

Advancement in Veterinary Services through Digitalization (data management, veterinary information systems, Big Data, metalanguage, artificial intelligence)

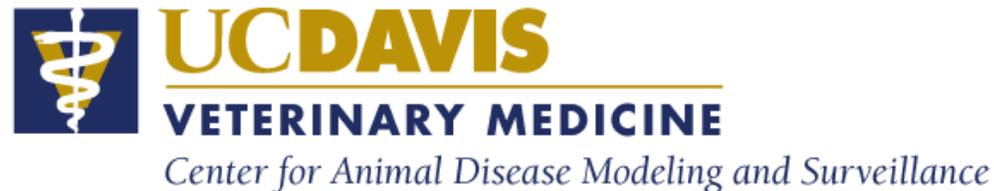
Dr. Beatriz Martínez López, DVM, MPVM, PhD.

Professor of infectious disease epidemiology

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FAO Ref. Center for Veterinary Epidemiology*

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31st Conference of the Regional Commission for Europe in
Samarkand, Uzbekistan, October 2, 2024



Livestock industry of the 21st century strives to...

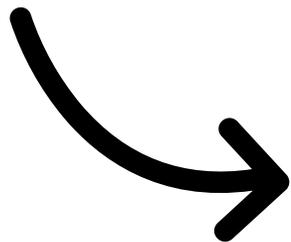
A man in a light blue short-sleeved button-down shirt and blue jeans stands with his hands on his hips in front of a long, modern livestock barn. The barn has a grey metal roof and a concrete base with a series of metal cages or stalls. The sky is a vibrant mix of orange, yellow, and blue, indicating a sunset or sunrise. The ground in front of the barn is a mix of grass and gravel.

Sustainable
Production

One Health

Food safety
& security

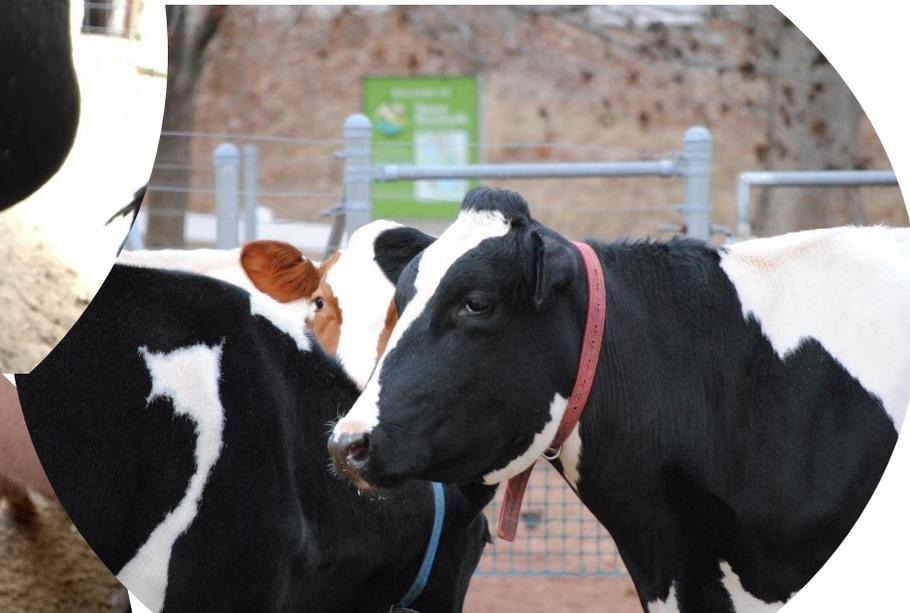
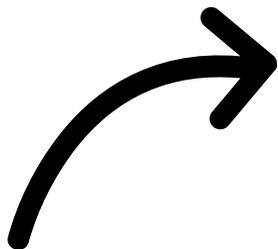
Foreign animal diseases



Difficult to manage and predict endemic agents



Antimicrobial resistance



How can we enhance **veterinary services** to better address all these challenges?



Traditional tools



Modern tools



AI-driven tools

Time to
complete
task "x"

5 weeks

Digitalization 5 days Advanced analytics

5 minutes

What is digitalization?

Lets ask chat GPT



Digitalization refers to the process of converting information into a digital format, allowing it to be processed, stored, and transmitted electronically. This transformation enables organizations to **improve efficiency, enhance data accessibility, and create new opportunities for innovation.**

It often involves integrating digital technologies into various aspects of a business or operation, such as **automating processes**, utilizing **data analytics**, and **improving customer interactions through digital platforms.**

Overall, digitalization helps organizations adapt to the evolving technological landscape and meet changing consumer demands.

Digitalization in Ag is expanding

- precision agriculture, including precision livestock farming (cyber physical systems)
- controlled environment production
- (Big) data and advanced analytical techniques (artificial intelligence)



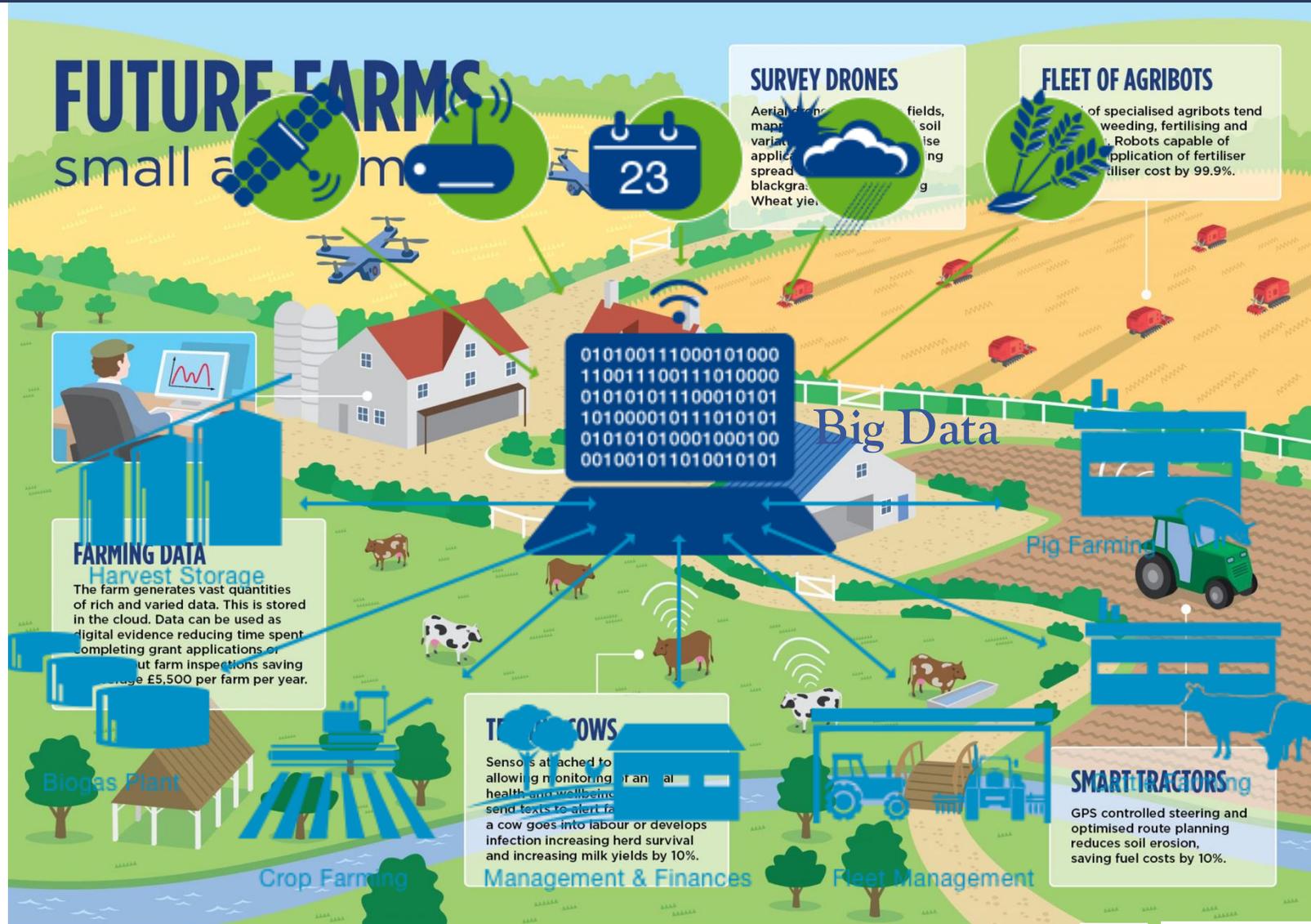
Farmers of the future will utilize drones, robots and GPS

March 18, 2015 6.17am EDT



<http://theconversation.com/>

What is coming...



<https://www.wespeakiot.com>

But what about digitalization in the veterinary services?

Applications:

Animal disease information

Tracing systems

Data analysis and epidemiology

Telematics

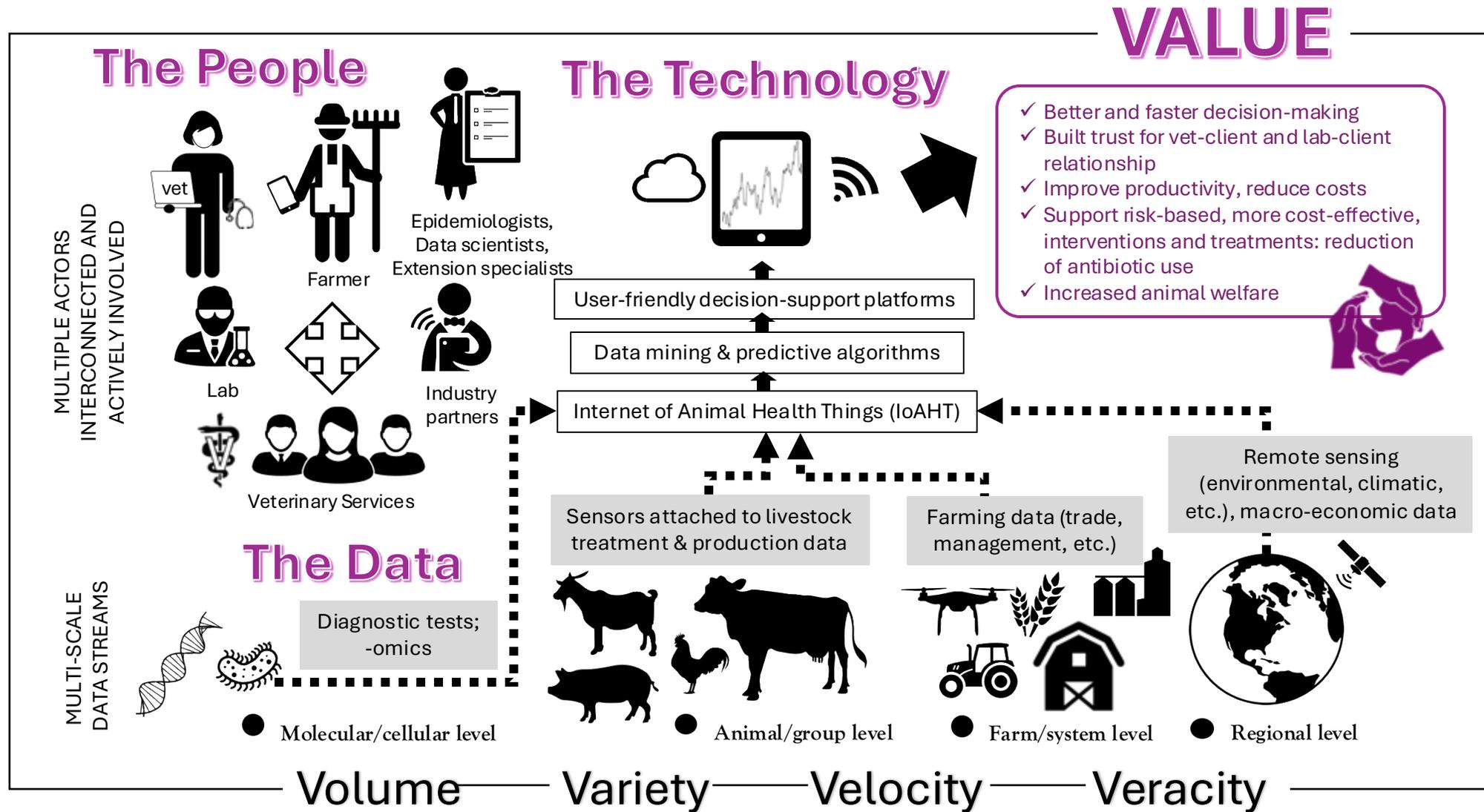
Communication tools

Inventory management

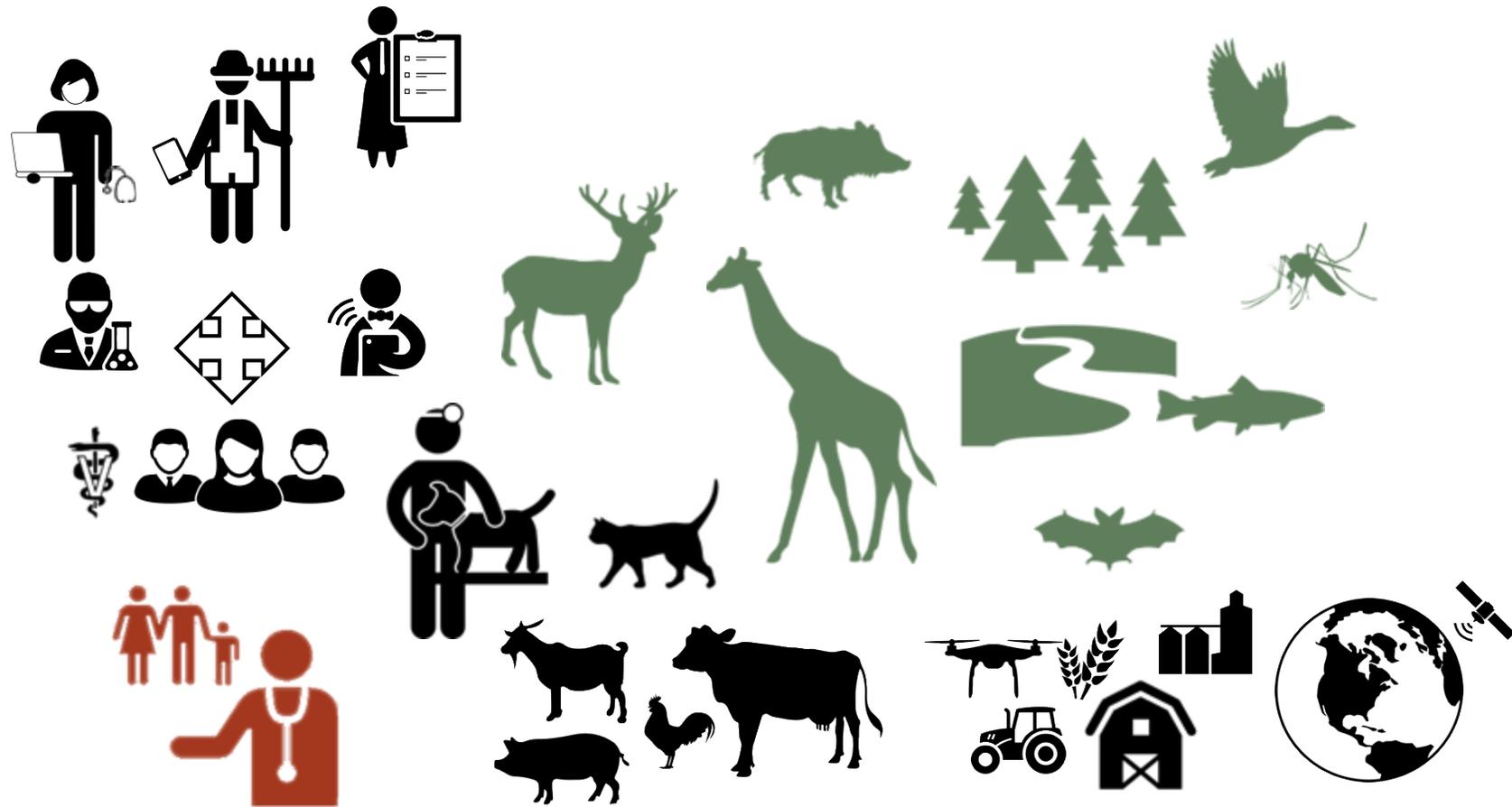
Etc.

Smarter animal health

Key components for “smarter veterinary services”



Help operationalize and co-design policies for One Health

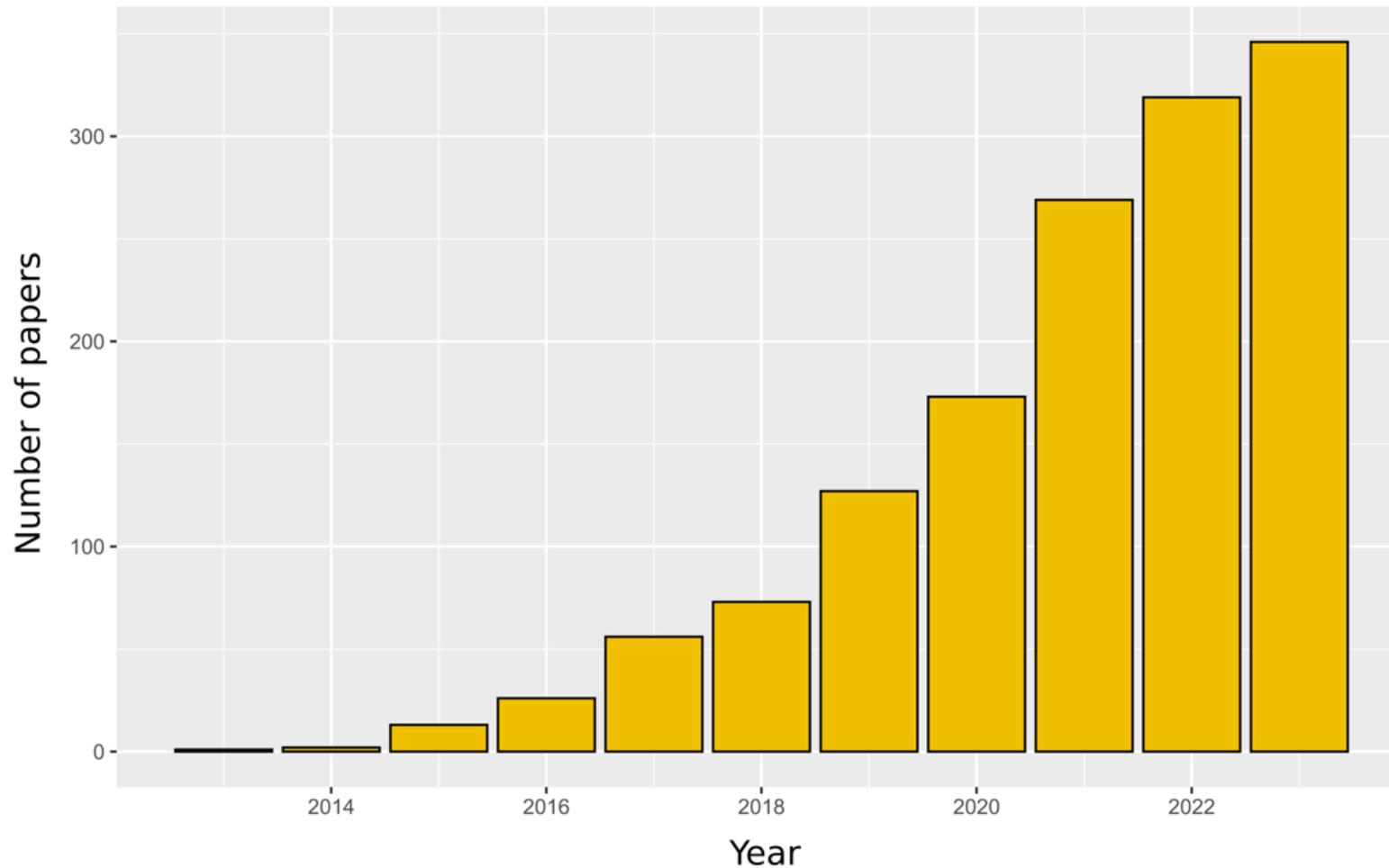


Digitalization and AI can effectively link **animal health** with **public health** and **wildlife/ecosystem** Big Data to better achieve “**One Health**”

Digitalization brings incredible opportunities to advance knowledge & **more timely** inform animal health & food safety decisions...
but also **new challenges**



Number of papers in English using Big Data analytics in animal/livestock health and food safety in the last 10 years is increasing... **but adoption is still small.**



What are the challenges to adopt digitalization and Big Data analytics in the veterinary services?

Please respond at: PollEv.com/beatrizm432

or

use the QR code below



What are the challenges to adopt digitalization and Big Data analytics in the veterinary services?

Nobody has responded yet.

Hang tight! Responses are coming in.

Some of the main challenges...(and proposed recommendations)

There is a need to:

1. Facilitate the integration of **genome-to-population** level data
2. Bridge the gap between the **data availability, access** and its **effective usage**
3. Develop **new (AI) algorithms** adapted to animal health (needs interdisciplinary teams with domain expertise)
4. Create **operational systems** to facilitate real-time data collection, integration, analysis, visualization and secure sharing to support decision making
5. **Train** next generation of “**vet-data-scientists**”

1. Facilitate the integration of **genome-to-population** level data

The Problem

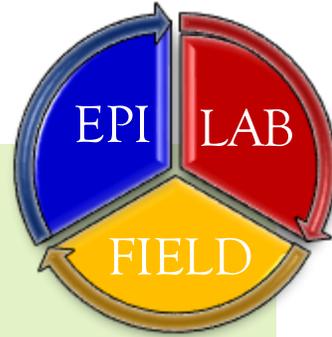
Data are scattered across stakeholders, no standardized, multi-scale, difficult to access, no AI-ready

- **Multi-level data** has analytical challenges due to the complex structures, lack independence and usually have **high dimensionality** (large number of features but small number of samples)

The Solution

Need to improve:

- **Data collection** – still using paper!!!
- **Communication (and real-time data sharing)** between laboratories, epidemiologists and field veterinarians
- **Data standardization and interoperability**
 - provide case definitions, metadata, data dictionaries
 - International Classification of Diseases (ICD) for animal diseases?
- **Data quality**



E.g. AWS data lake architecture for the Disease BioPortal

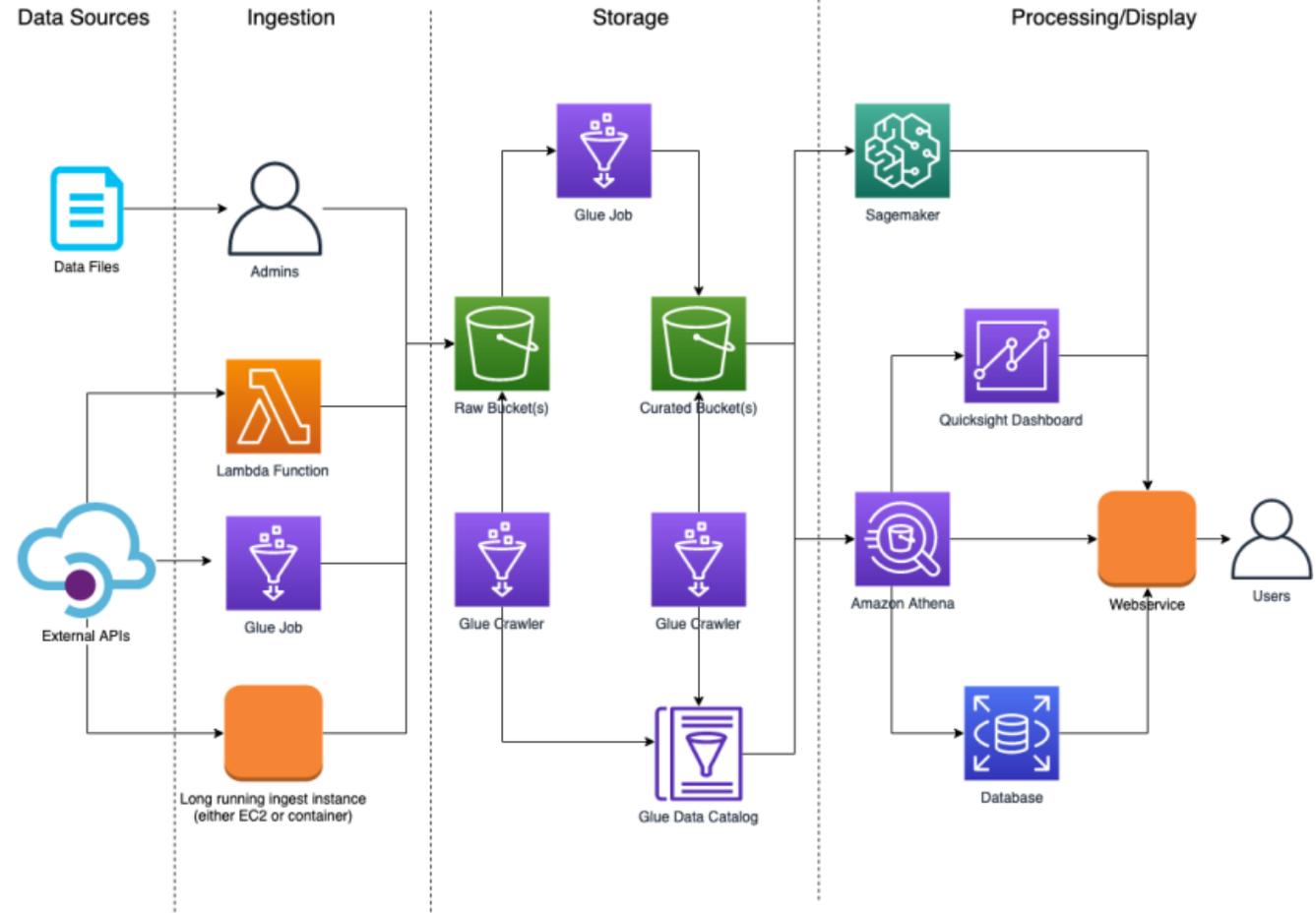


Modern, scalable architecture

Integration of multiple data sources

- Diagnostics
- Treatments
- Vaccinations
- Production
- Trade
- Biosecurity

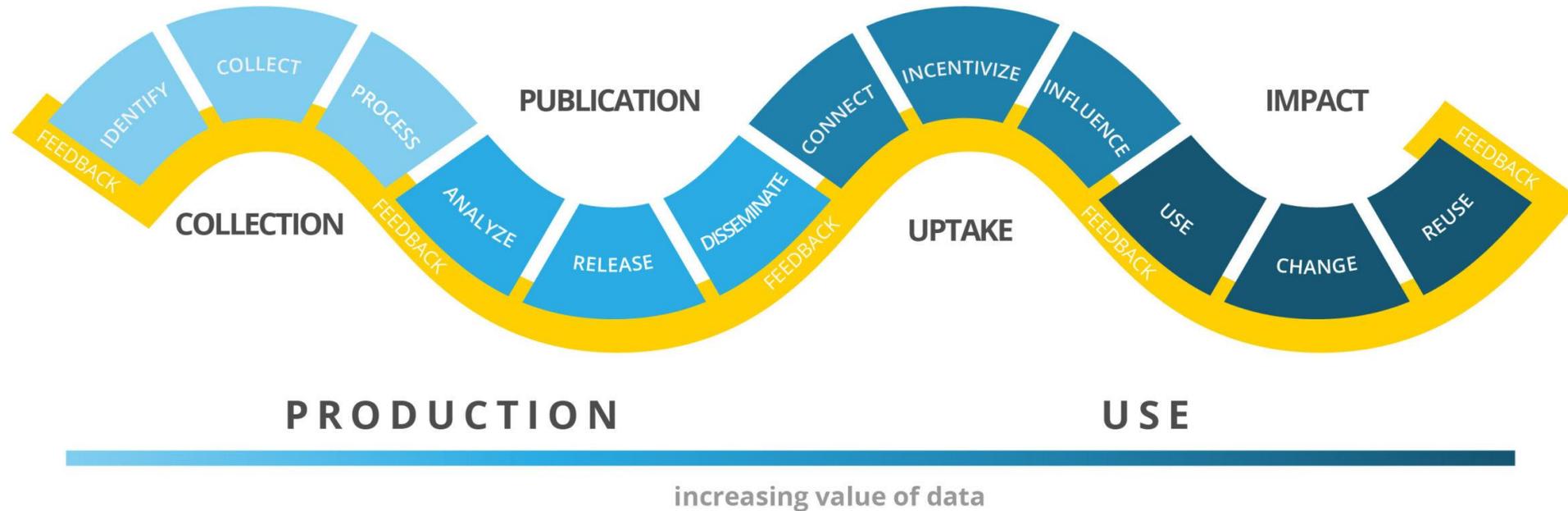
Data standardization, entry, preservation, documentation, quality control, data back up & data mapping



2. Bridge the gap between data availability, access and its effective usage



DATA VALUE CHAIN

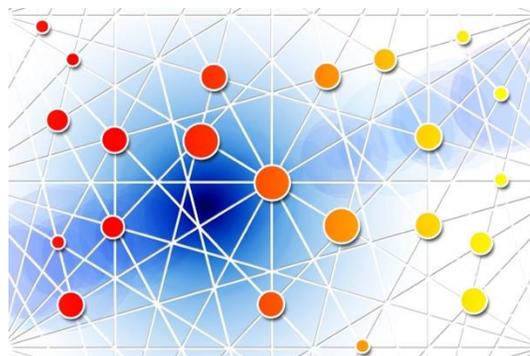


<https://opendatawatch.com>

2. Bridge the gap between data availability, access and its effective usage

The Problem

Large amounts of data is collected but data usage is often restricted to simple descriptive statistics of specific aspects of animal production and pathogen diagnostics



The Solution

Need to:

- embrace **multipurpose data collection**
- **Advance towards equitable and inclusive digitalization** for smallholders and veterinary services in low-resource settings
- Improve **data accessibility and sharing**, while **keeping security, privacy and confidentiality**

Initiatives like **Digital Innovation Hubs**, where hubs (e.g. university) create interdisciplinary groups and assist parties delivering digital applications and adopt precision Ag. A similar approach could be applied to improve digitalization of the veterinary services.

3. Develop **new algorithms** specifically adapted to animal health

The Problem

The development and adoption of machine learning (ML) algorithms have increased exponentially in different disciplines including health, but their application in animal health remains limited

The Solution

- Existing ML techniques are primarily developed for single level data, so ML algorithms **need to be adapted to the multilevel reality** in livestock.
- We need **interdisciplinary teams** in the veterinary services that could develop and apply advanced analyses to better support animal health decisions.



Infection prediction in swine populations with machine learning

[Avishai Halev](#), [Beatriz Martínez-López](#) ✉, [Maria Clavijo](#), [Carlos Gonzalez-Crespo](#), [Jeonghoon Kim](#), [Chao Huang](#), [Seth Krantz](#), [Rebecca Robbins](#) & [Xin Liu](#)

6 ML: logistic regression, support vector machines, decision trees, gradient boosting, random forest and multi-layer perceptron model.

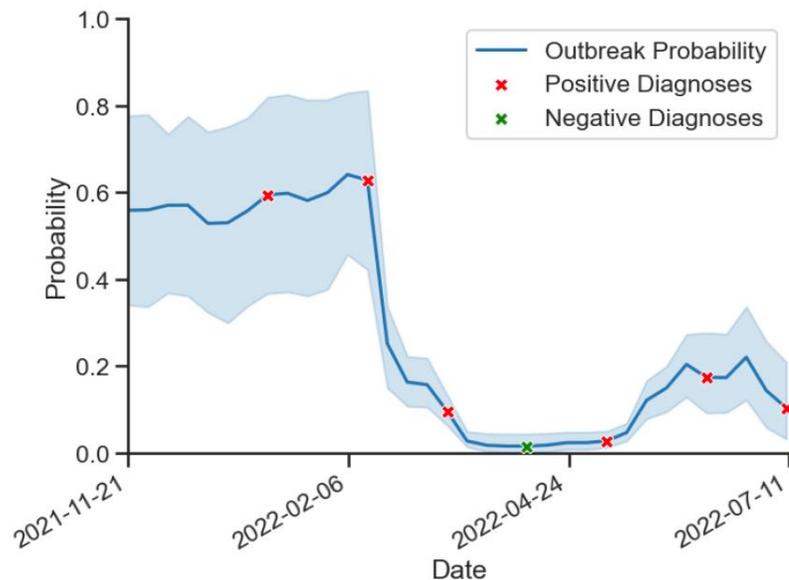


Figure 10. Outbreak prediction on a single farm using our model compared to true diagnoses. Outbreak probability is calculated on a weekly basis.

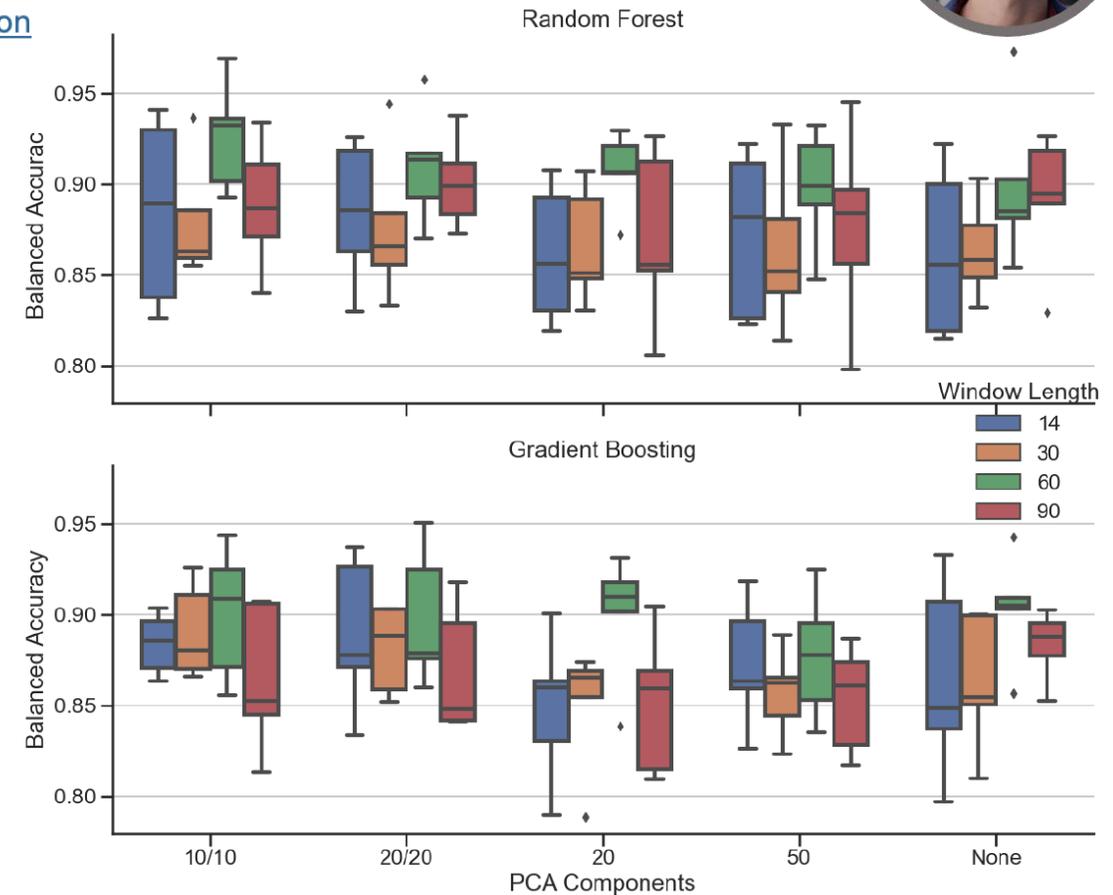


Figure 3. Effects of changing the number of components of the features set across cross-validation splits on system A; points represent the scores on each split for random forest and gradient boosting models on the top and bottom, respectively. Components labeled as pairs are components of close out and sow features, respectively, while single values are components across the entire feature set. None refers to no PCA, or usage of all features.

4. Create **operational systems** to facilitate real-time data collection, integration, analysis, visualization and secure sharing to support decision making

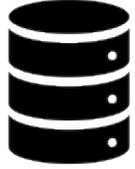
The Problem

Lack of user-friendly platforms to help in outbreak investigation, identification of trends, analysis, visualization & sharing

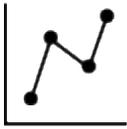
The Solution

- Real-time analytics and decision frameworks for multi-scale data
- User-friendly visualization
- Security, data privacy and confidentiality
- Decision support systems that facilitate dashboard generation and data interpretation

E.g.: Platforms like **WAHIS** (WOAH) for notifiable diseases or the **Disease Bioportal** (UCDavis) for endemic diseases are already integrating complex data structures, with real-time visualization and analysis aiding to the decision-making



Disease BioPortal[®]



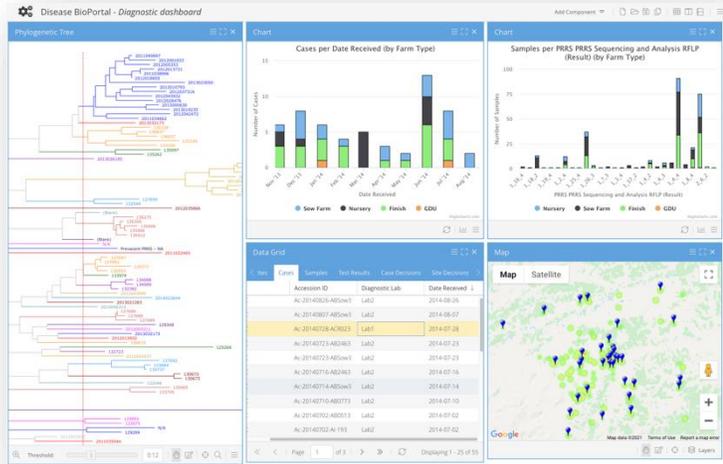
INTEGRATION

ANALYSIS

VISUALIZATION

REPORTING

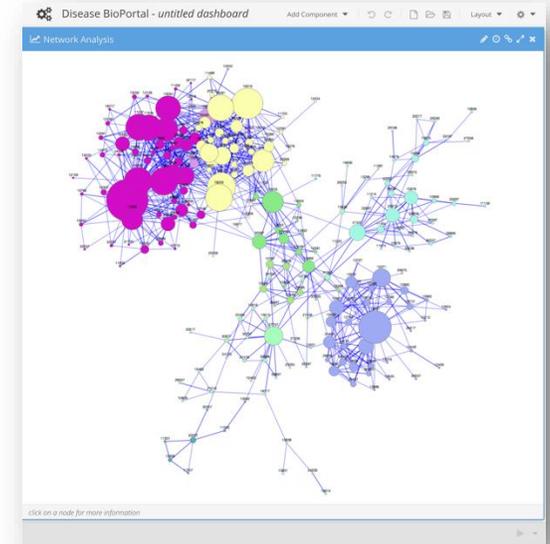
We focused in 3 main themes:



Early detection of outbreaks



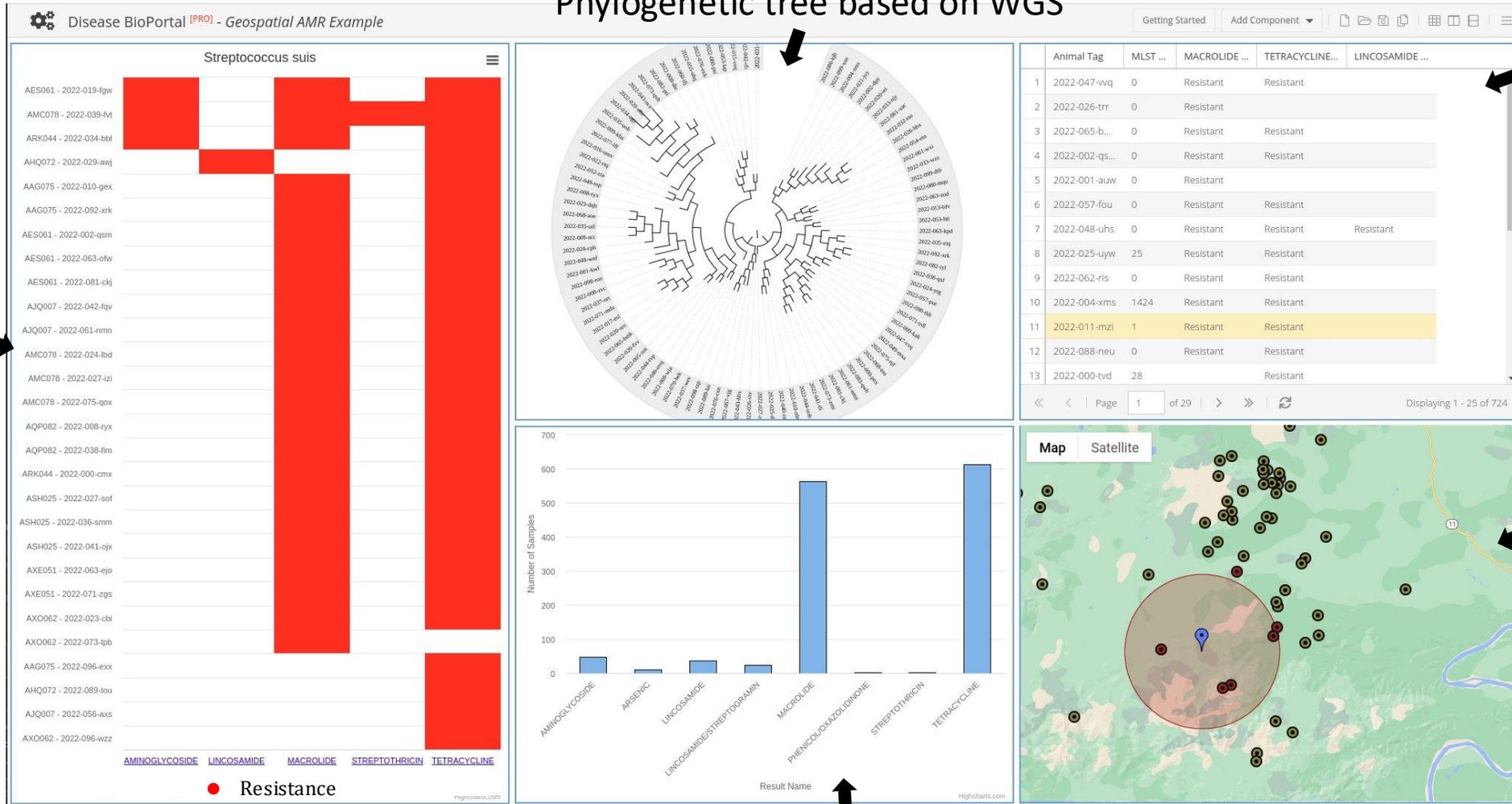
Antimicrobial resistance



Contact tracing & disease modeling

AMR (phenotypic and genotypic) dashboards

Phylogenetic tree based on WGS



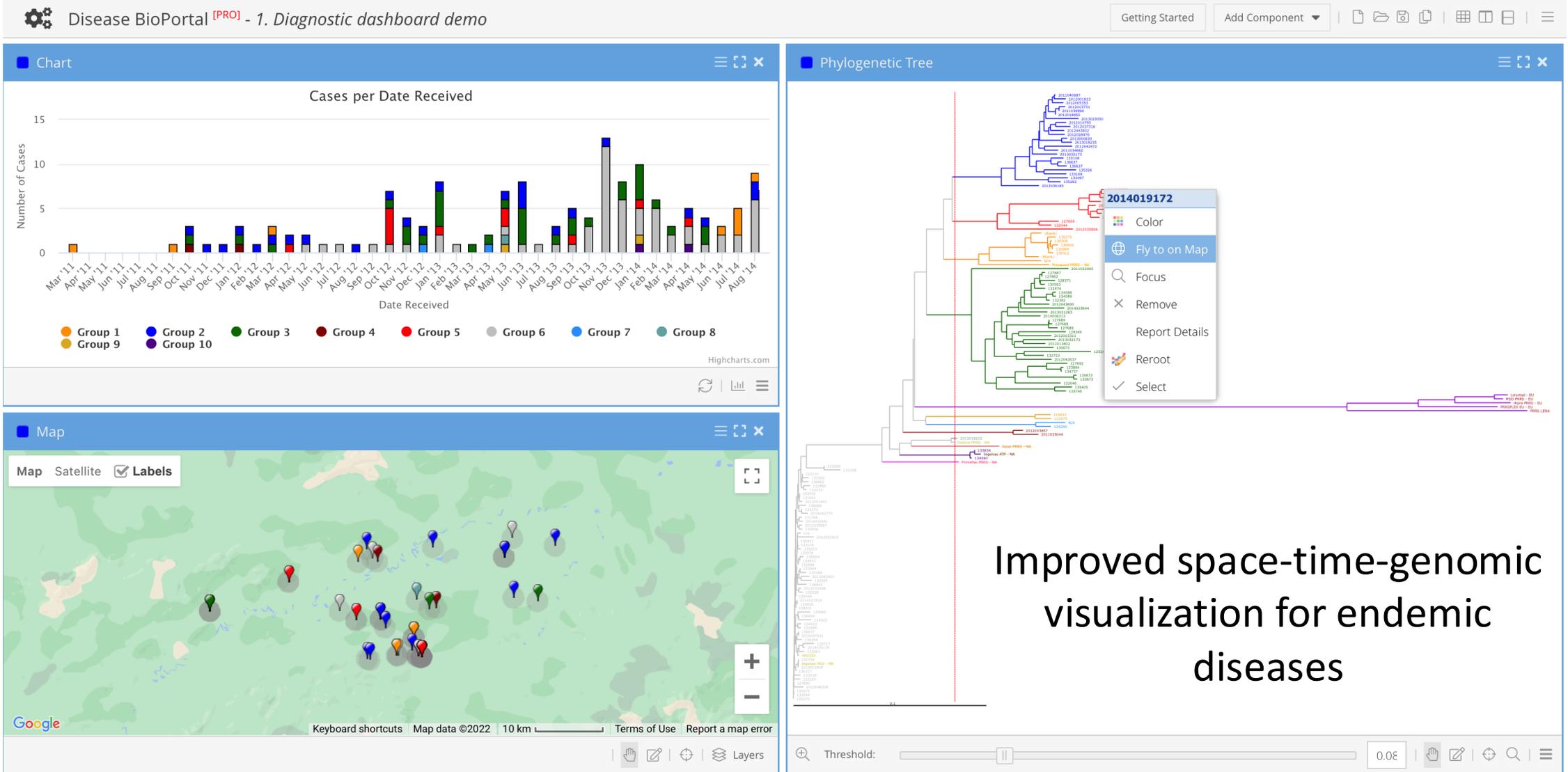
AMR phenotypic distribution

Resistant Table + MLST

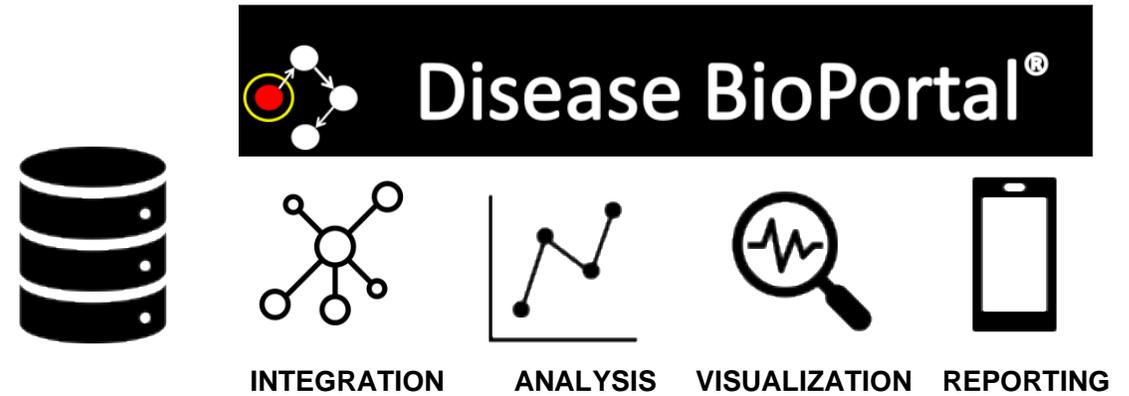
AMR Spatio-temporal Clusters (Scan statistics)

No. of samples per antibiotics

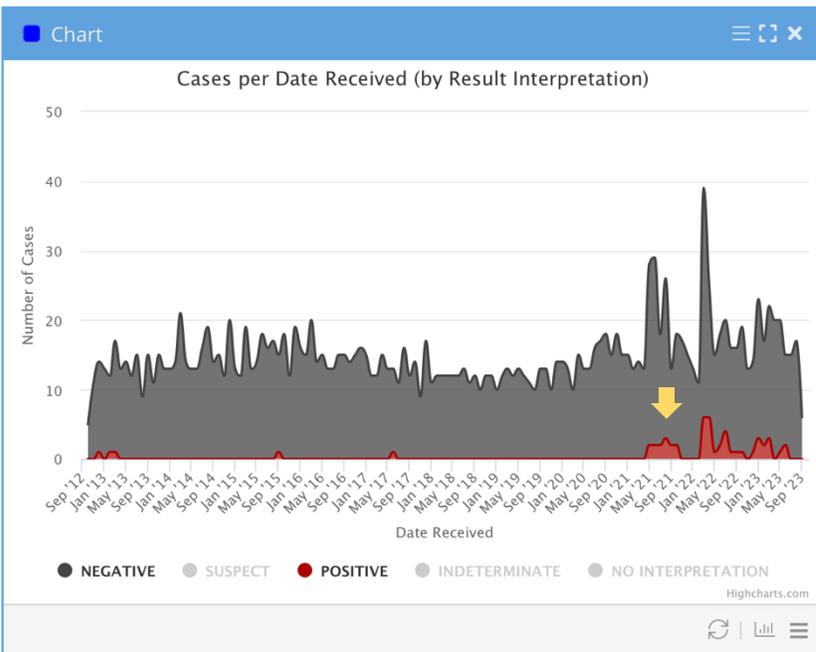
Diagnostic dashboards



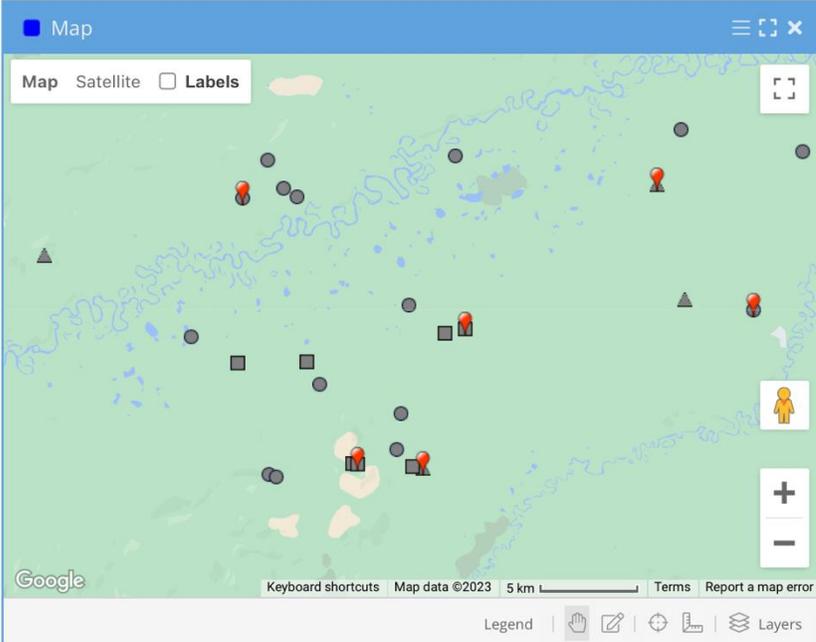
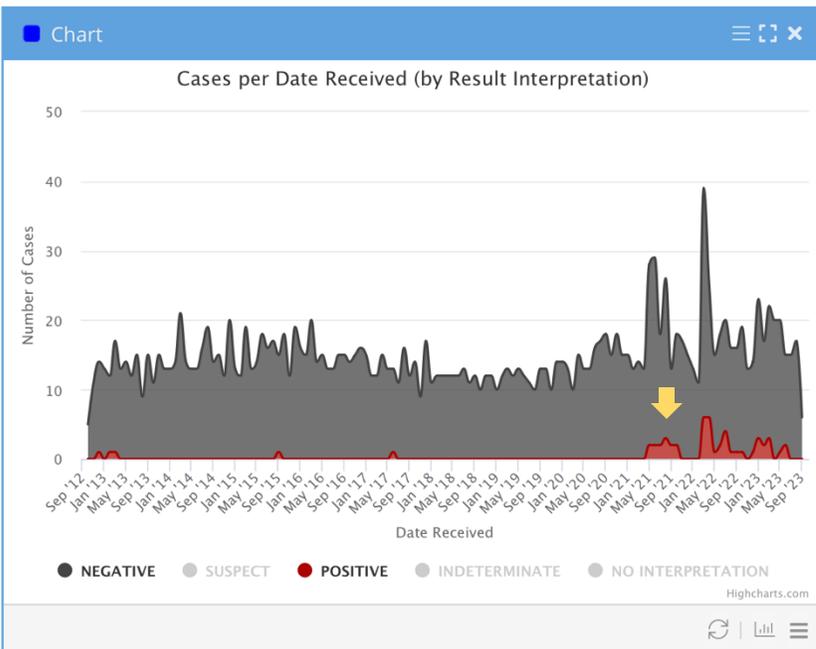
Example of a “custom” dashboard for a PRRS outbreak investigation in a production system with >500 farms



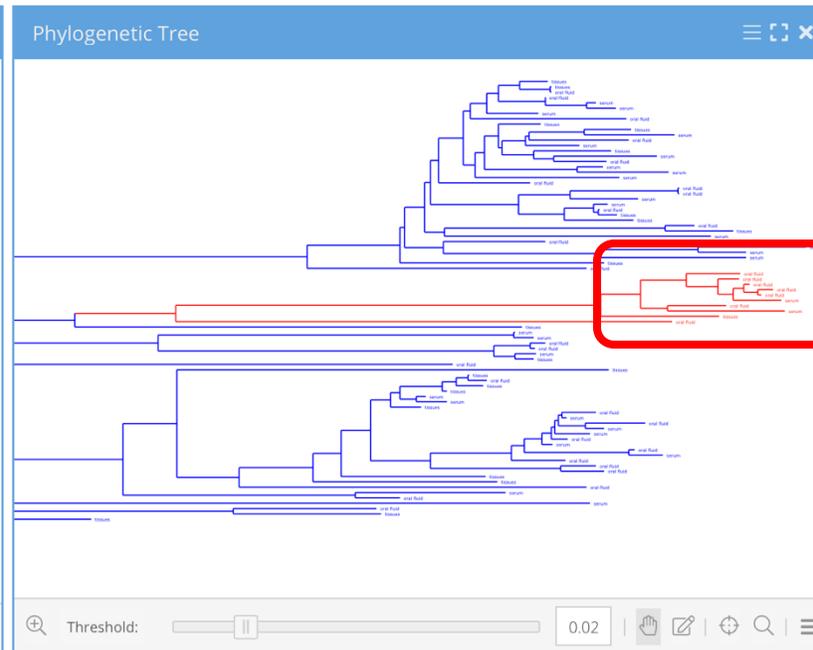
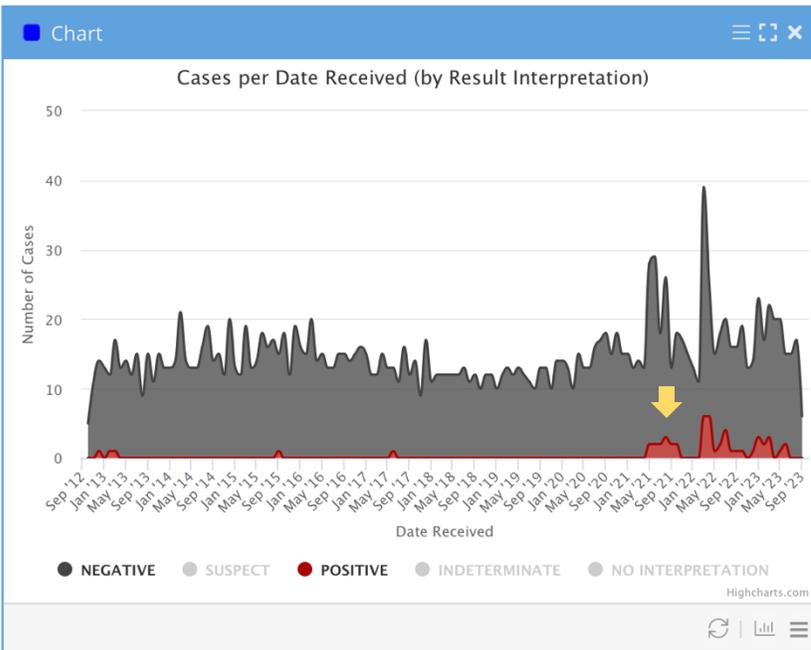
It is all about
story telling...



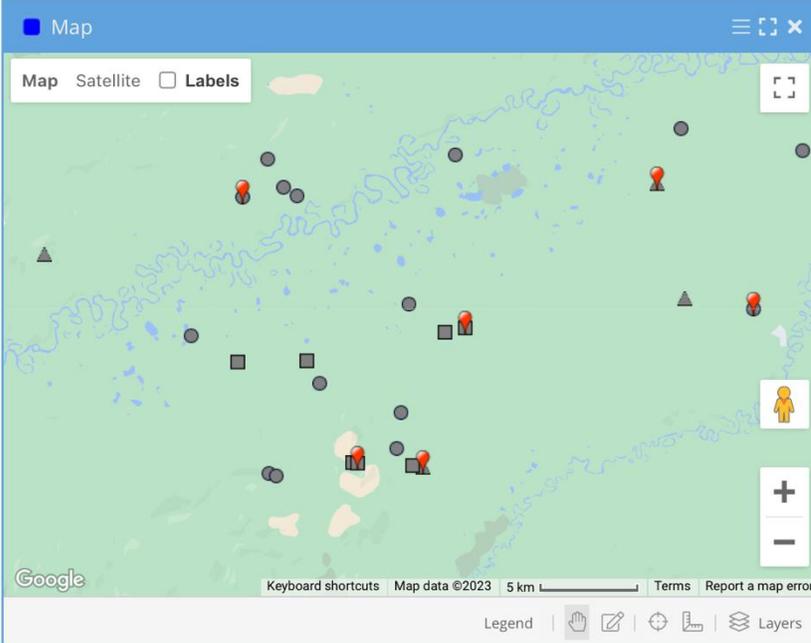
A very healthy production system starts having PRRS outbreaks in May 2021

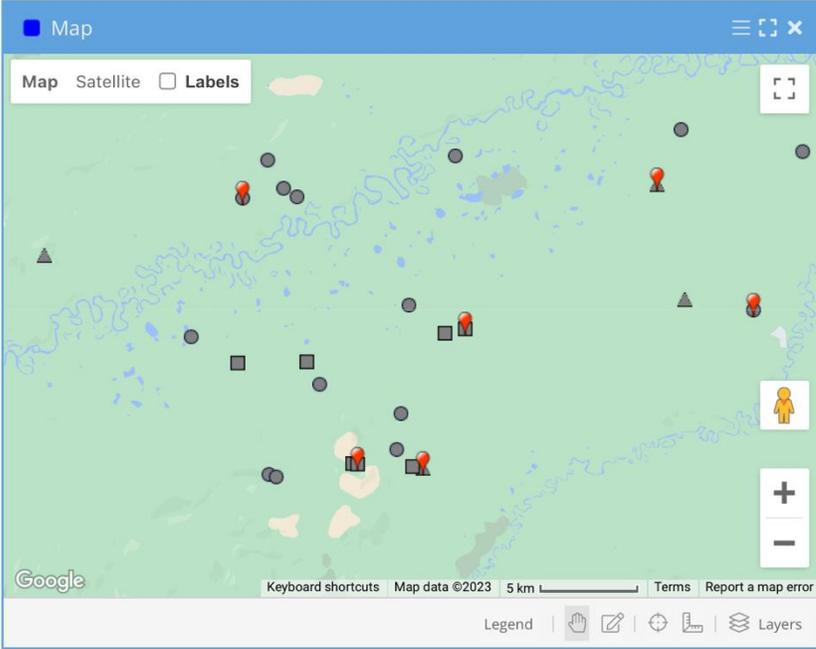
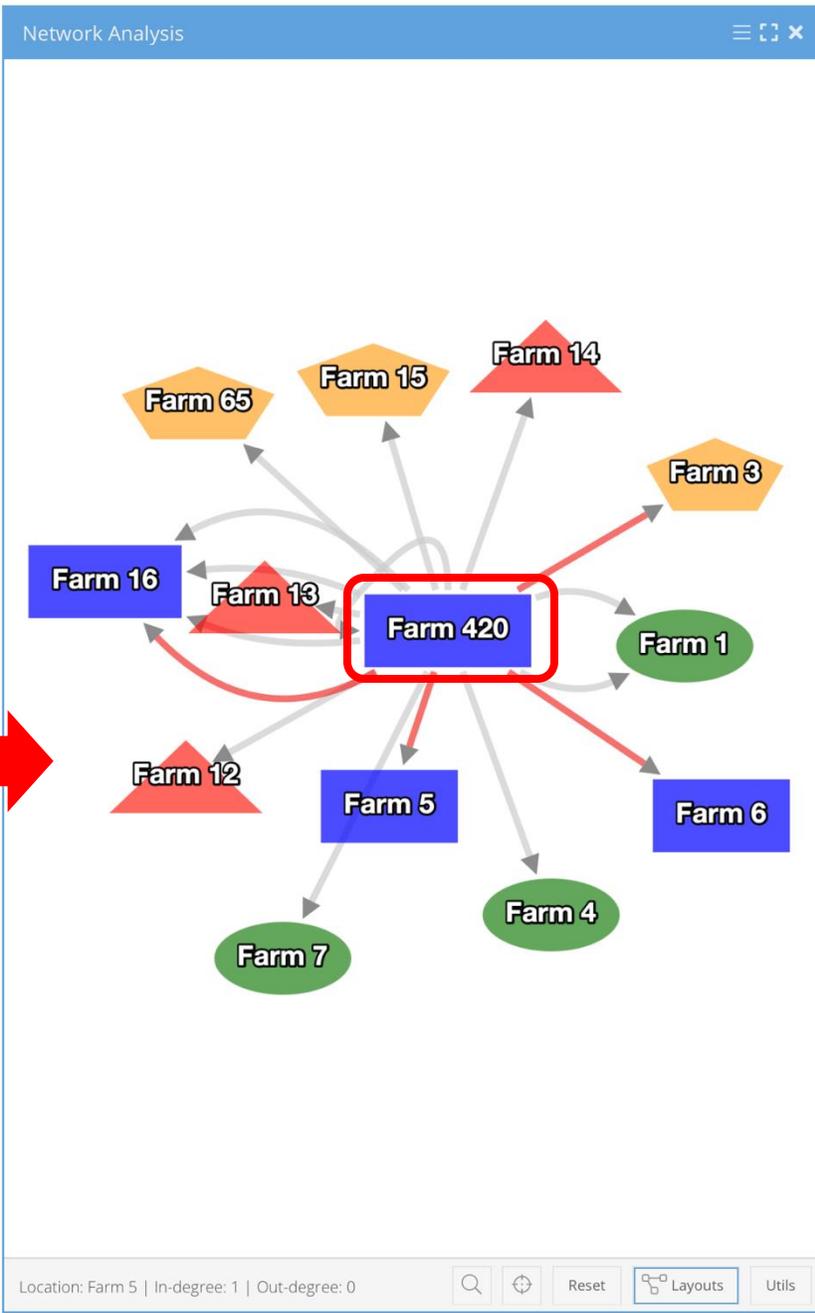
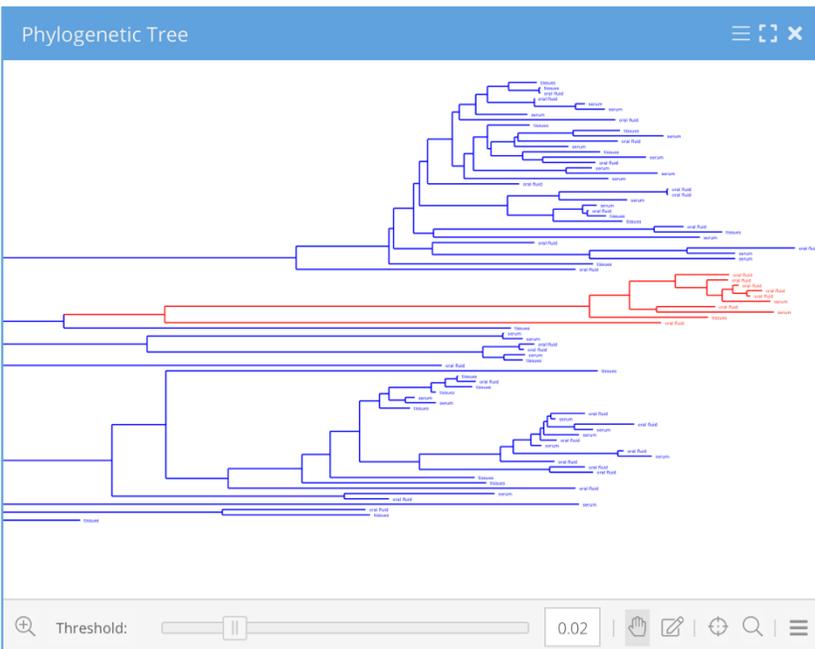
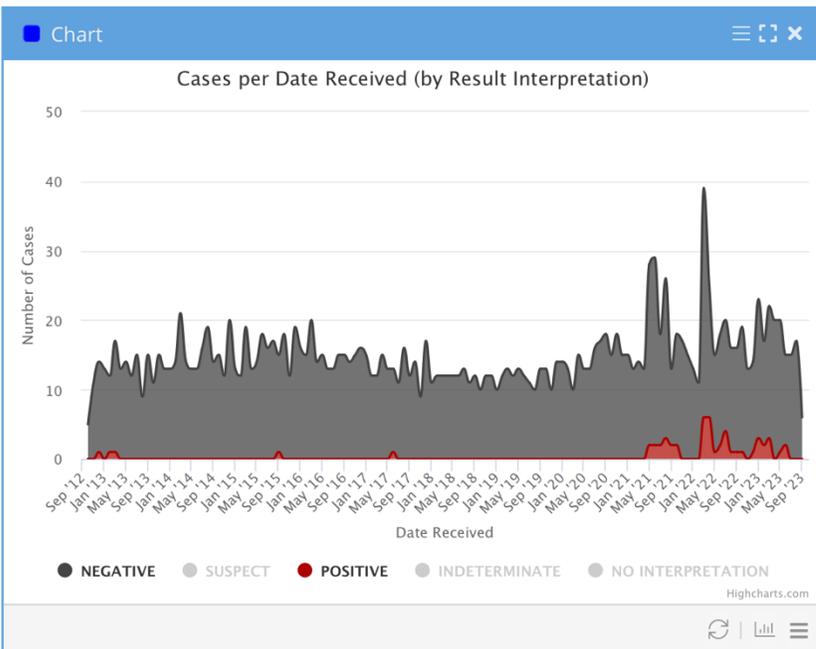


← Affected farms are relatively far apart (>5km).
Maybe multiple non-related PRRS viruses? or
just one virus with long-distance transmission?

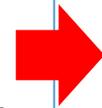


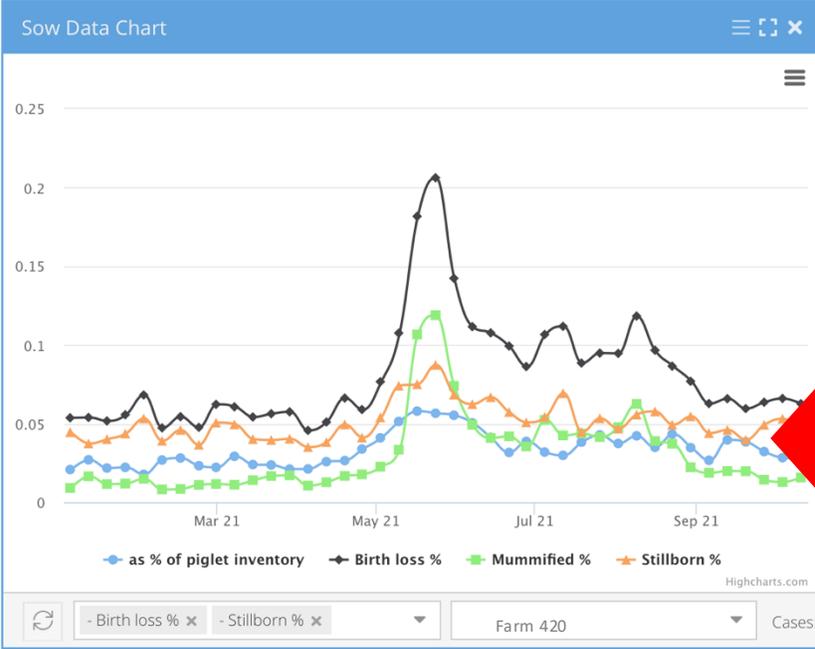
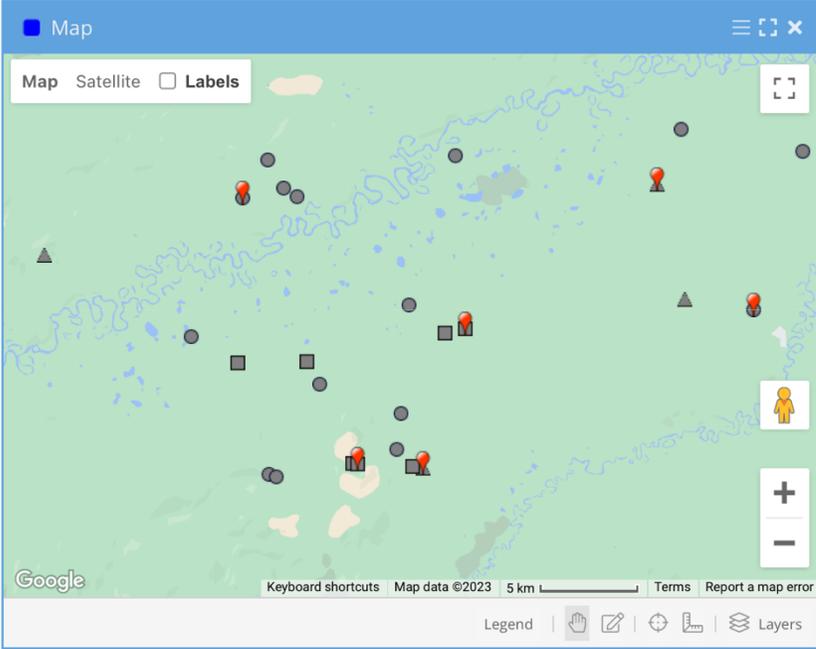
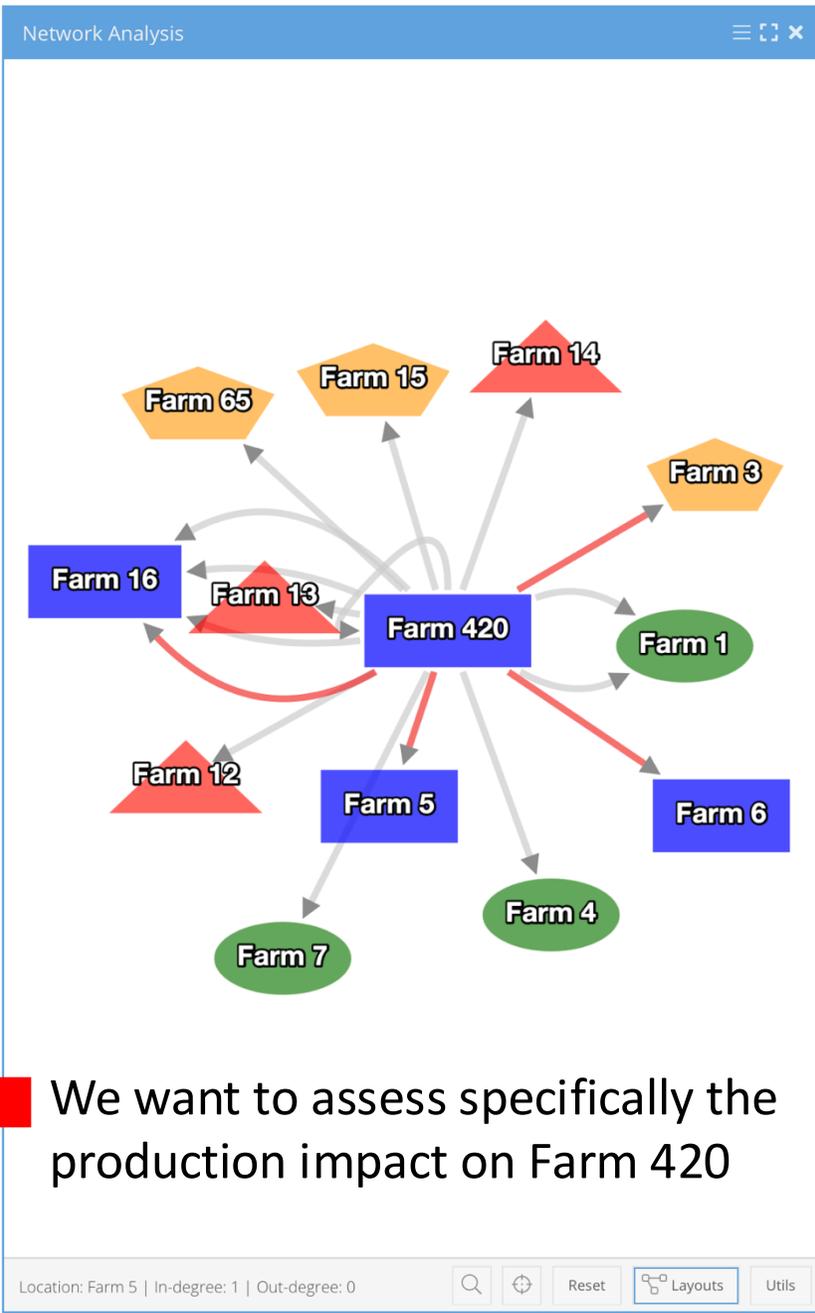
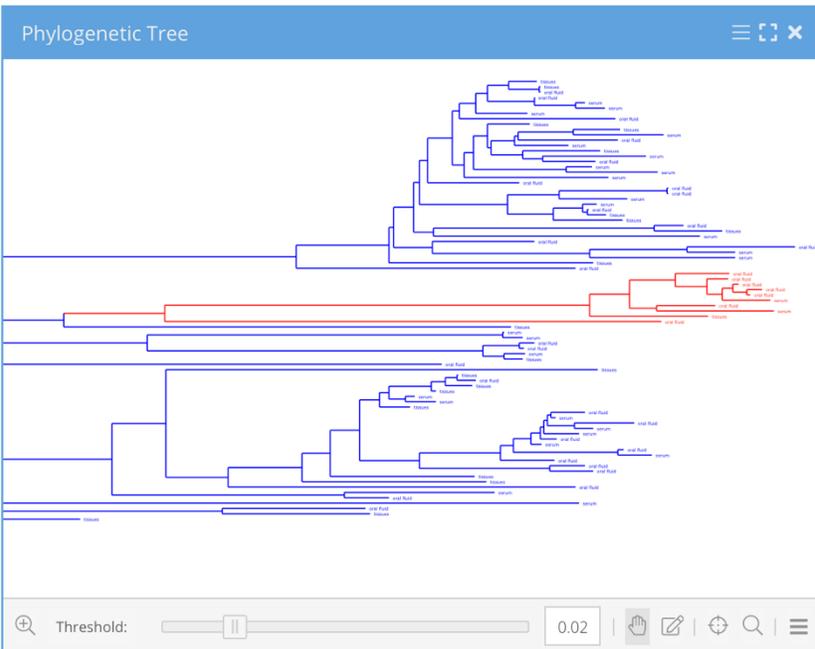
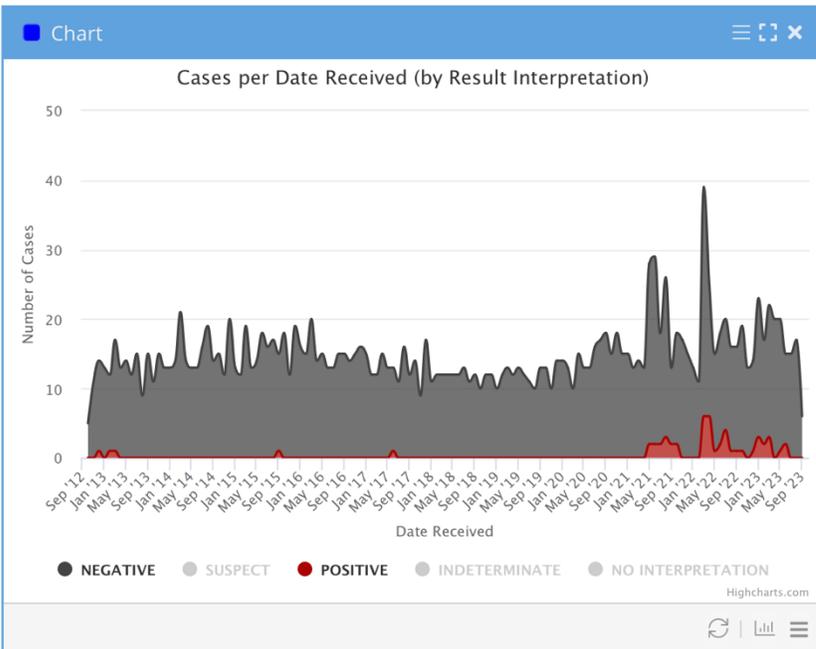
It seems it is just ONE PRRS virus, and NEW one (not diagnosed in the system before) as all isolates are closely related to each other





It is most likely coming from a common source (farm 420) based on the **high risk** (red) pig movements occurring within the last 15 days





We want to assess specifically the production impact on Farm 420

Signed in successfully.



Disease BioPortal®

Get the most out of your data to make more informed decisions

Connect, visualize, analyze and share animal health and management data as never before!

Welcome, BEATRIZ

[GO TO MY BIOPORTAL DASHBOARD](#)

HOW IT WORKS



Select Database

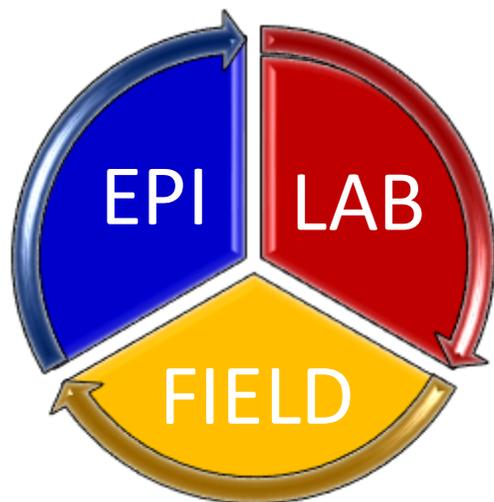
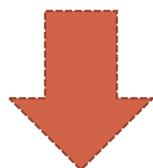


Visualize + Analyze



Save Dashboard

Next generation decision-support systems can significantly enhance animal health and food safety



Power to the people!

Make digitalization and AI-driven tools available for the veterinary services (and other stakeholders) to use

Transdisciplinary and One Health approach:

- Official vets and administrations + VDLs
- Epidemiologists + Computer scientists + other researchers
- Producers, Industry and Private Practitioners

A lot of value, but still substantial challenges

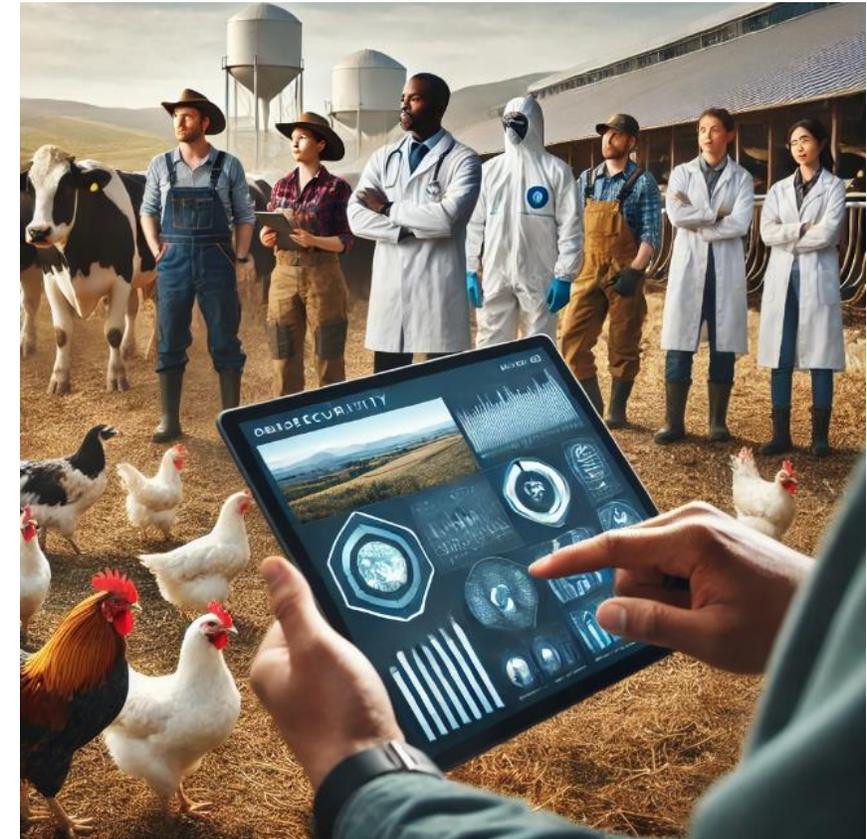
5. Train next generation of vet-data-scientists

The Problem

Next generation animal health workforce needs not only knowledge of veterinary health, but also of diverse areas that aid to process and analyze data which are simply too large to be used with conventional tools.

The Solution

Capacity building, technology transfer and continue education at **Universities** and **Veterinary Services**



5. Train next generation of vet-data-scientists

Capacity building, technology transfer and continue education at **Universities** and **Veterinary Services**

E.g. Integration into the curriculum of the Master of Preventive Veterinary Medicine (MPVM) and Graduate Group of Epidemiology (GGE) at UC Davis

But **NEEDS TO BE INTEGRATED IN THE DVM curriculum !!!**

Interactive, problem-solving approach

R-language & Python Programming



5. Train next generation of vet-data-scientists

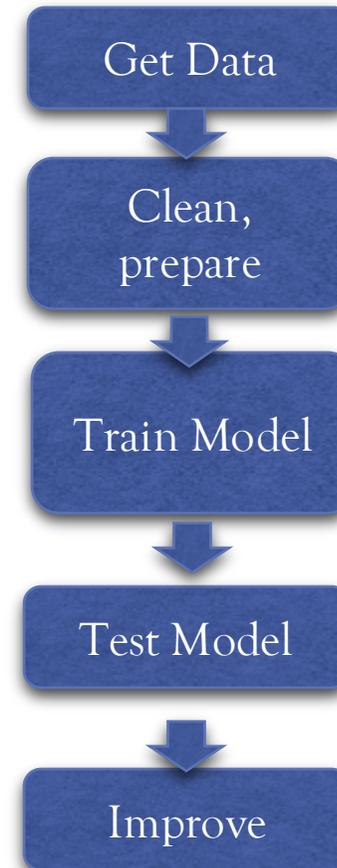
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But **NEEDS TO BE INTEGRATED IN THE DVM curriculum !!!**

Interactive, problem-solving approach

R-language &
Python
Programming



- Dealing with dirty data
- Develop analytical skills
- Real-world experimentation



Take home messages

- ✓ Technological advances
 - Data collection & aggregation
 - Computational power
 - Precision farming
 - Blockchain



- ✓ Mentality changes
 - Data sharing/use



Interest and favorable trends... but still a lot of work to do!



THE FUTURE??...

...SMART FARMING

...SMART EPIDEMIOLOGY & ANIMAL HEALTH

The Precision Epidemiology Consortium



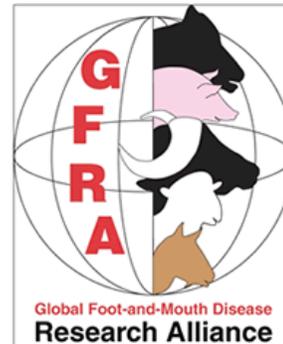
Acknowledgements

Thanks to our collaborators and funders. Welcome new collaborators & partners!

Digital revolution for animal health



Global African Swine Fever
Research Alliance



Global Foot-and-Mouth Disease
Research Alliance

Carnegie
Mellon
University

IOWA STATE
UNIVERSITY
College of
Veterinary Medicine

KANSAS STATE
UNIVERSITY

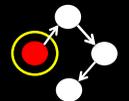


PIPESTONE®
VETERINARY SERVICES



SEABOARD
farms

Tosh FARMs



Disease BioPortal

<https://bioportal.ucdavis.edu/>

CADMS team

Thank you!

Katta rahmat!



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