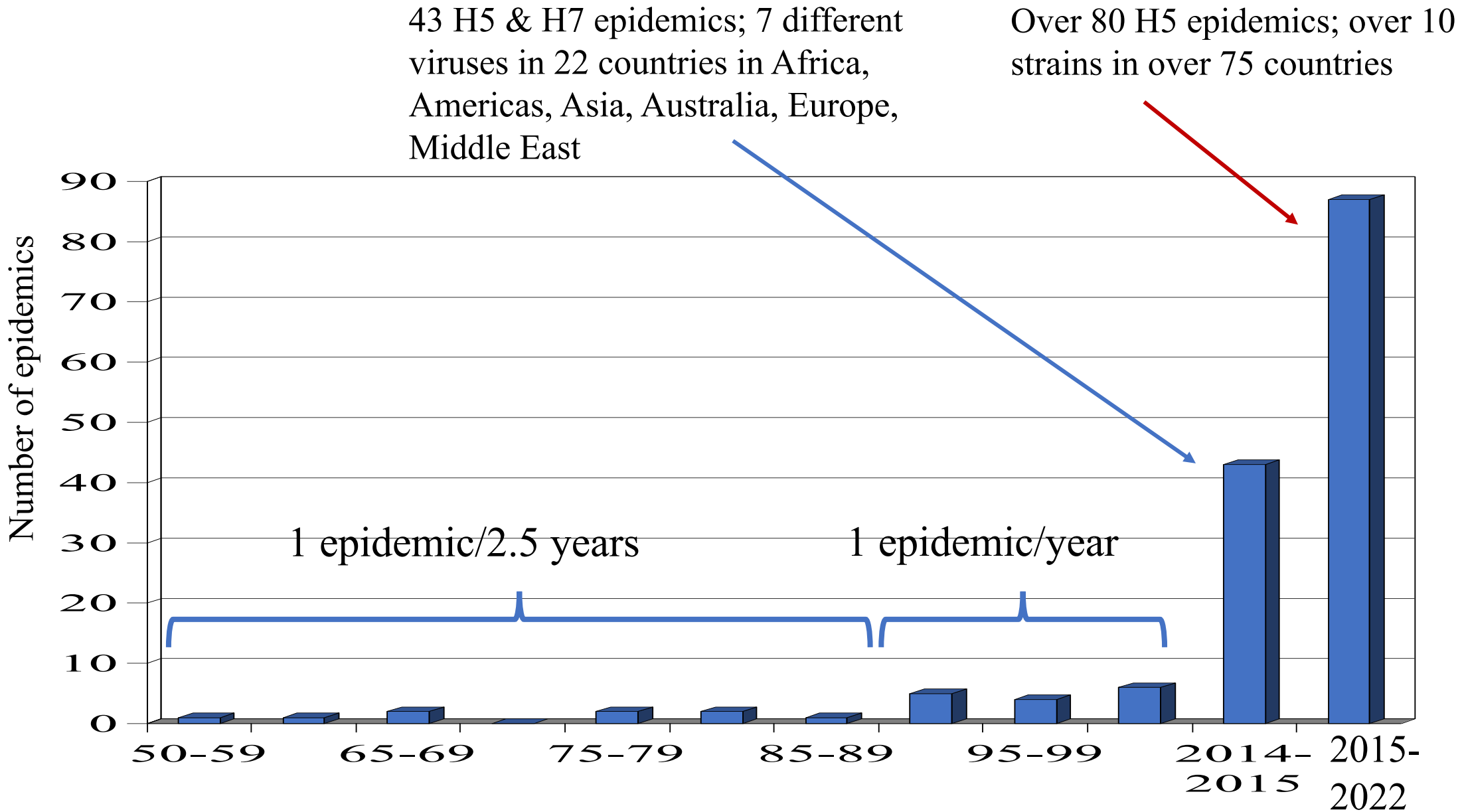
What works
Why it often does not
What we can do about it

Jean-Pierre Vaillancourt

Université de Montréal



Highly Pathogenic Avian Influenza



Avian Influenza Viruses With Zoonotic Potential

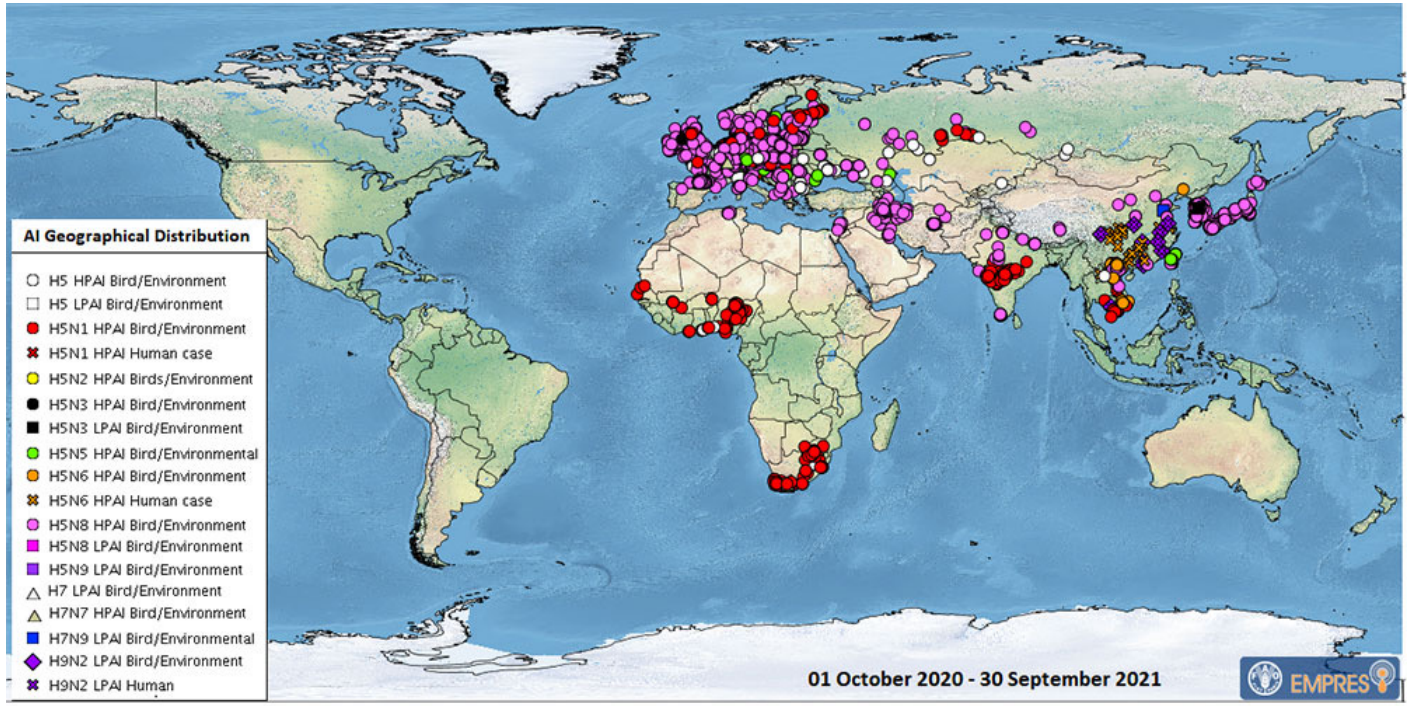
October 2020 to
September 2021

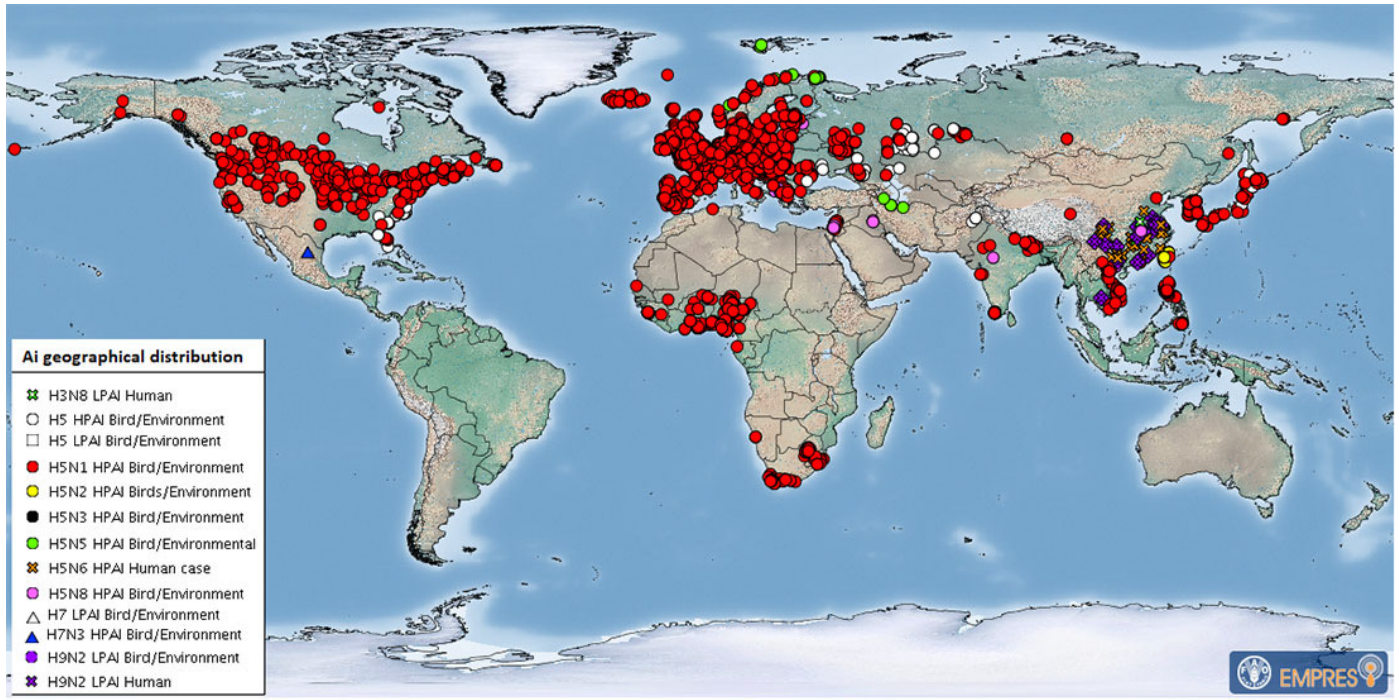
H5N8

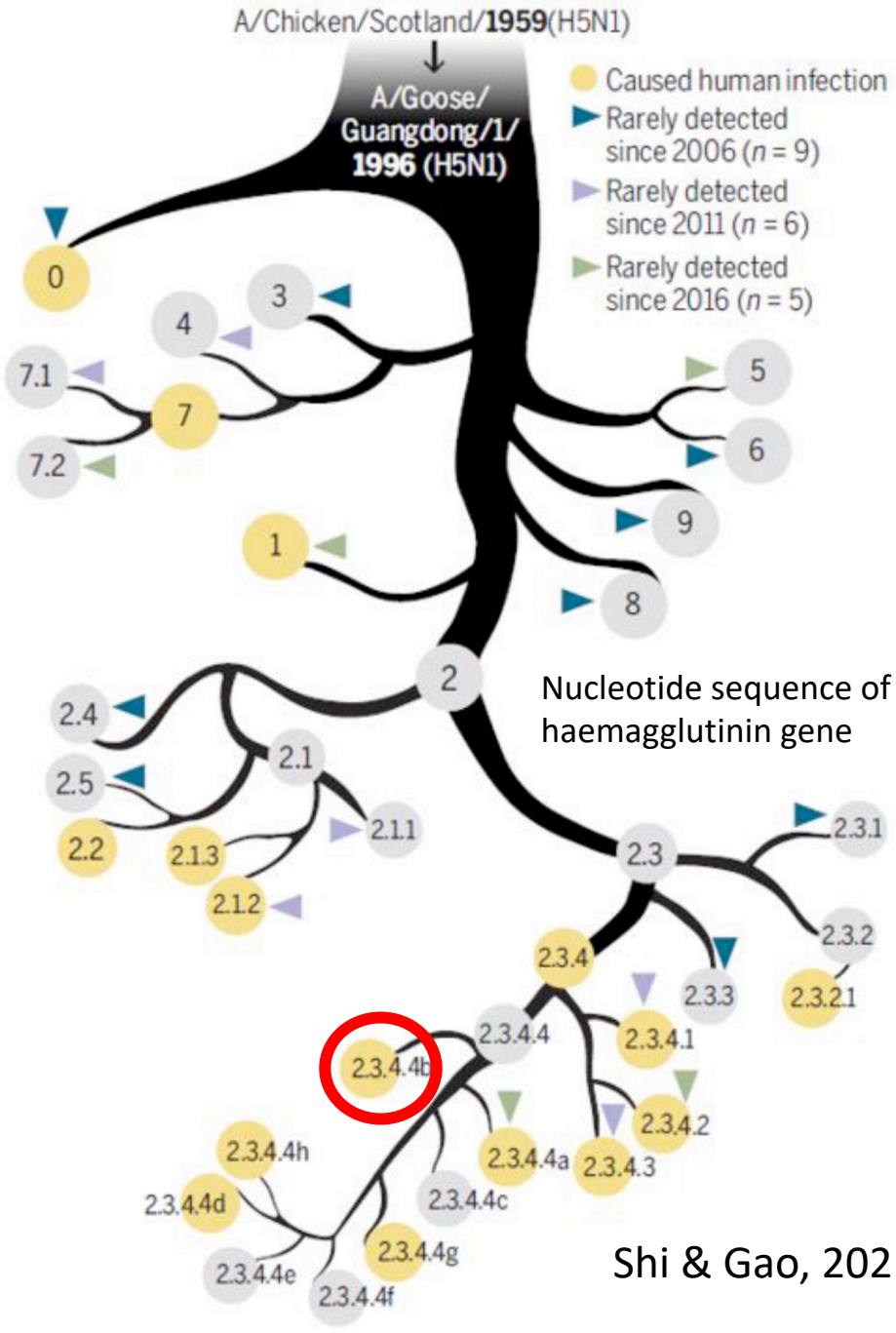
Dominance

October 2021 to
September 2022

H5N1

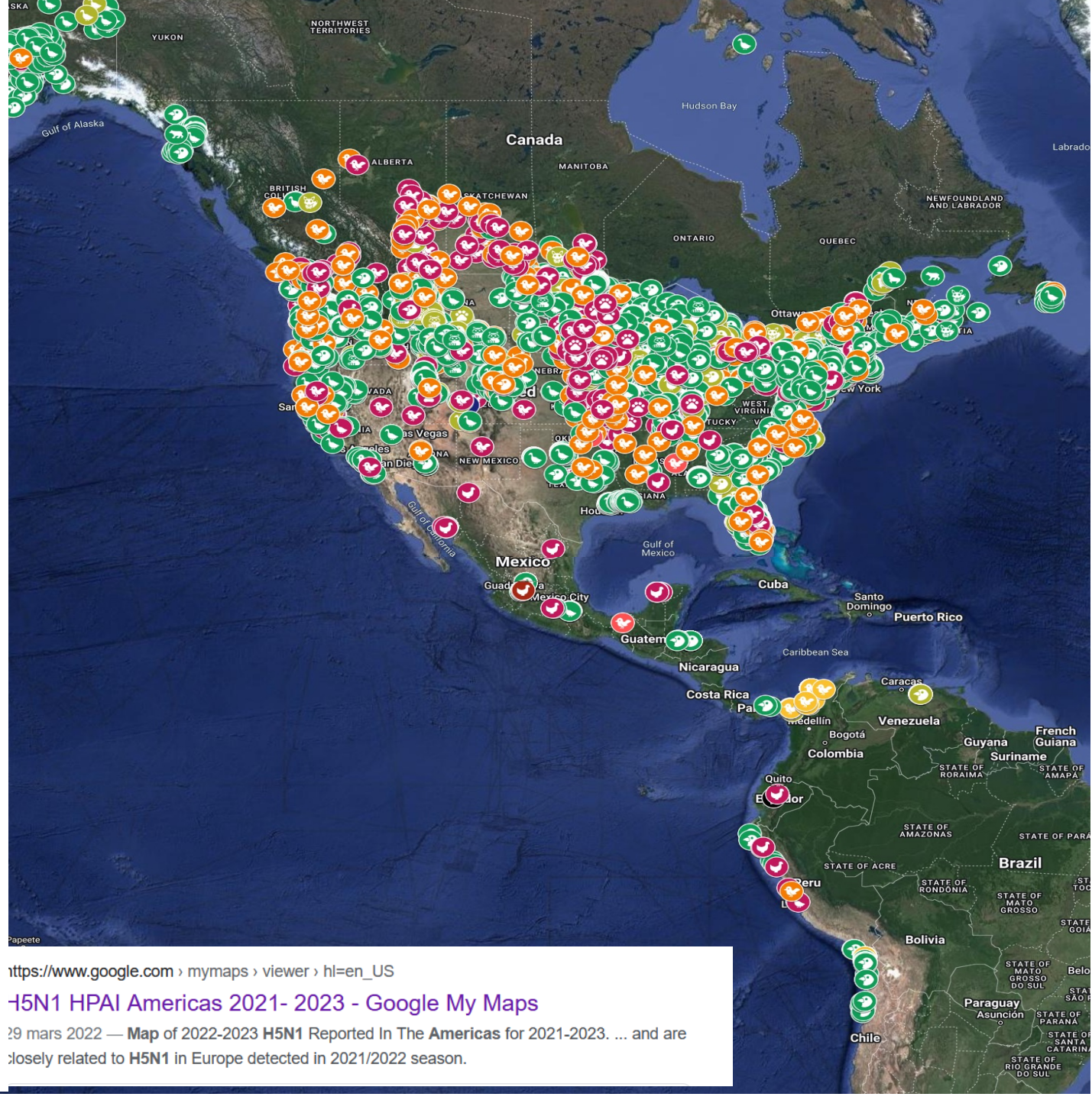






Nucleotide sequence of the haemagglutinin gene

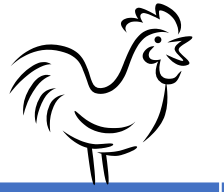
Shi & Gao, 2021



https://www.google.com › mymaps › viewer › hl=en_US

H5N1 HPAI Americas 2021- 2023 - Google My Maps

29 mars 2022 — **Map** of 2022-2023 **H5N1** Reported In The **Americas** for 2021-2023. ... and are closely related to **H5N1** in Europe detected in 2021/2022 season.



Risk factors associated with Avian Influenza

Country	Species	Significant Factors	Reference
USA	Turkey Chicken	Odds are 7.3 times higher when disposing dead birds by rendering	McQuiston et al. , 2005
Japan	Layer	Odds are 37 times higher when introducing end-of-lay chickens	Nishiguchi et al., 2007
		Odds are 29.4 times higher when sharing farm equipment between farms	
		Odds are 7 times higher when visitors have incomplete hygiene measures (shoes, clothes hands)	
Korea	Layer	Odds are 500 times lower when farms have disinfection stations (hand & boot washing/disinfection)	Yoo et al. 2002
		Odds are 6 times lower when changing boots between barns	
France	Duck	Odds are 9 times higher when inadequate management of vehicles and people movements	Guinat et al., 2020
		Odds are 6.5 times higher if inadequate delimitation of farm and units (leading to inadequate use of anteroom)	
Netherlands	All	Odds are 2 times higher in layer compared to other types of birds	Thomas et al., 2005
Italy	All	Farms located within 1500 m from case farms are 12 times more likely to be infected.	Mannelli et al., 2006
		Turkeys are 4 times more likely to be infected compared to other species.	

Risk identification – we know the risks

- Birds
- Multi-species sites
- Water
- Visitors & employees
- Equipment
- Dead bird disposal
- Manure management
  - Storage
  - Spread
- Rodents & other wildlife
- Insects
- Regional farm density
- The wind?

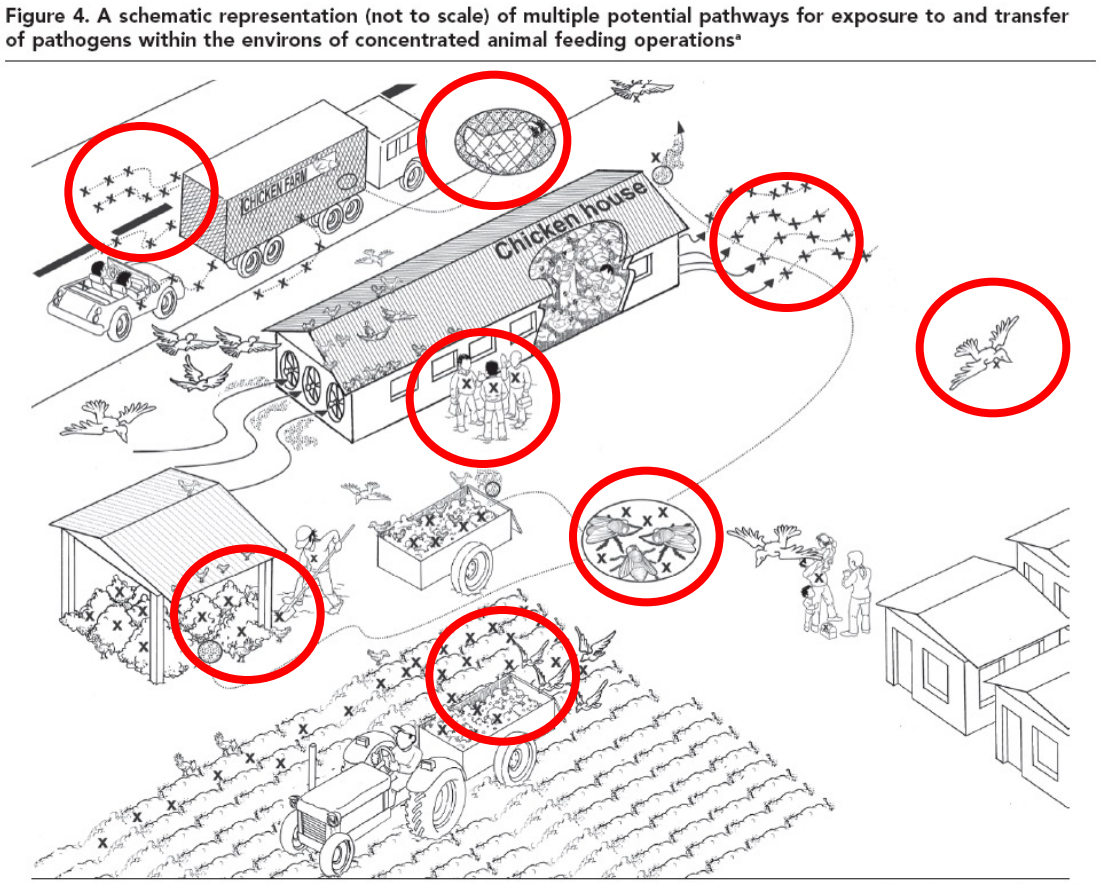
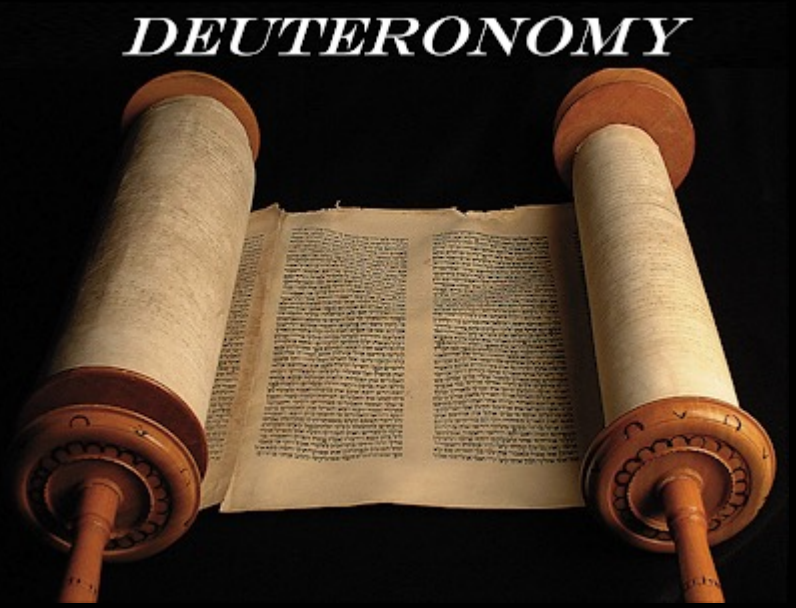


Figure 4. A schematic representation (not to scale) of multiple potential pathways for exposure to and transfer of pathogens within the environs of concentrated animal feeding operations[a]

(Artist: Salvador Saenz)

[a]Compromises to biosecurity include: (1) workers lacking protective clothing or opportunities for personal hygiene or decontamination on-site; (2) inadequate management of animal biosolids, often applied to land without treatment; (3) flies and other insects that carry pathogens in and out of facilities through ventilation systems and small openings; (4) ventilation with high-volume fans resulting in considerable movement of materials into the external environment; and (5) transporting animals in open trucks or containers to the farm or for processing.

Graham et al, 2008

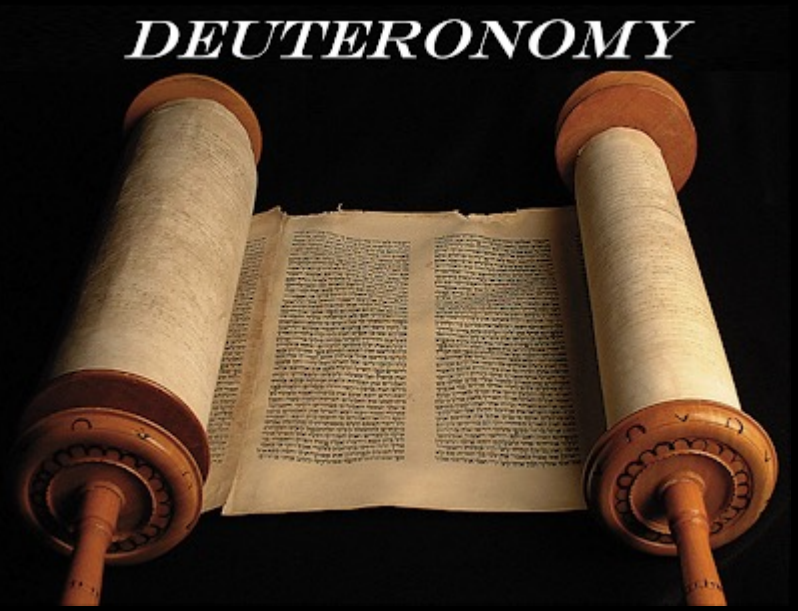


"You shall have a place outside the camp, and you shall go out to it. And you shall have a trowel with your tools, and when you sit down outside, you shall dig a hole with it and turn back and cover up your excrement."

"And he that is to be cleansed shall wash his clothes, …wash himself in water, …and after that he shall come into the camp, but shall stay outside of his tent seven days."

Leviticus/14/8

Soldiers returning from war were required to flame all their equipment and to plunge garments in boiling water.



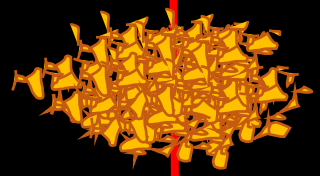
"You shall have a place outside the camp, and you shall go out to it. And you shall have a trowel with your tools, and when you sit down outside, you shall dig a hole with it and turn back and cover up your excrement."

- ✓ "I forbid you to ever enter a …an assembly of people.
- ✓ I forbid you to leave your house unless dressed in your recognizable garb
- ✓ I forbid you to drink at any stream or fountain, unless using your own barrel
- ✓ I forbid you to touch anything…until it becomes your own.
- ✓ I forbid you to share house with any woman but your wife.
- ✓ If accosted by anyone…set yourself downwind of them
- ✓ I forbid you to enter any narrow passage, lest a passerby bump into you.
- ✓ I forbid you…to touch anything without donning your gloves.
- ✓ I forbid you to drink or eat from any vessel but your own."

Separatio Leprosorum (Mass of separation)

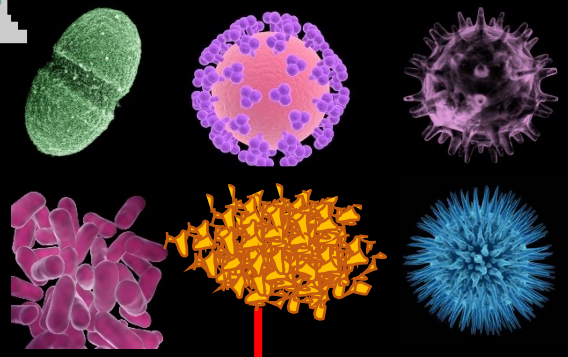
Basic Biosecurity Principles

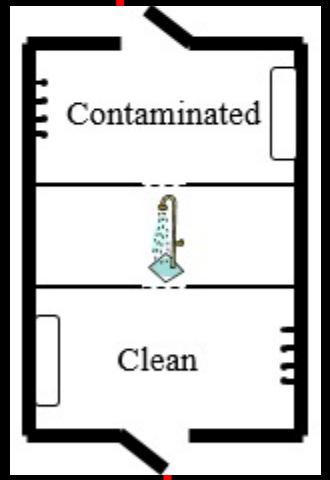
Reduce

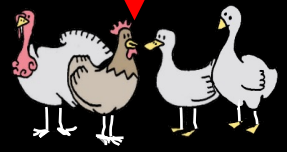


Clean

Separate

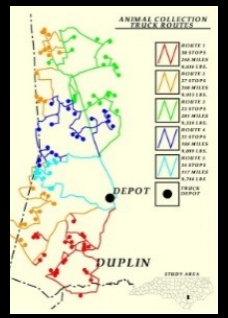


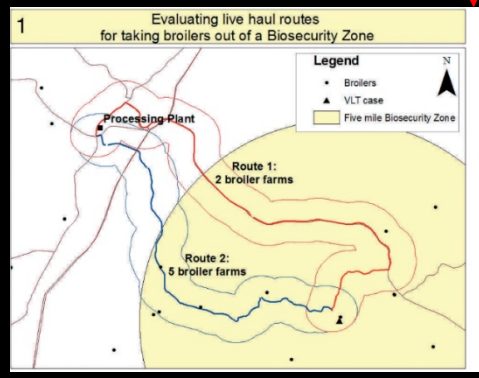


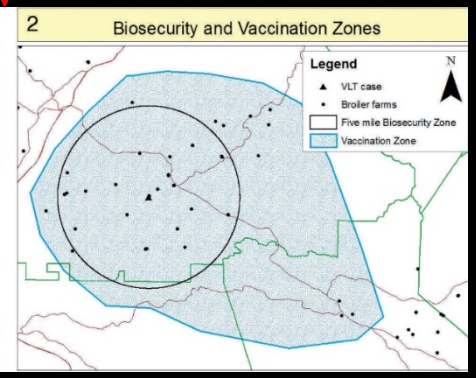


Communicate

Organize







Cleaning & Disinfection

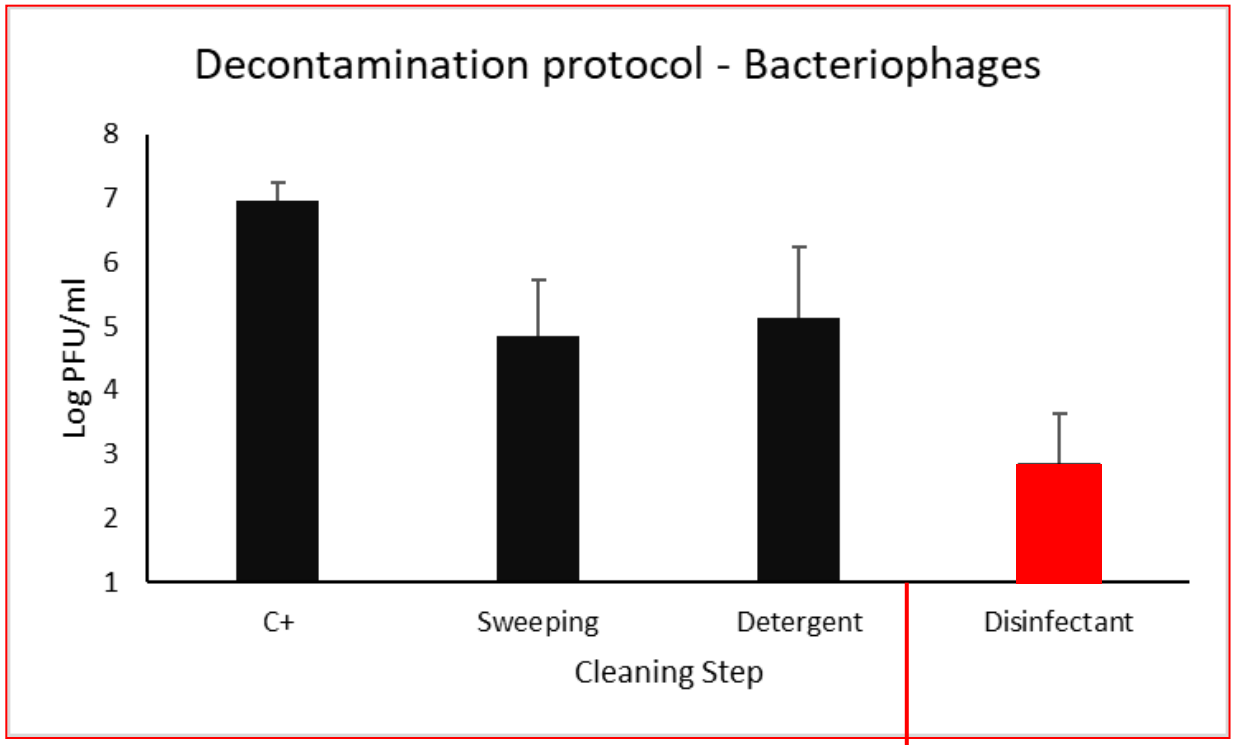
- Inadequate contact time (detergent and disinfectant)
- Failure to use soap/detergent when cleaning
- Failure to get everything dry before disinfecting
- Disinfecting immediately after cleaning rather than just prior to use (equipment being stored outside after C&D and getting contaminated with bird droppings)
- Monitoring C&D (changes in personnel, interpretation differences on “clean”, etc.)
- Failure to observe the process
- Failure to make sure C&D and biosecurity supplies are being ordered and available

Gonder, 2023



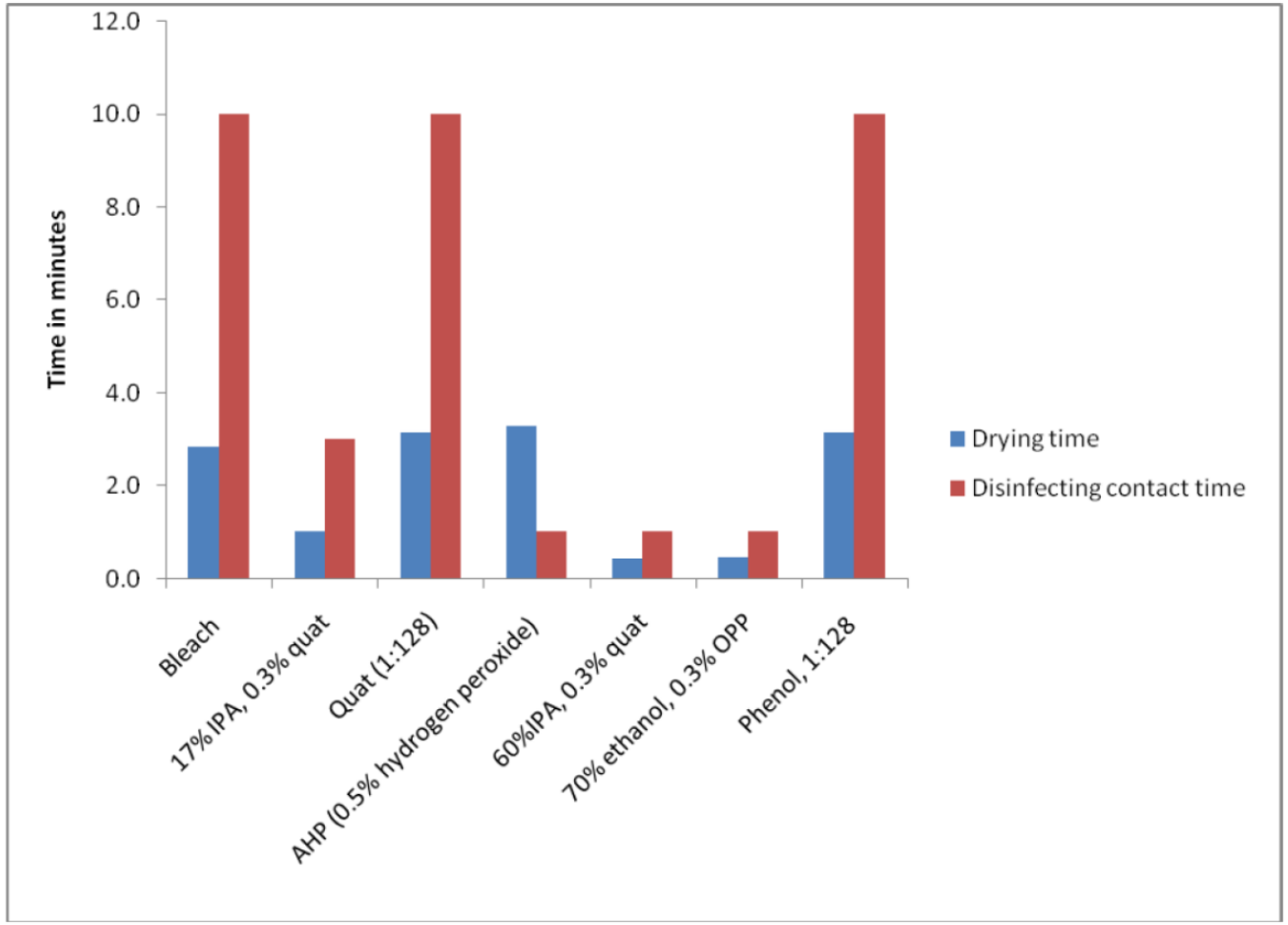


Impact of drying and disinfection on viruses



Drying

Table 1: Drying Time versus Disinfectant Label Contact Time



The Importance of Contact Times for Disinfectants
(Omidbakhsh, N. CJIC 2008; 23:49)

An assessment of sanitation protocols for commercial transport vehicles contaminated with porcine reproductive and respiratory syndrome virus

Scott Dee, John Deen, Danny Burns, George Douthit, Carlos Pijoan

Table II. Summary of diagnostic data from Wash only **and** Wash + Formaldehyde

Area tested				Trt 4	Neg Ctrl
Trailer interior pretreatment	20/20[a]	20/20	19/20	20/20	0/20
Trailer interior 60 min posttreatment	20/20	20/20	2/19	NT	0/20
Trailer interior 90 min posttreatment	20/20	20/20	0/19	NT	0/20
Trailer interior allowed to dry (8 h)	NT	NT	NT	0/20	0/20
Number of PRRSV (+) pigs postexposure	2/4[b]	2/4	0/4	0/4	0/4

Trt 1 — Treatment 1, washing only; Trt 2 - Trt 3 — atment 3, washing plus glutaraldehyde: quaternary ashing p overnight drying; Neg Ctrl — Sham-inoculated proto cine rep uctive and respiratory syndrome virus

Wash + Glutaraldehyde: quaternary ammonium chloride

Wash + Overnight drying

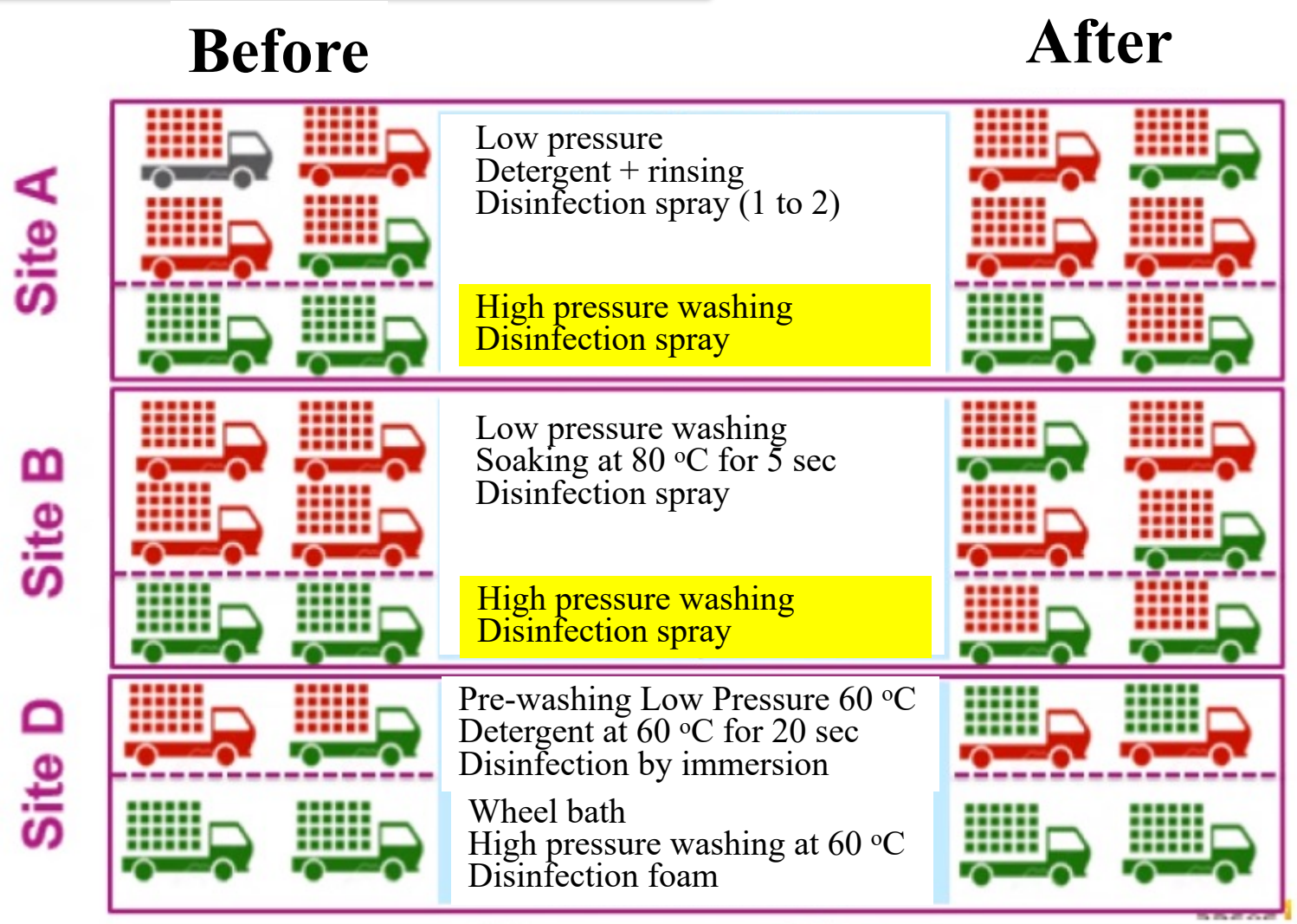
[a] Number of polymerase chain reaction (PCR)-positive swabs per number of replicates conduc

[b] Number of replicates that demonstrated PRRSV infection of naïve sentinel pigs ho for 2 h per number of replicates conducted

Immunology, Health and Disease

Cleaning and disinfection of crates and trucks used for duck transport: field observations during the H5N8 avian influenza outbreaks in France in 2017

Adeline Huneau-Salaün, Axelle Scoizec, Rodolphe Thomas, Sophie Le Bouquin



Gene M+

Gene M -

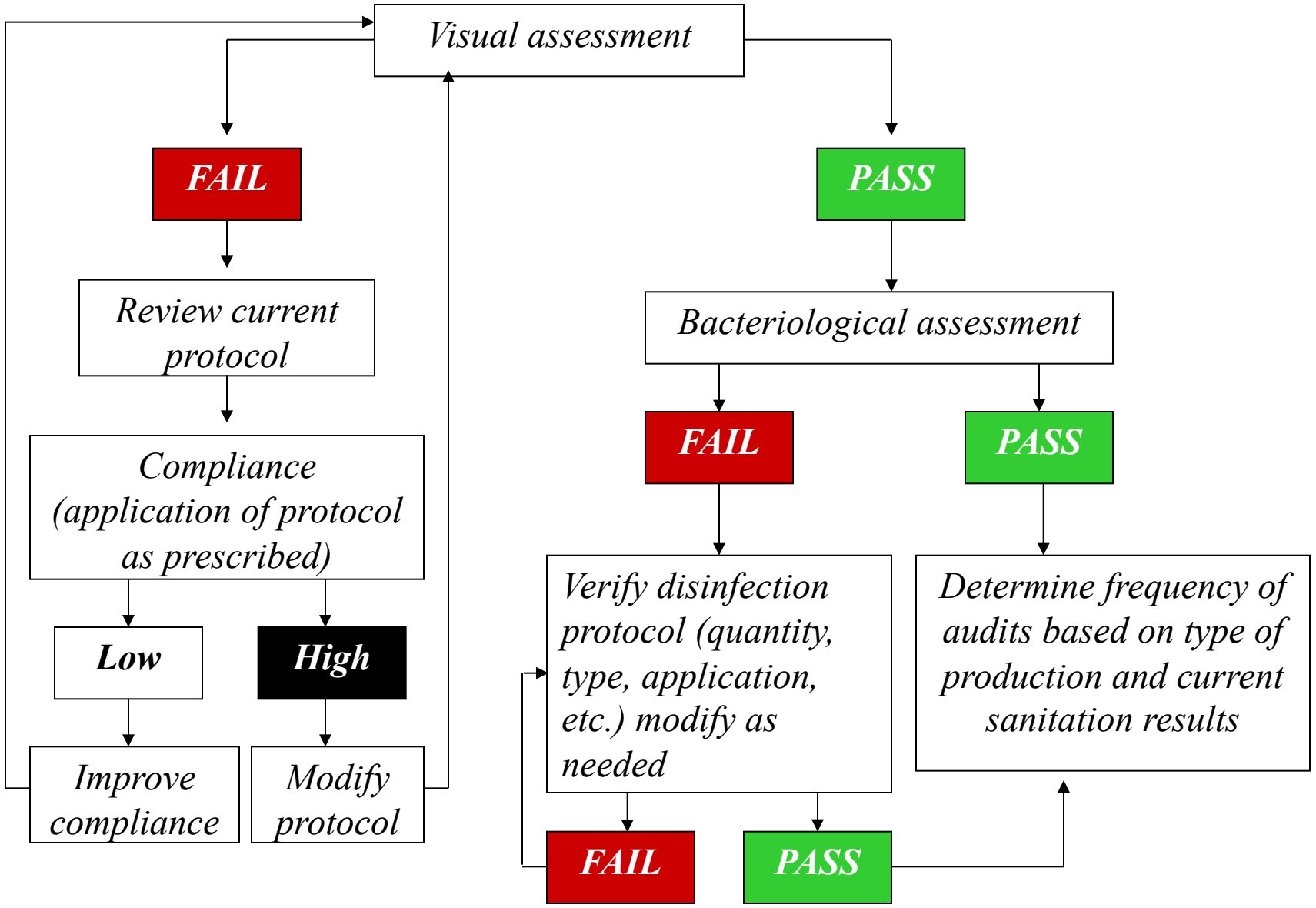
Failure

Initial amount of contamination

Poor execution

Cross-contamination after cleaning

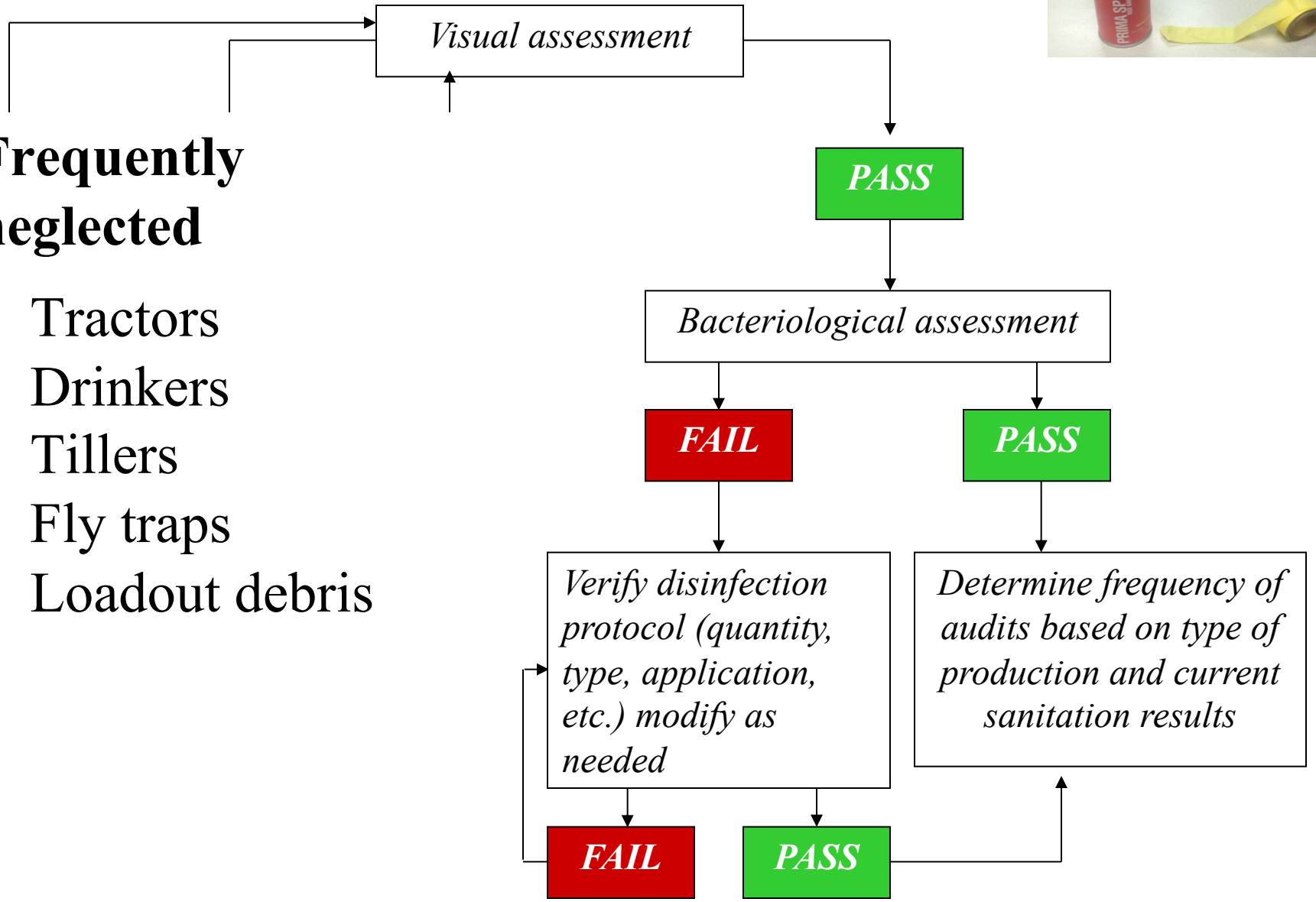
Monitoring of sanitation



Mark the spots needing attention, especially if person responsible is not present

Frequently neglected

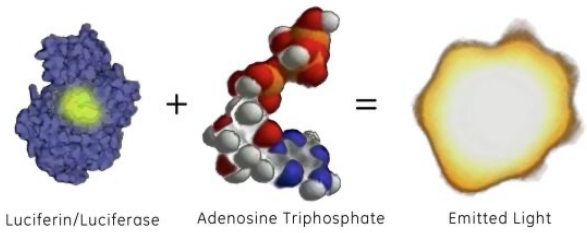
- Tractors
- Drinkers
- Tillers
- Fly traps
- Loadout debris



Colorimetric representation of important attributes for a successful microbial monitoring system

Detection method	Accurate	Rapid	Cost-effective	Commercially practical
Agar air plate				
RODAC plate				
Direct swab				
Fluff evaluation				
MPN enumeration				
ATP bioluminescence				

Positive
Neutral
Negative
Unknown



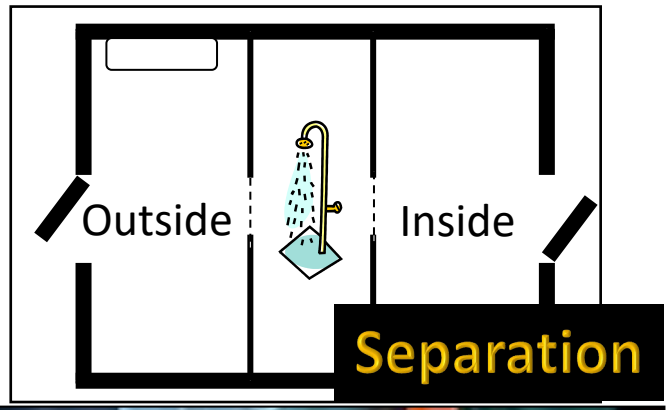
https://www.hygiena.com/

Julia S. Mcelreath, 2019


France


Mexico


Ethiopia
3/2018


Outside
Inside
Separation


USA


Cameroon
08/23/20


France

Study on the usage of footbaths under field conditions

Farms

Total Bacterial Counts from Shoe Swabs

	Fresh Solution	After 3 hours of use
Active Ingredient	% Change in bacterial count	% Change in bacterial count
Phenol	-45.8	+130.5
Quaternary Ammonium	-57.5	+73.3
Water	+87.2	+44.8

Robert L. Owen and John La

25. QUINN
In Disin
Philadel

22

Dry footbath

Active Ingredient	% Change in Bacterial count	Average Residual Life
Detergent + Dry Bleach	-92.6	14 days
Dry Bleach	-98.06	14 days
Phenol	+ 10.8	<2 hours
Quaternary ammonium	-23.6	<2 hours

Study on the usage of footbaths under field conditions

Farms

Dry footbath

Total Bac from Sho

Active Ingredient		
Phenol	-4	
Quaternary Ammonium	-5	
Water	+87.2	+44.8

Robert L. Owen and John La

25. QUINN
In Disin
Philadel

22

Persistence of Highly Pathogenic and Low Pathogenic Avian Influenza Viruses in Footbaths and Poultry Manure

R. Hauck,[A] B. Crossley,[B] D. Rejmanek,[B] H. Zhou,[C] and R. A. Gallardo[AD]

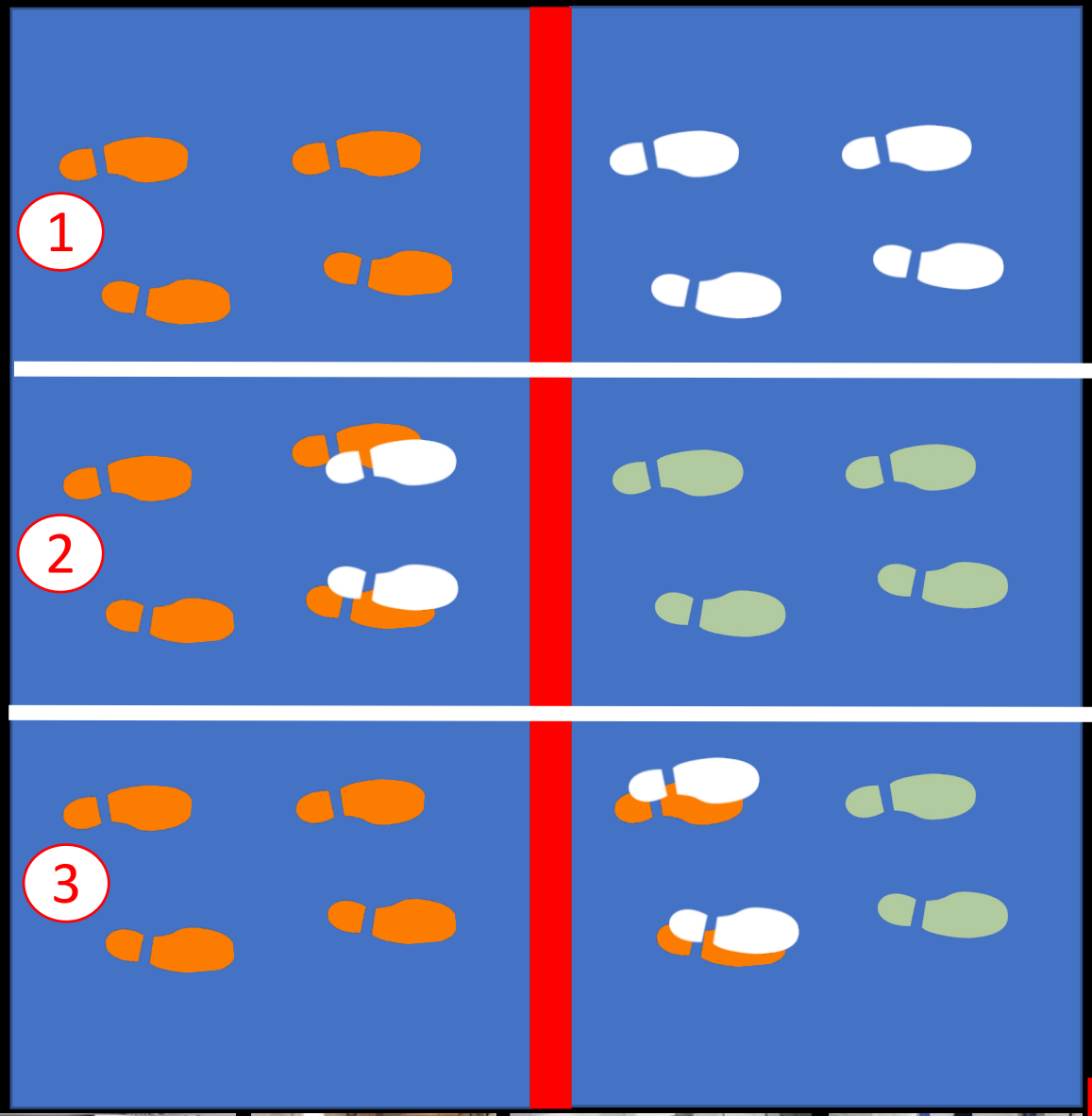
Table 1. Detection of HPAI and LPAI by RT-qPCR and virus isolation in spiked bedding material scraped from boots treated with quaternary ammonia + glutaraldehyde–, quaternary ammonia only–, or bleach powder–based footbaths.

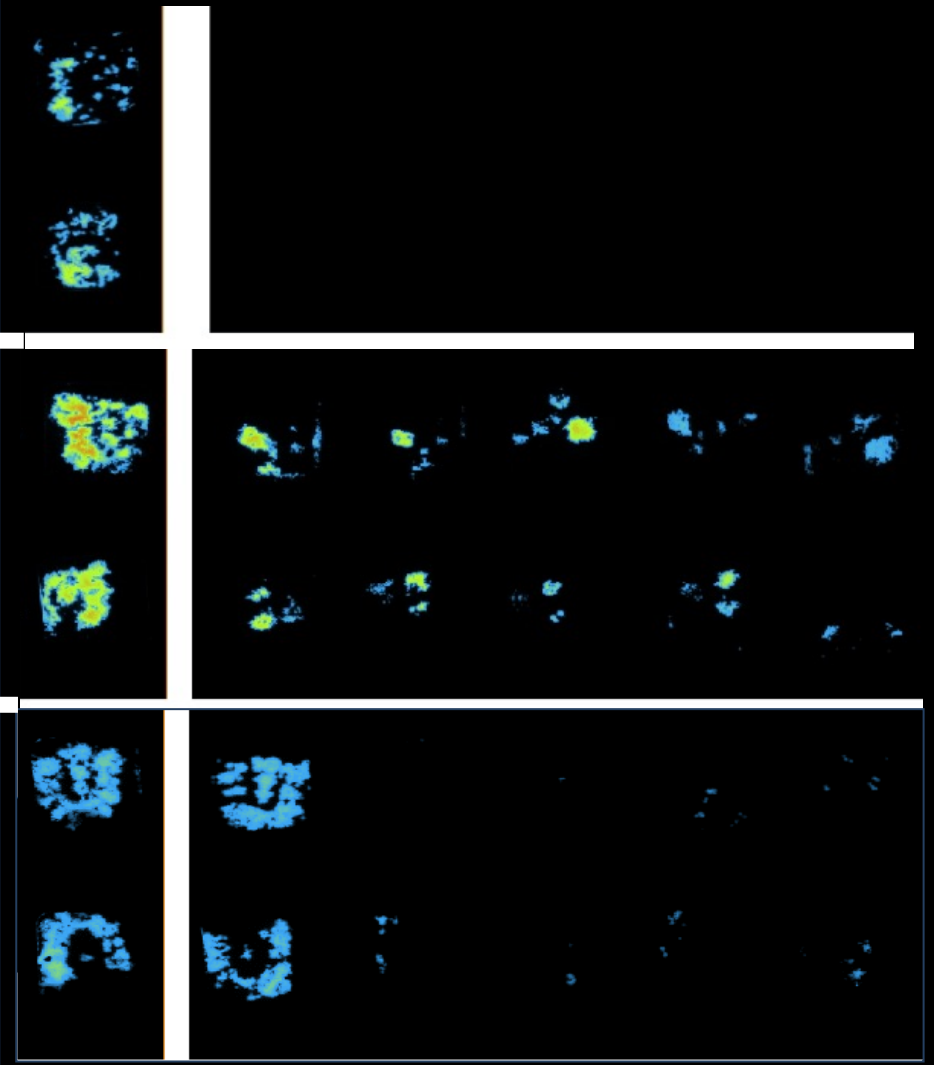
	Hours after preparation of footbath							
	0		24		48		72	
	HPAI	LPAI	HPAI	LPAI	HPAI	LPAI	HPAI	LPAI
Control (feces no disinfectant)								
RT-qPCR	+[A]	+	+	+	+	+	+	+
Isolation	+	+	+	+	+	+	+	+
Quaternary ammonia + glutaraldehyde								
RT-qPCR	+	+	+	+	+	+	+	+
Isolation	+	+	+	+	+	+	+	+
Quaternary ammonia								
RT-qPCR	+	+	+	+	+	+	+	+
Isolation	+	+	+	+	+	+	+	+
Bleach powder								
RT-qPCR	–[B]	–	–	–	–	–	–	–
Isolation	–	–	–	–	–	–	–	–

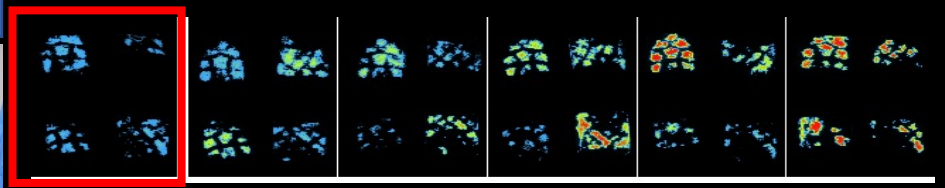
[A]Virus detected.
[B]Virus not detected.

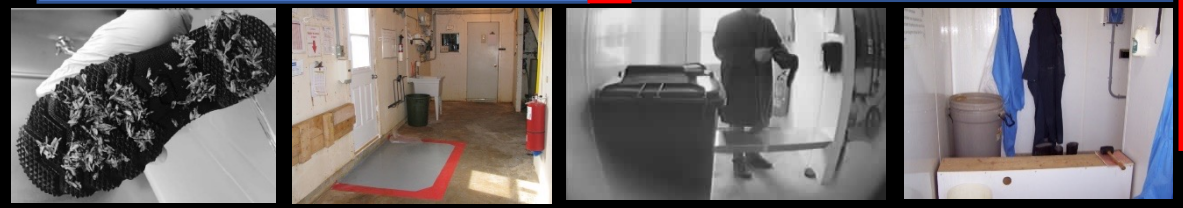
Fig. 1. (a) Manure accumulated in the boot crevices. (b) Sampling involved elimination of the excess of material in the surface and collection of the material inside the crevices.

Contamination









Outside door

Contaminated zone

- ✓ Remove coat
- ✓ Sign logbook
- ✓ Wash hands

Plan to have:

- Lockers or hooks
- Pen; paper
- Soap; alcohol gel
- Towels
- Garbage container & bags

BENCH

Changing footwear

Hand washing

Clean zone

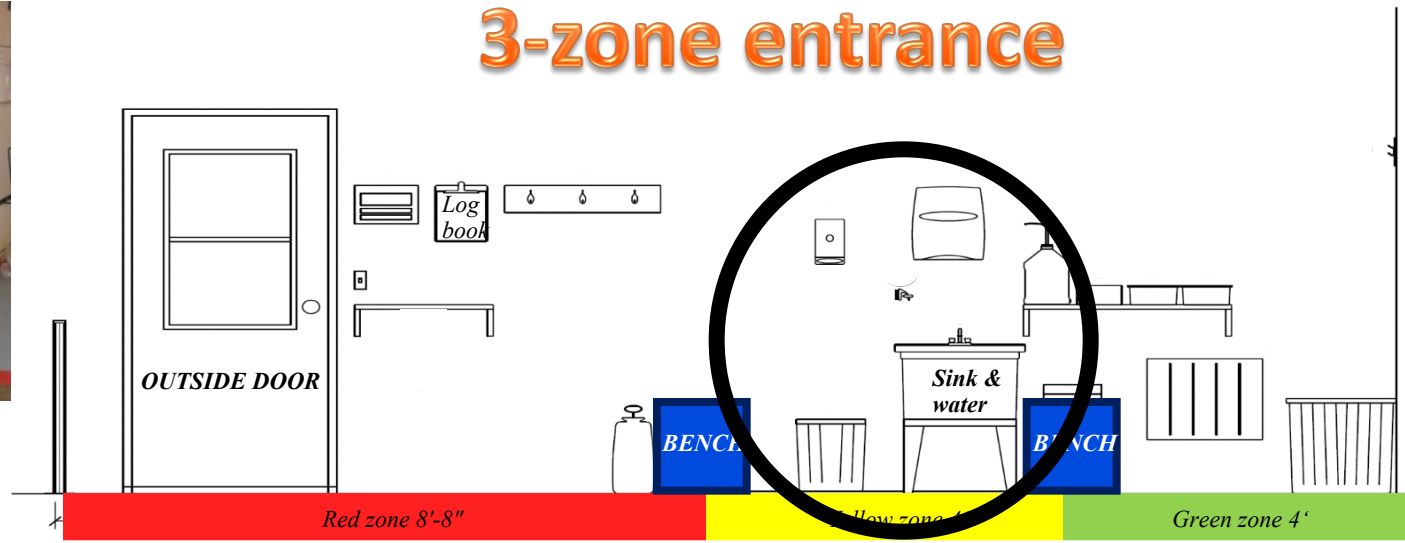
- ✓ Put on dedicated barn boots or disposable plastic boots

Apply any other biosecurity measures:

- Coveralls
- Head net
- Gloves

Animals

3-zone entrance



Outsi

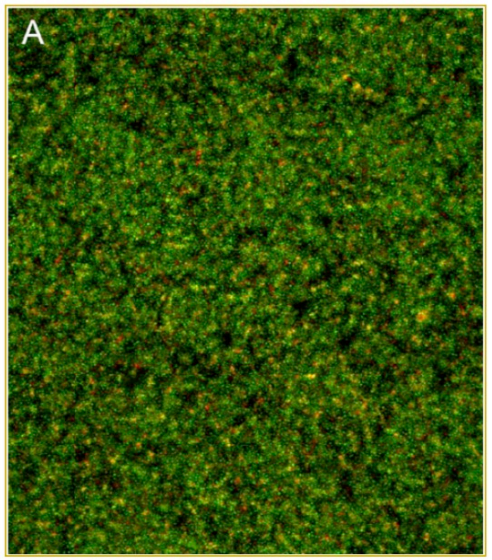
Plan to have:
- *Lockers or hooks*
- *Pen; paper*
- *Soap; alcohol gel*
- *Towels*
- *Garbage container & bags*

footwear

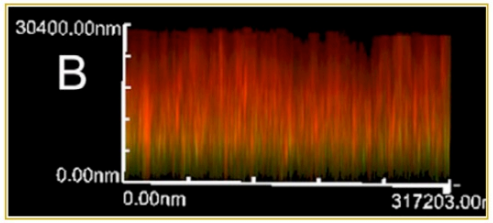
Hand washing

Apply any other biosecurity measures:
- *Coveralls*
- *Head net*
- *Gloves*

Ani



Source : Y.D.N. Tremblay



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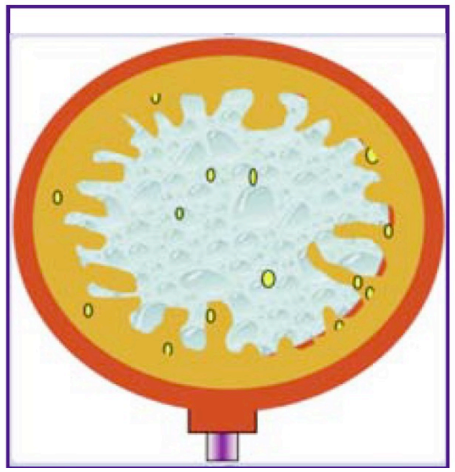
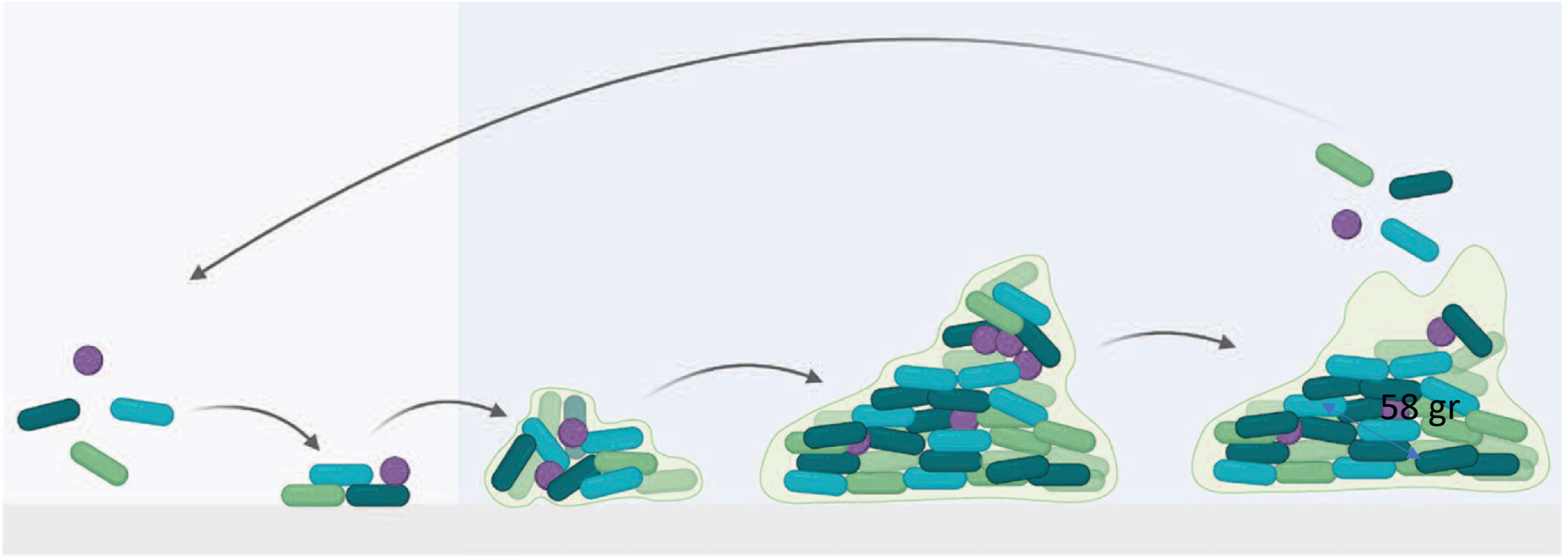


SE Watkins

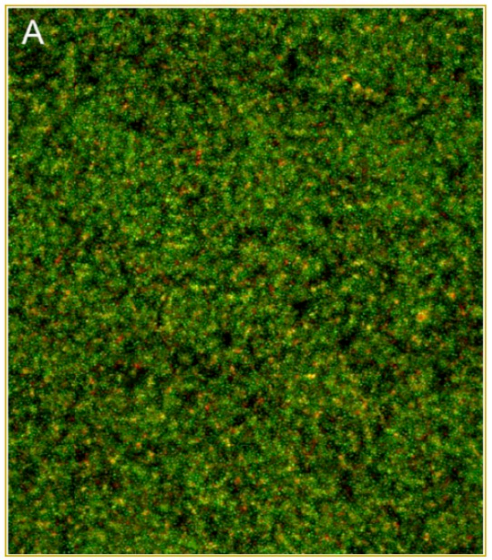
D Venne

D Venne

SE Watkins



Mobility	Adhesion	Growth	Maturation	Dispersion
Getting to the surface	Adhesion to the surface	Matrix formation	Bacterial growth & development of the matrix	Start of a new cycle



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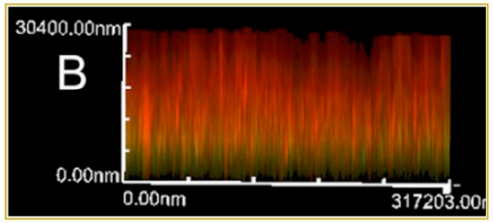

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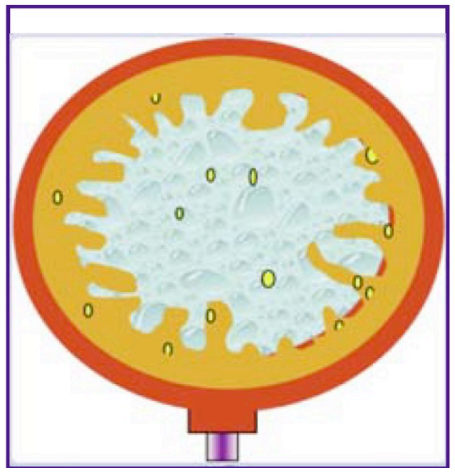


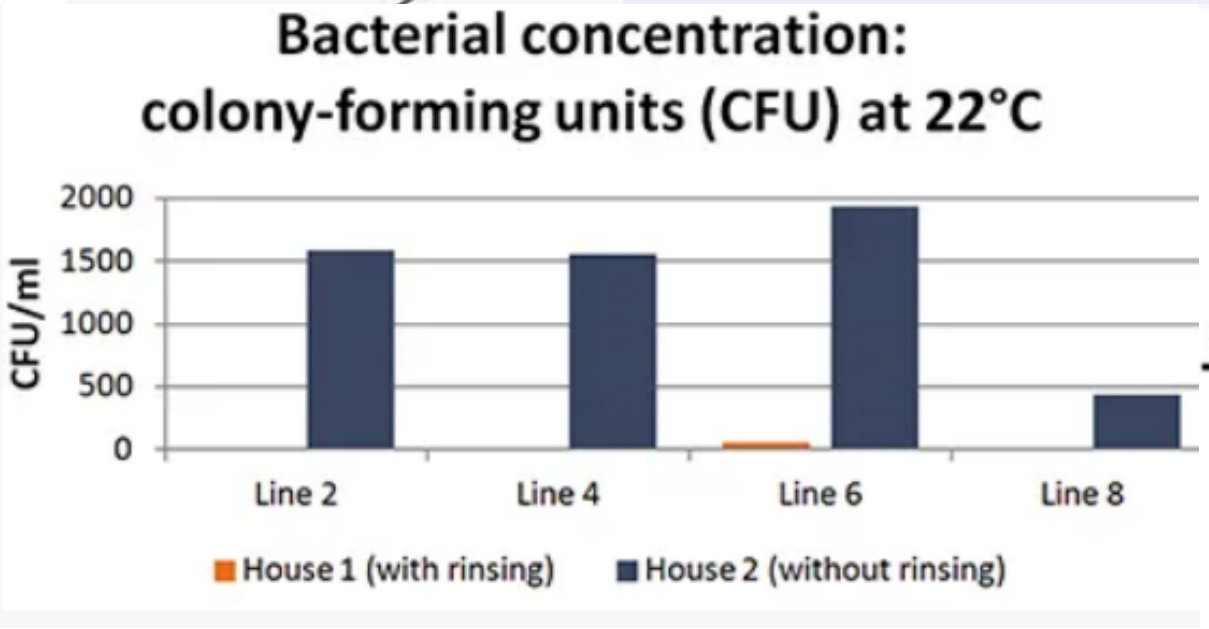
SE Watkins

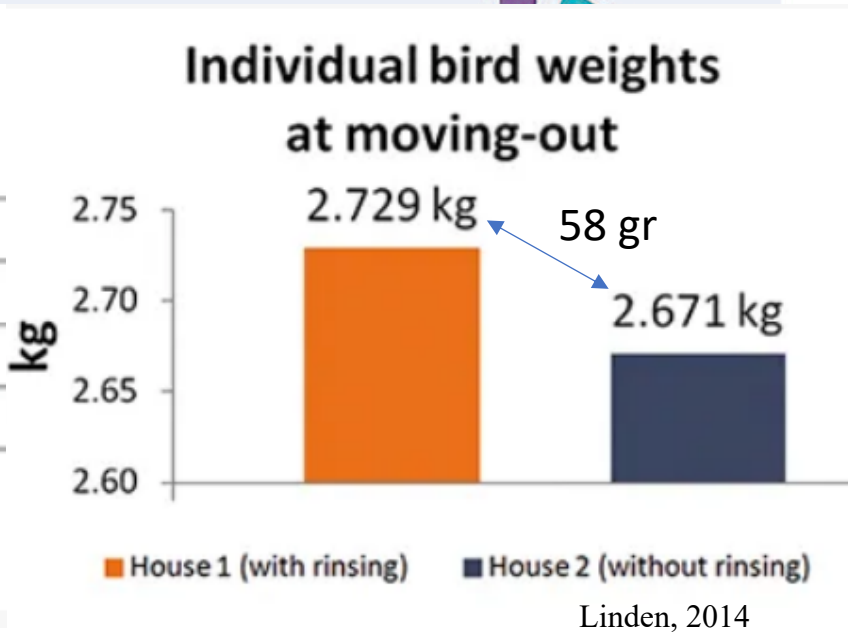
D Venne

D Venne

SE Watkins

2557 lbs for 20000 birds





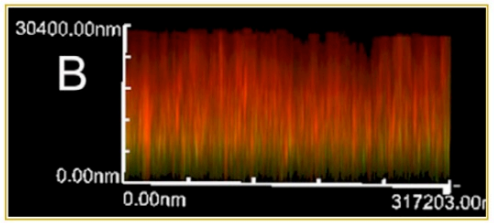
Linden, 2014

Animal Health Research Reviews 11(2); 97–121

Biofilm formation in bacterial pathogens of veterinary importance

Mario Jacques[1]*, Virginia Aragon[2,3] and Yannick D. N. Tremblay[1]

Bordetella
Campylobacter coli
Campylobacter jejuni
Clostridium perfringens
Enterococcus feacalis
Erysipelothrix rhusiopathiae
Escherichia coli
Listeria monocytogenes
Mycoplasmas
Pasteurella multocida
Pseudomonas aeruginosa
Riemerella anatipestifer
Samonella
Staphylococcus
Streptococcus

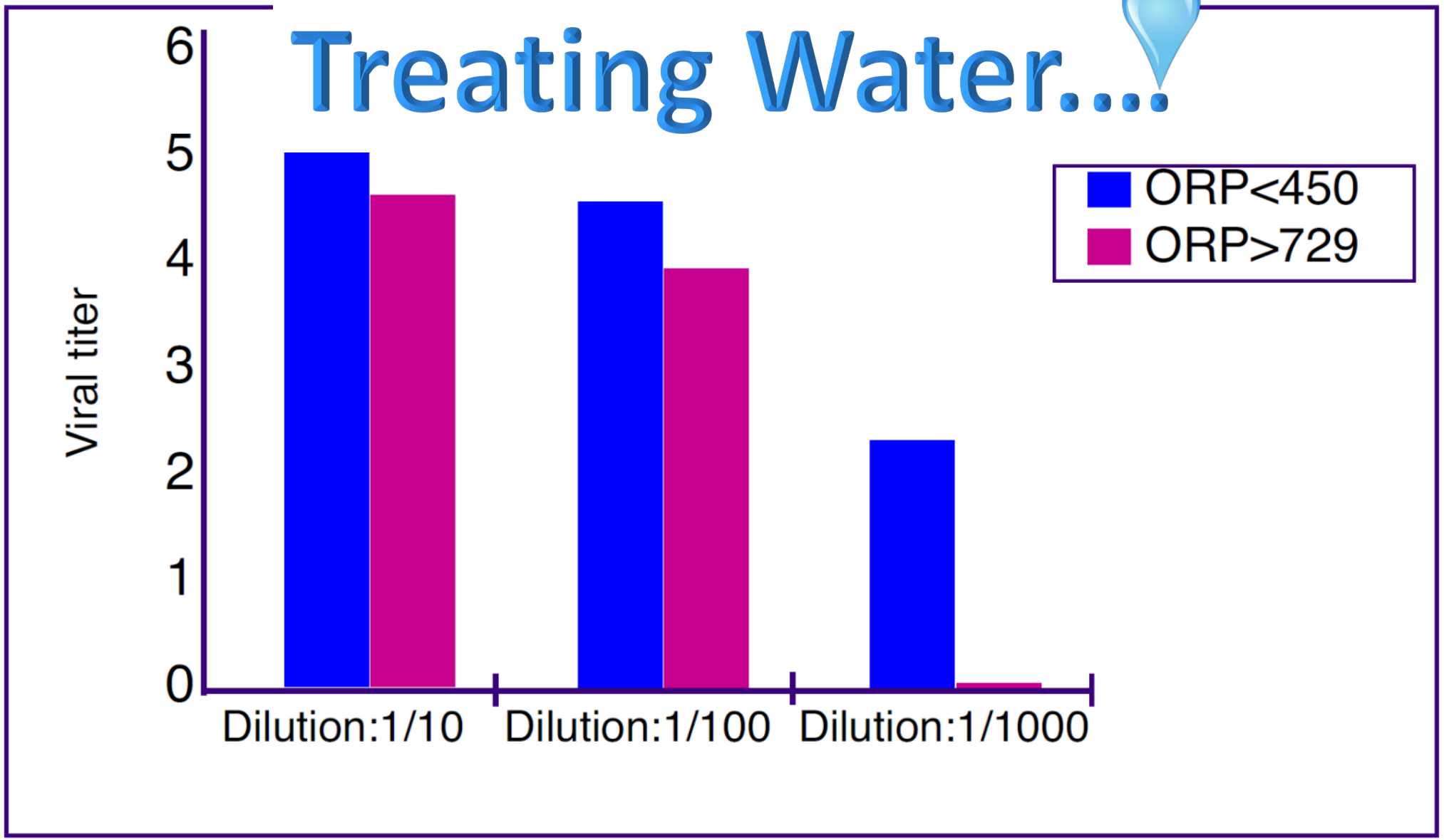


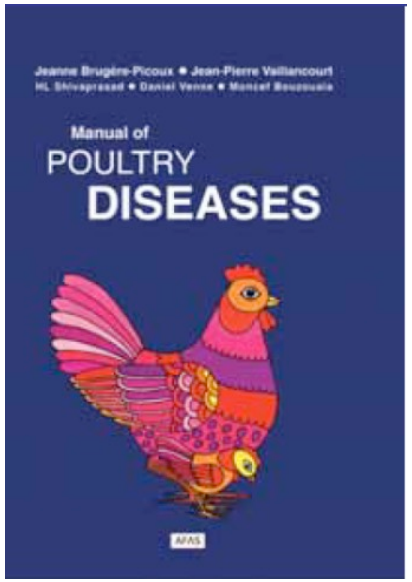
Source : Y.D.N. Tremblay

Table 1. Studies on biofilm formation of bacterial pathogens of veterinary importance

Bacterial species	References
Actinobacillus pleuropneumoniae	Auger *et al.* (2009a), Bossé *et al.* (2010), Buettner *et al.* (2008), Dalai *et al.* (2009), Ganeshnaryan *et al.* (2009), Izano *et al.* (2007), Kaplan *et al.* (2004), Kaplan and Mulks (2005), Kerrigan *et al.* (2008), Labrie *et al.* (2010), Li *et al.* (2008), Liu *et al.* (2008), Tegetmeyer *et al.* (2009)
Aeromonas hydrophila	Asha *et al.* (2004), Gavìn *et al.* (2002), Kozlova *et al.* (2008), Lynch *et al.* (2002), Truchado *et al.* (2009)
Arcanobacterium pyogenes	Jost and Billington (2005), Olson *et al.* (2002)
Bacillus cereus group	Auger *et al.* (2006), Auger *et al.* (2009b), Houry *et al.* (2010), Lee *et al.* (2007), Schuch and Fischetti (2009), Shaheen *et al.* (2010), Shi *et al.* (2004), Wijman *et al.* (2007)
Bartonella henselae	Kyme *et al.* (2003)
Bordetella bronchiseptica *Bordetella parapertussis*	Irie *et al.* (2004), Irie *et al.* (2005), Irie *et al.* (2006), Mishra *et al.* (2005), Parise *et al.* (2007), Sloan *et al.* (2007)
Brucella melitensis	Uzureau *et al.* (2007)
Burkholderia pseudomallei	Boddey *et al.* (2006), Korbsrisate *et al.* (2005), Lee *et al.* (2010), Sawasdidoln *et al.* (2010), Taweechaisupapong *et al.* (2005), Tunpiboonsak *et al.* (2010)
Campylobacter coli *Campylobacter jejuni*	Fields and Thompson (2008), Gunther and Chen (2009), Hanning *et al.* (2008), Hanning *et al.* (2009), McLennan *et al.* (2008), Moe *et al.*, (2010), Murphy *et al.* (2006), Naito *et al.* (2010), Peyrat *et al.* (2008), Reeser *et al.* (2007), Reuter *et al.* (2010), Sulaeman *et al.* (2010), Svensson *et al.* (2009), Trachoo and Frank (2002), Trachoo *et al.* (2002)
Clostridium perfringens	Varga *et al.* (2008)
Corynebacterium pseudotuberculosis *Corynebacterium renale*	Olson *et al.* (2002)
Enterococcus faecalis *Enterococcus faecium*	Ballering *et al.* (2009), Ciftci *et al.* (2009), Guiton *et al.* (2009), Macovei *et al.* (2009), Mohamed and Huang (2007), Oliveira *et al.* (2010), Teng *et al.* (2009)
Erysipelothrix rhusiopathiae	Shimoji *et al.* (2003)
Escherichia coli	Agladze *et al.* (2005), Beloin *et al.* (2008), Hancock *et al.* (2010), Olson *et al.* (2002), Prigent-Combaret *et al.* (2000), Puttamreddy *et al.* (2010), Uhlich *et al.* (2010), Wood (2009), Zogaj *et al.* (2001)
Francisella novicida *Francisella tularensis*	Amer *et al.* (2010), Durham-Colleran *et al.* (2010), Margolis *et al.* (2010)
Haemophilus parasuis	Jin *et al.* (2006, 2008)
Histophilus somni	Olson *et al.* (2002), Sandal *et al.* (2007, 2009)
Leptospira	Ristow *et al.* (2008)
Listeria monocytogenes	Amalaradjou *et al.* (2009), Gandhi and Chikindas (2007), Habimana *et al.* (2009), Harmsen *et al.* (2010a, 2010b), Latorre *et al.* (2010), Riedel *et al.* (2009), Takahashi *et al.* (2010), Todhanakasem and Young (2008)
Mannheimia haemolytica	Olson *et al.* (2002)
Mycobacterium	Carter *et al.* (2004), Cook *et al.* (2010), Johansen *et al.* (2009), Ojha *et al.* (2008), Wu *et al.* (2009), Yamazaki *et al.* (2006a, 2006b)
Mycoplasma	Daubenspeck *et al.* (2009), Justice-Allen *et al.* (2010), McAuliffe *et al.* (2006, 2008), Simmons and Dybvig (2007, 2009)
Pasteurella multocida	Olson *et al.* (2002)
Pseudomonas aeruginosa	Bazire *et al.* (2010), Davies and Marques (2009), Deligianni *et al.* (2010), Fuxman Bass *et al.* (2010), Harmsen *et al.* (2010b), Lenz *et al.* (2008), Ma *et al.* (2009), Olson *et al.* (2002), Pérez-Osorio *et al.* (2010), Ryder *et al.* (2007)
Riemerella anatipestifer	Hu *et al.* (2010)
Salmonella	Jain and Chen (2007), Kim and Wei (2009), Marin *et al.* (2009), Olson *et al.* (2002), Römling (2005), Van Parys *et al.* (2010), Wong *et al.* (2010)
Staphylococcus	Boles *et al.* (2010), Dhanawade *et al.* (2010), Fox *et al.* (2005), Futagawa-Saito *et al.* (2006), Melchior *et al.* (2006a, 2006b, 2009), Nemati *et al.* (2009), Oliveira *et al.* (2006, 2007), Olson *et al.* (2002), Pérez *et al.* (2009), Tormo *et al.* (2005), Vancraeynest *et al.* (2004)
Streptococcus	Bonifait *et al.* (2008), Grenier *et al.* (2009), Konto-Ghiorghi *et al.* (2009), Moscoso *et al.* (2009), Olson *et al.* (2002), Rinaudo *et al.* (2010), Tanabe *et al.* (2010), Wei *et al.* (2009)
Yersinia	Coquet *et al.* (2002), Darby (2008), Hinnebusch and Erickson (2008), Kim *et al.* (2008), Sun *et al.* (2009), Truchado *et al.* (2009), Wortham *et al.* (2010)

Treating Water...





D Venne

Fig.81.36: Effect of dilution of a vaccine and Oxidation Reduction Potential (ORP) on the survival of Gumboro virus *in vitro*.

Daniel Venne, 2015

PREMISE

% on-farm compliance

SUCKS

...or is not as good as you think

Preventive Veterinary Medicine 100 (2011) 193–199

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

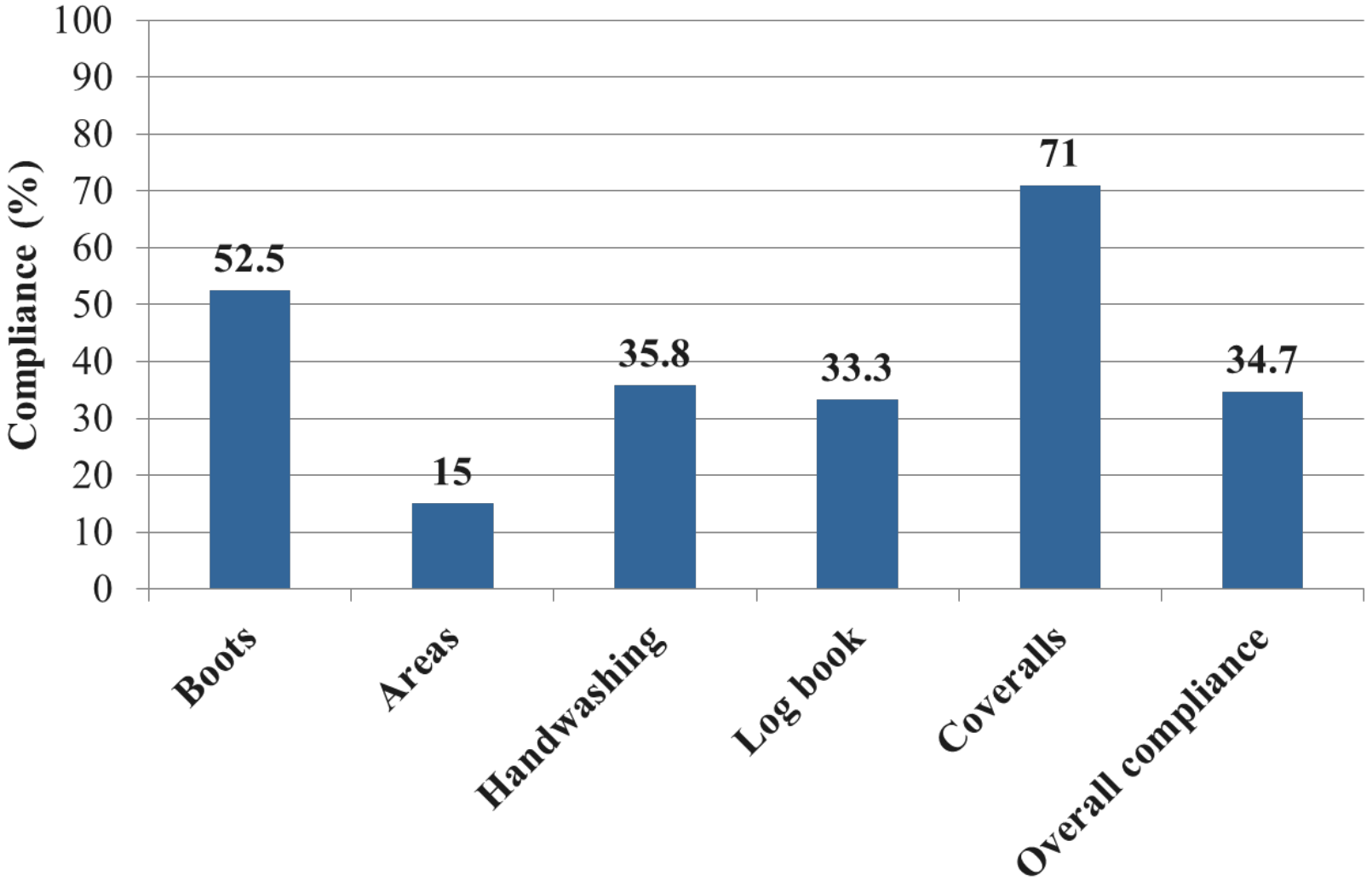
journal homepage: www.elsevier.com/locate/prevetmed

Biosecurity compliance
Poultry Farms

Description of 44 biosecurity errors while entering and exiting poultry barns based on video surveillance in Quebec, Canada

Manon Racicot[a,b,*], Daniel Venne[c], André Durivage[d], Jean-Pierre Vaillancourt[a]

8 farms
883 visits
102 individuals



Human nature

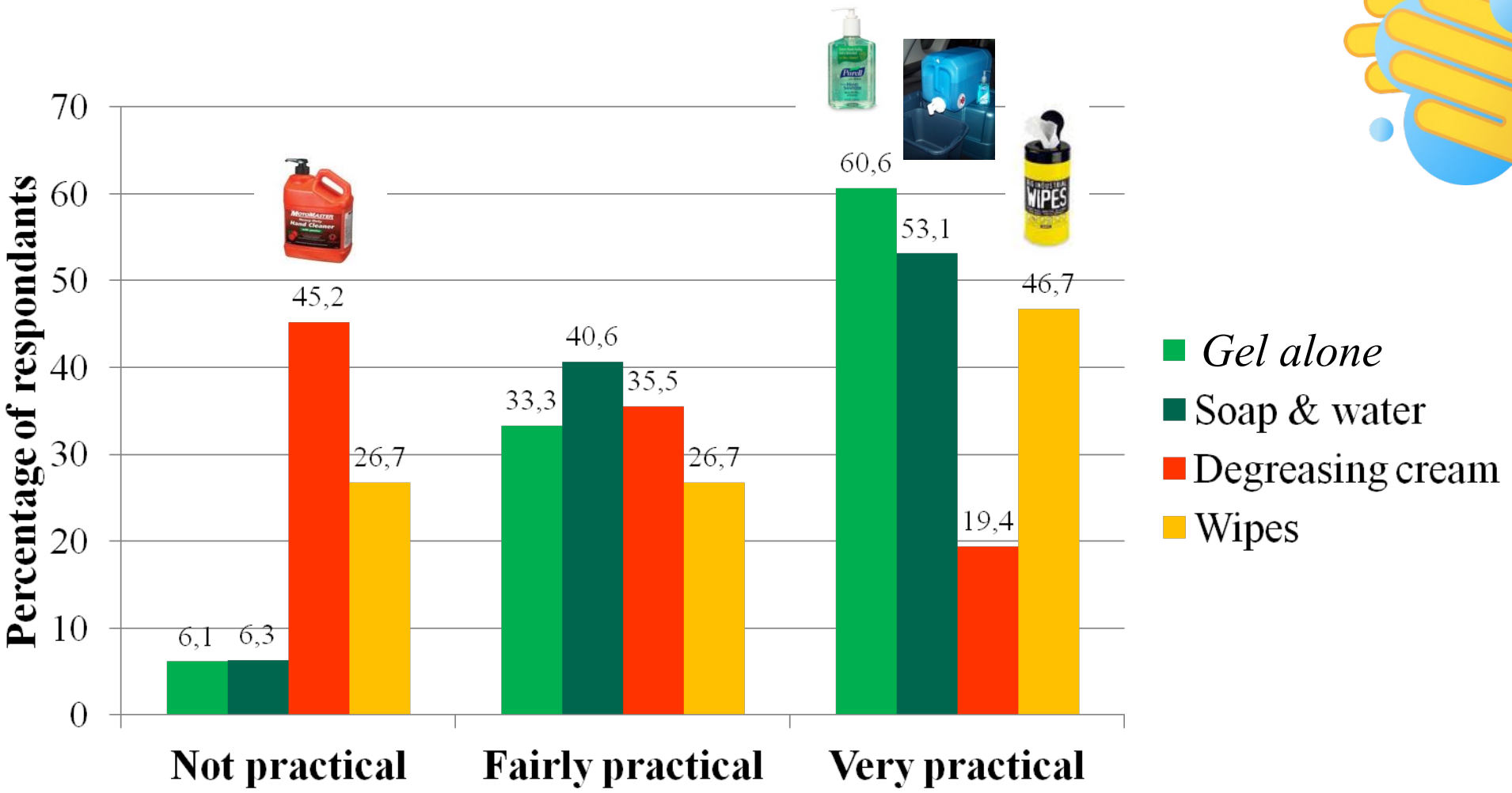
Different situations require different measures

But there are universal elements to include in a biosecurity strategy

- Reach the right people
- Keep it simple
- Lead by example
- Communicate
- Provide feedback
- Incentive (reward)
- Make it easy: design
- Training - Simulations
- Buy-in: get all involved
- Innovate: technology

Human Perception & Beliefs

Practicality of protocols



Building design and farm layout

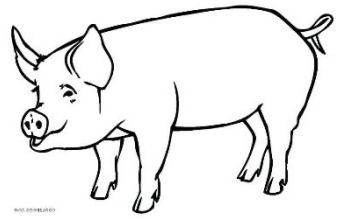
- Extremely large farms with multiple buildings
- Ponds/water bodies on farms
- Anything that requires regular and repeated entry to a building
- Open-sided buildings
- Uncontrolled fan outlets
- Inlets/fan with no biofilters
- Moving clean and dirty stuff in and out the same building entrance (cross-contamination)

Gonder, 2023

Mycoplasma: ”Farm localization is the most important factor associated with reinfection….the second factor is the size of the neighboring farm”

RFW Goodwin, 1985

Regional farm density

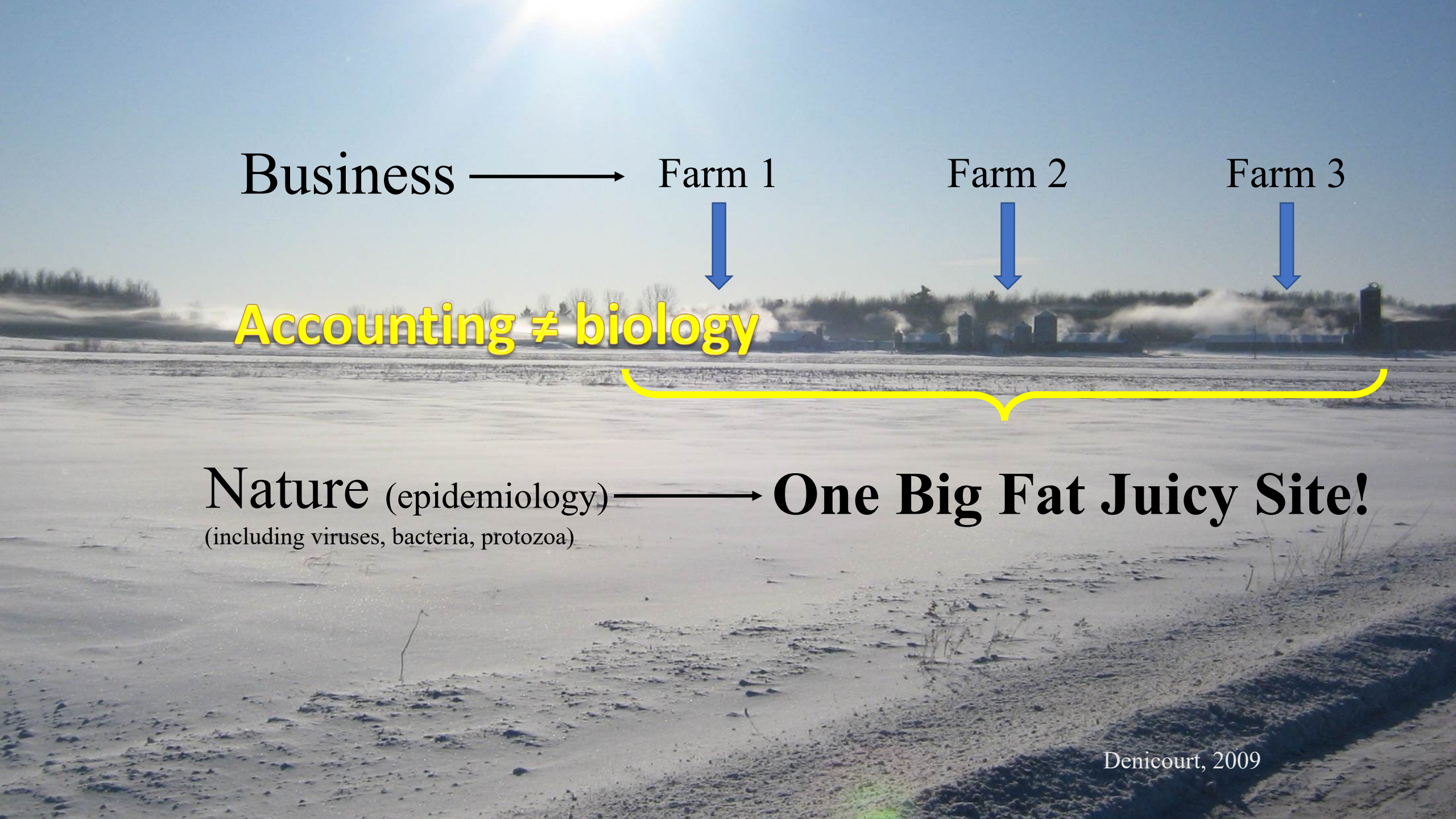


Diseases	Risk factor	Risk level	Reference
Salmonella	High farm density	OR 2.2	Snow et al., 2012; Great Britain
Newcastle		OR 4.2	East et al., 2006; Australia
E. Coli		OR 6.3	Vandekerchove et al., 2004; Belgium
Avian influenza		OR 34.7	Boender et al., 2003, The Netherlands
PRRS		OR 7.3	Lambert et al., 2012, Canada

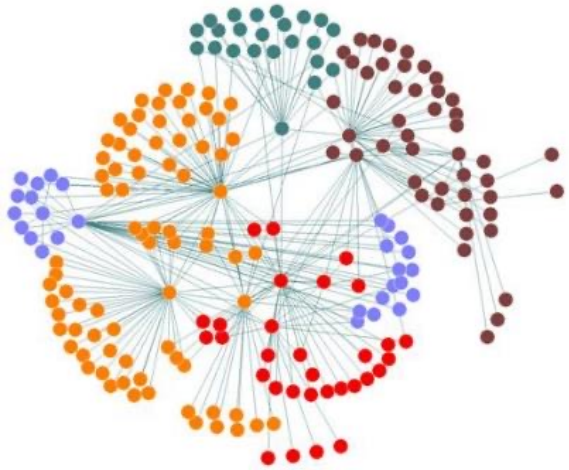
Less than 1 km (0.6 mile) between farms

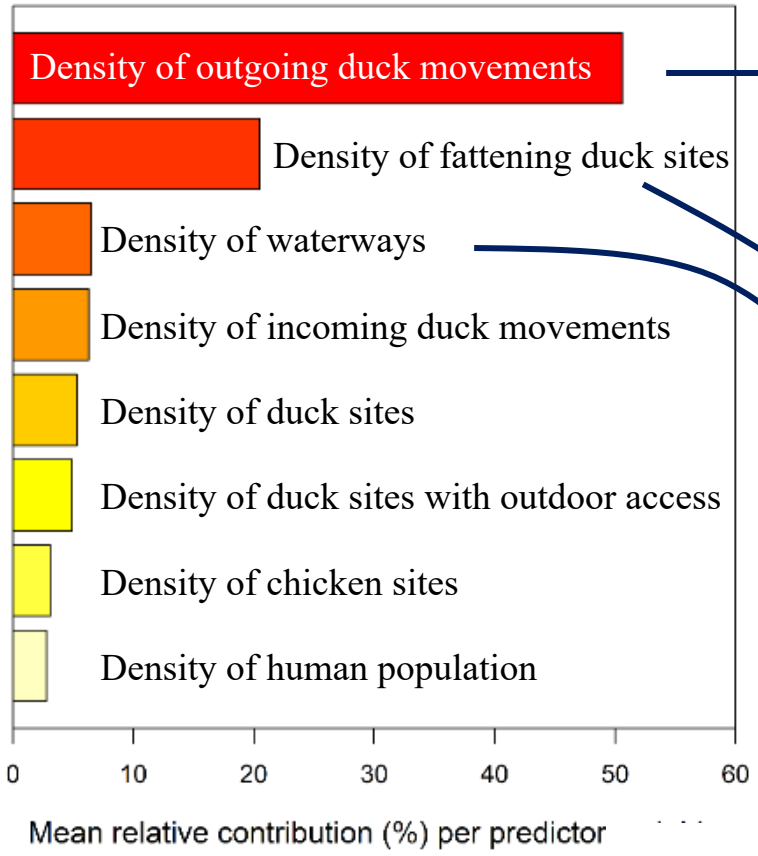
- 2 x more chances → *Salmonella*
- 4 x more chances → Newcastle
- 6 x more chances → *E. Coli*
- 35 x more chances → A. influenza
- 7 x more chances → P.R.R.S.

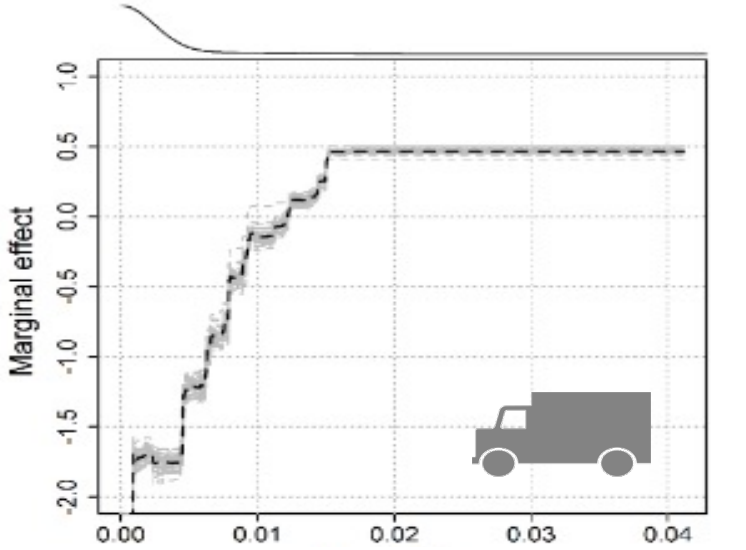
⇒ equipment, people, vehicles, wildlife, insects


Business
Farm 1
Farm 2
Farm 3
Accounting ≠ biology
Nature (epidemiology)
(including viruses, bacteria, protozoa)
One Big Fat Juicy Site!
Denicourt, 2009

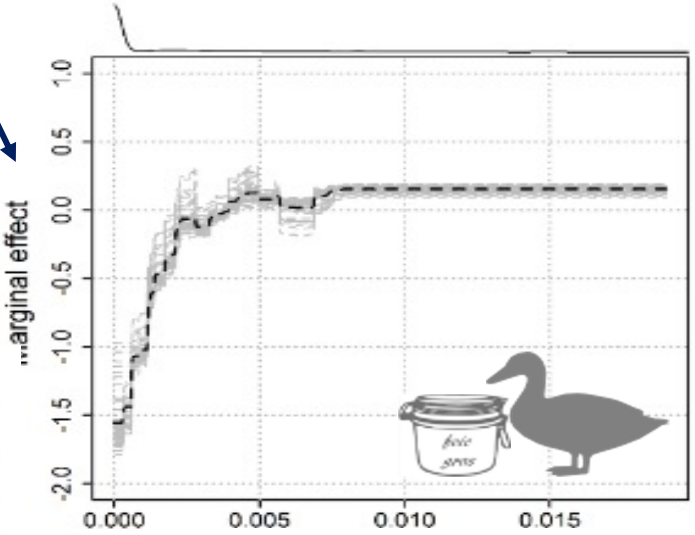
Hierarchy of explicative variables



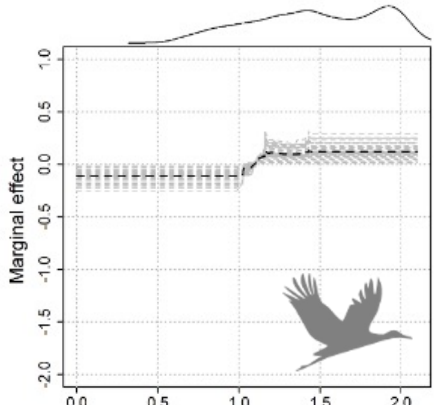




Density of outgoing duck movements (/ha)



Density of duck sites (/ha)

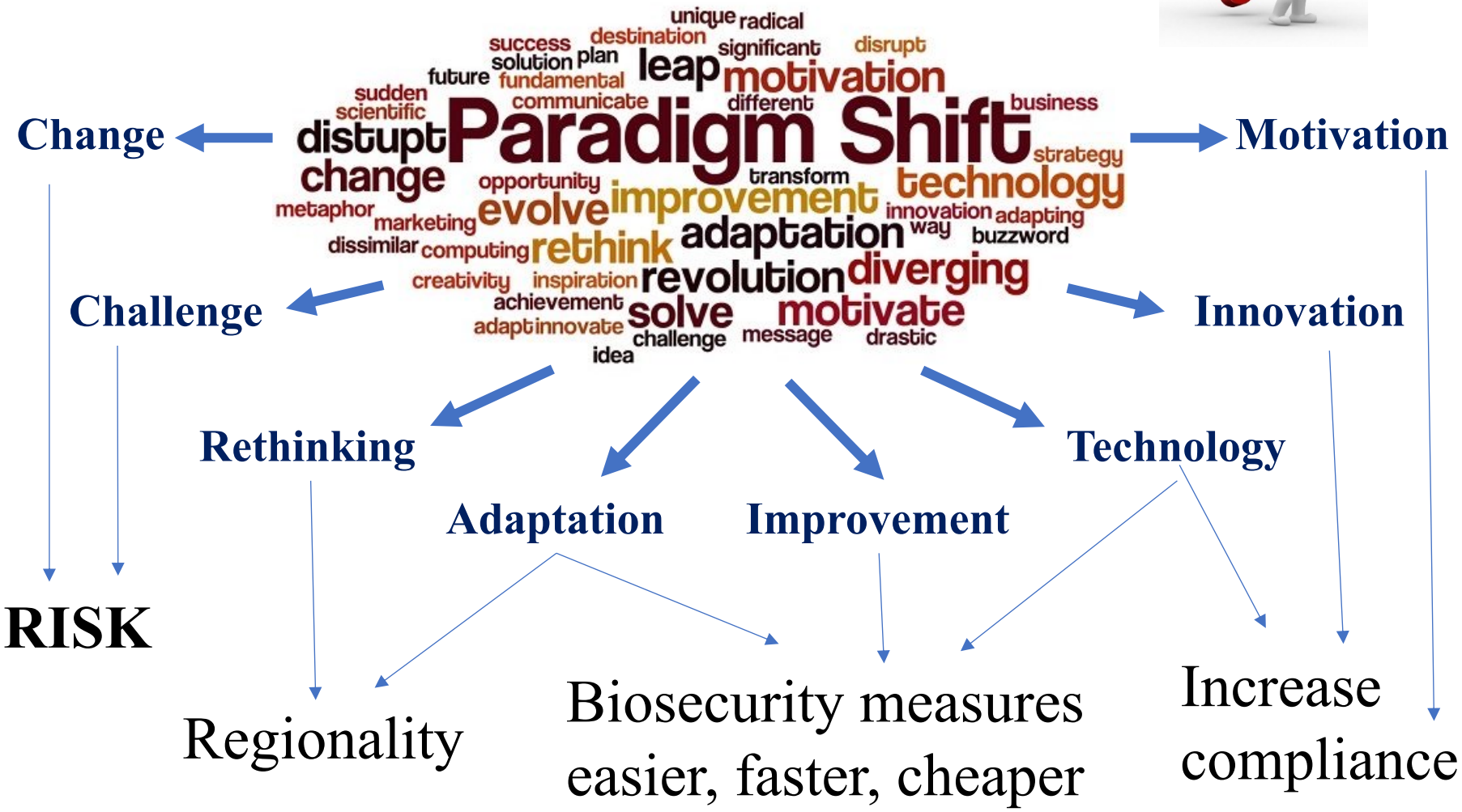


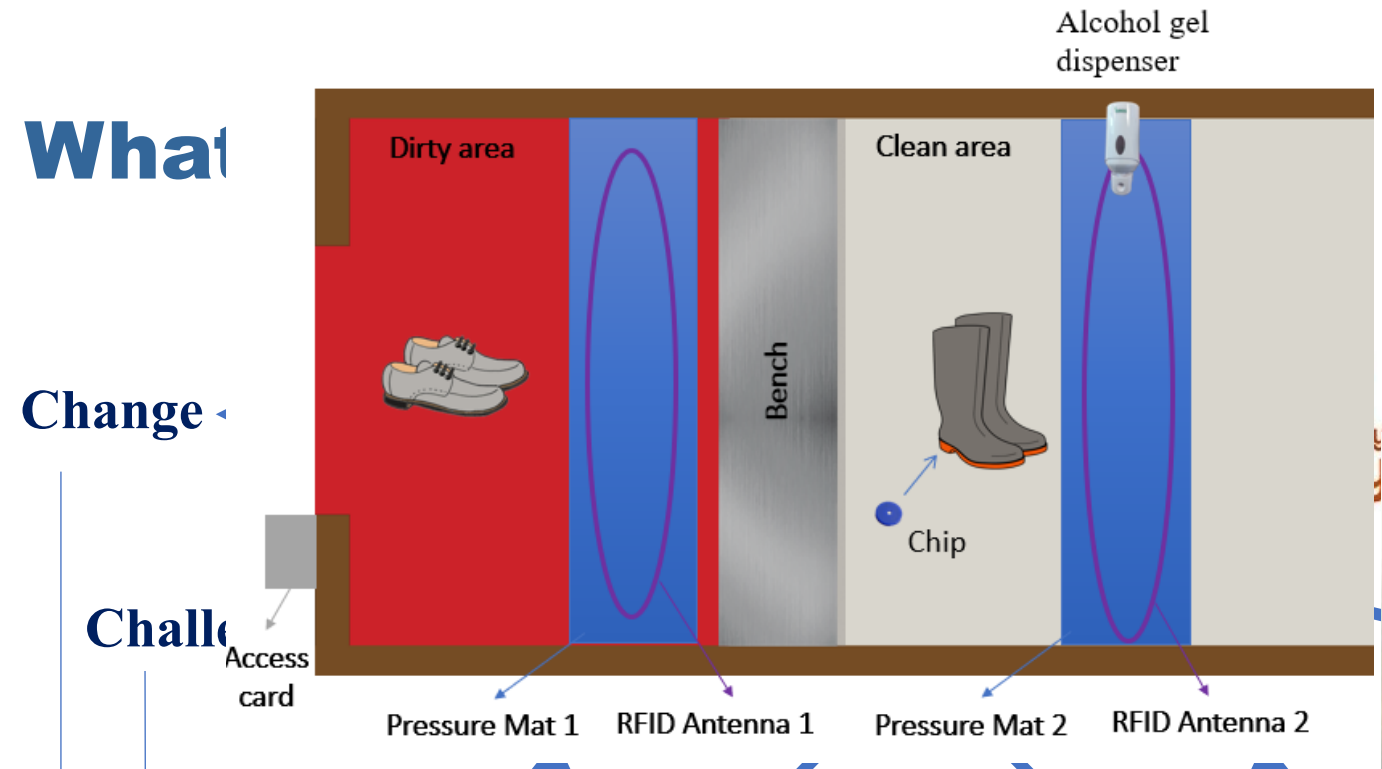
Density of waterways (/ha)

Risk factors associated with highly pathogenic avian influenza in France – 2015-2017

Paul, Guinat, Guérin, 2018

What should we do?





The pressure-sensitive strings play music while you go, and you can even download an “M-Pee-3” of your urinal masterpiece online afterwards.

Wha

Change

Chal

RISK

Need fixing/improvement:

- Movement of vehicles & personnel
- Zoning of production sites
- Rules for new constructions
- Dead bird management
- Anteroom (compliance)
- Cleaning & Disinfection
- Rodent control
- **Communication**

Adaptation **Improvement**

Regionality

Biosecurity measures
easier, faster, cheaper

The pressure-sensitive strings play music while you go, and you can even download an “M-Pee-3” of your urinal masterpiece online afterwards.

Thank you!

Questions?