How can the management of clinical and subclinical mastitis be supported by sensor systems?

A DISARM and IDF Webinar

Disseminating Innovative Solutions for Antibiotic Resistance Management

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 817591

Disseminating Innovative Solutions for

disarm

Antibiotic Resistance Management

www.disarmproject.eu

@ProjectDisarm

disarm

Disseminating Innovative Solutions for Antibiotic Resistance Management

INTERNATIONAL DAIRY FEDERATION
70/B, Boulevard Auguste Reyers
1030 Brussels - Belgium
Tel: +32 2 325 67 40
Email: info@fil-idf.org

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 817591

Coordinated by

ILVO
Flanders research institute for agriculture, fisheries and food

Partners

INNOVATION for AGRICULTURE

ifip institut du porc

nutrition sciences

ZLTO

ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
AGRICULTURAL UNIVERSITY OF ATHENS

Fédération Internationale du Lait · International Dairy Federation

LANDBRUG FØDEVARER SEGES

USAMV BUCUREŞTI 1852 EX TERRA AVRVM

ANPROGAPOR
ASOCIACIÓN NACIONAL DE PRODUCTORES DE GANADO PORCINO

ITAVI

copa cogeca
european farmers european agri-cooperatives

UNIVERSITEIT GENT

angst

acta LES INSTITUTS TECHNIQUES AGRICOLES

INSTITUT DE L'ELEVAGE idele

WAGENINGEN UNIVERSITY & RESEARCH

Latvijas Lauksaimniecības universitāte

OUR SPEAKERS AND OUTLINE

- Detection of severe clinical mastitis - **DR ILKA KLAAS, DELAVAL INTERNATIONAL AB, DENMARK**
- Detection of mild/moderate mastitis - **DR GUNNAR DALEN, TINE DAIRIES SA, NORWAY**
- Detection to support dry-off decisions - **PROF. DAVID KELTON, UNIVERSITY OF GUELPH, CANADA & DR ALFONSO ZECCONI, UNIVERSITA DEGLI STUDI DI MILANO, ITALY**
- Detection of herd level mastitis problems - **DR HONIG HEN, VETERINARY SERVICE, MINISTRY OF AGRICULTURE, ISRAEL**
- Conclusions: Thinking outside the box: Novel ways to utilize sensor data to improve mastitis management - **PROF. HENK HOGEVEEN, WAGENINGEN UNIVERSITY, NETHERLANDS**

- **QUESTIONS & ANSWERS ON ZOOM CHAT**

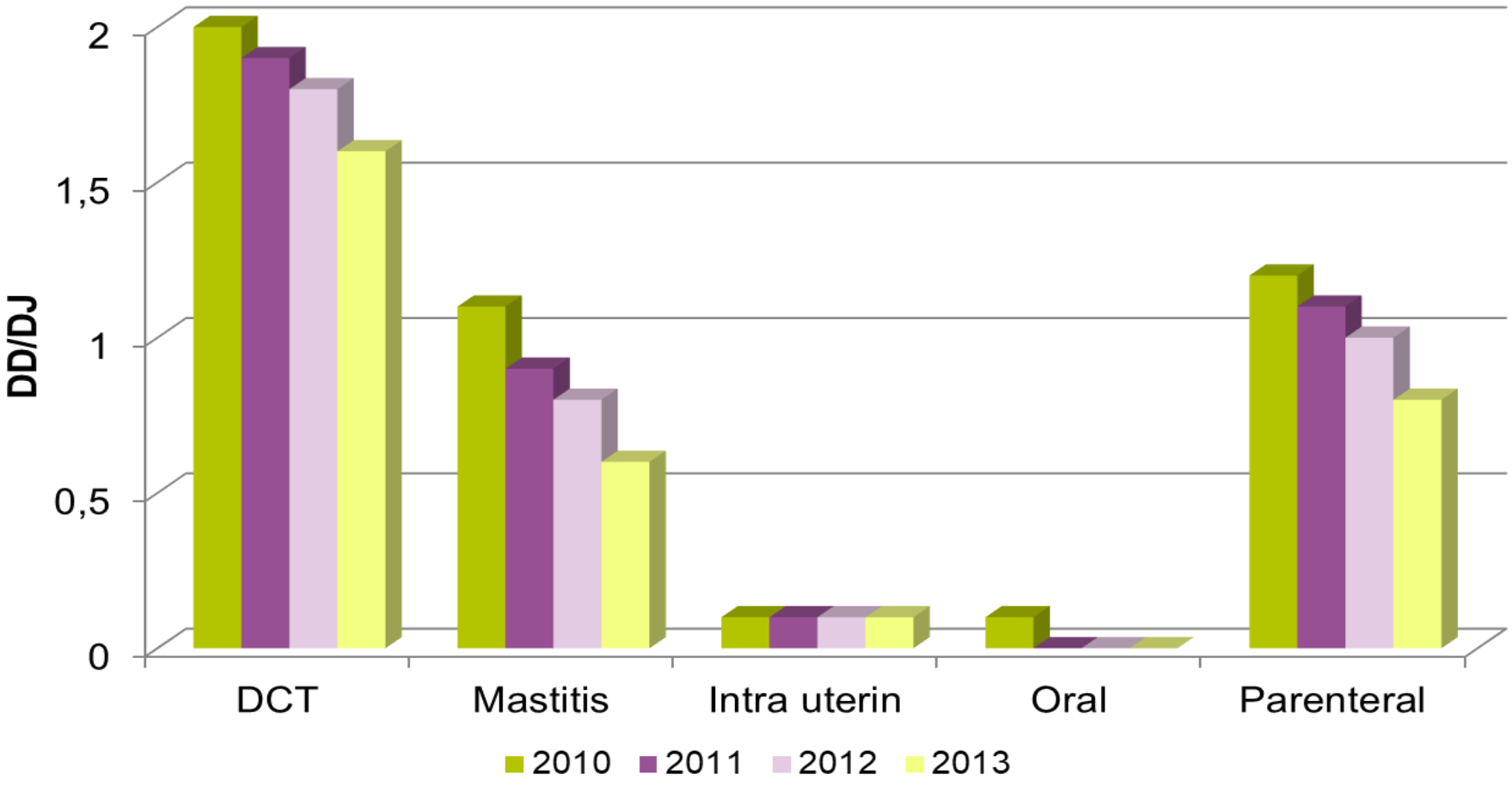
How can the management of clinical and subclinical mastitis be supported by sensor systems

Introduction

Henk Hogeveen

WAGENINGEN
UNIVERSITY & RESEARCH

Mastitis is the most important reason for use of antibiotics in dairy farming



WAGENINGEN UNIVERSITY & RESEARCH

No difference in use of antibiotics on farms with/without AMS

	Gemiddelde/mediaan		P
	AMS (n = 42)	CMS (n = ~ 254)	
Totaal antibiotica gebruik (DDD)	2,18	2,11	0,73
AB gebruik mastitis intrammair lactatie (DDD)	0,48	0,62	0,08
Antibiotica gebruik droogzetters (DDD)	0,86	0,88	0,94
Antibiotica gebruik intramusculair (DDD)	0,56	0,47	0,11
Percentage AB gebruik voor IMM lactatie	24 %	32 %	0,02
Percentage AB gebruik droogzetters	39 %	39 %	0,69
Percentage AB gebruik IM	29 %	23 %	0,01

- Udder health is a little better on non-AMS farms
  - 18 AMS farms: high cow SCC: 15.5 %
  - 24 CMS farms: high cow SCC: 1344 %

J. Dairy Sci. 103
https://doi.org/10.3168/jds.2019-17960

Antimicrobial use and farmers' attitude toward mastitis treatment on dairy farms with automatic or conventional milking systems

Z. Deng,[1*] T. J. G. M. Lam,[1,2] H. Hogeveen,[1,3] M. Spaninks,[1] N. Heij,[1] M. Postema,[1] T. van Werven,[1,4] and G. Koop[1]

WAGENINGEN UNIVERSITY & RESEARCH

Precision Dairy Farming can improve

Definition

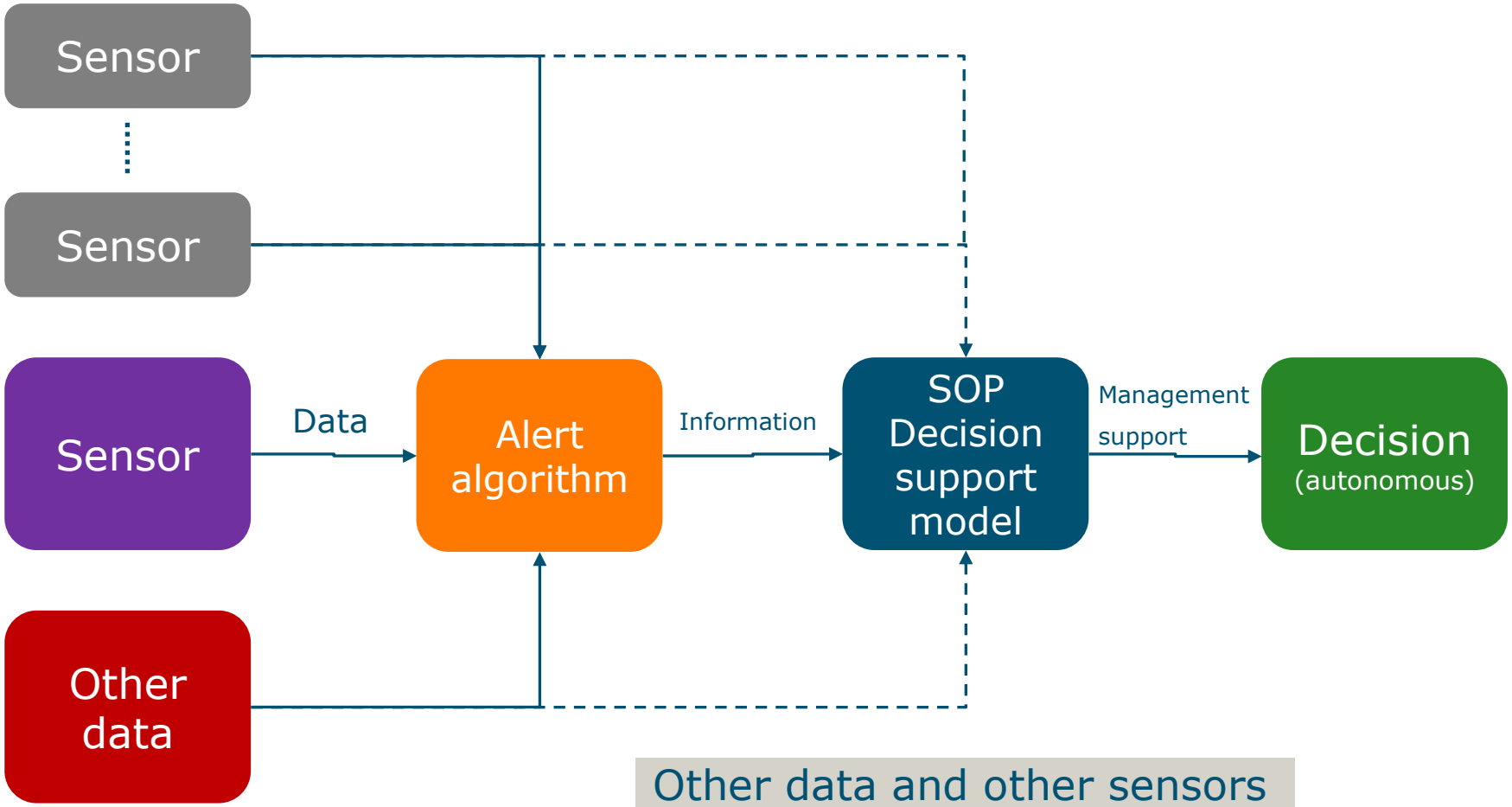
- More than labour savings
- Support (daily) management
- Improve farm profitability and sustainability

Can be done by...

- Monitor physiological parameters related to health or fertility of individual cows
- Automatic detection of events (e.g. mastitis)

WAGENINGEN
UNIVERSITY & RESEARCH

Elements of a sensor system



Other data and other sensors may also be used to improve decision support models

Current status of sensor systems for mastitis management

- Two reviews available
- Until 2013: 30 papers on detection of clinical mastitis
  - 16 Electrical conductivity
  - 6 EC plus colour
  - 4 Infrared
  - 3 Biosensor (LDH)
  - 1 SCC

Sensors **2010**, *10*, 7991-8009; doi:10.3390/s100907991

OPEN ACCESS

sensors

ISSN 1424-8220

www.mdpi.com/journal/sensors

Review

Sensors and Clinical Mastitis—The Quest for the Perfect Alert

Henk Hogeveen [1,2]*, Claudia Kamphuis [2], Wilma Steeneveld [2] and Herman Mollenhorst [2]

J. Dairy Sci. 96:1928–1952

http://dx.doi.org/10.3168/jds.2012-6107

***Invited review:* Sensors to support health management on dairy farms**

C. J. Rutten,*[1] A. G. J. Velthuis,† W. Steeneveld,† and H. Hogeveen*†

How should we evaluate sensor systems?

- Sensitivity: proportion of Cases correctly classified
- Specificity: proportion of non-cases correctly classified
  - Negative trade-off between Sens. and Spec.
  - Clinical mastitis requirements:
    - 80 % sensitivity
    - > 90 % specificity
- True-positive alerts: Alerts that are correct
- False-negative alert: Case that is not detected

Journal of Dairy Research (2005) **72** 406–414. © *Proprietors of Journal of Dairy Research 2005*
doi:10.1017/S0022029905000993 *Printed in the United Kingdom*

Visual scoring of clots in foremilk

Morten D Rasmussen*

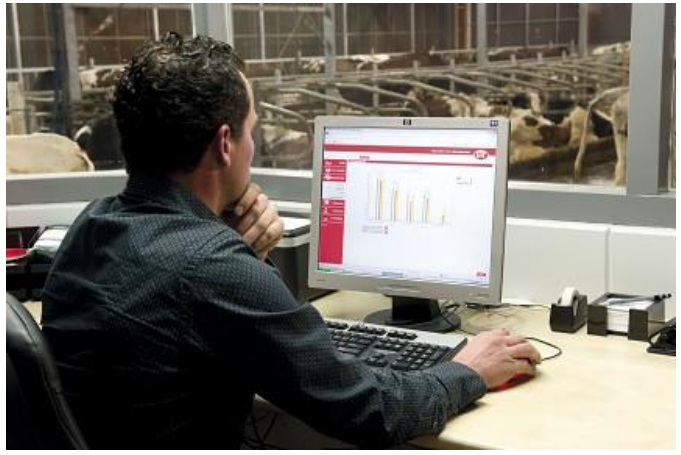
J. Dairy Sci. 96:4047–4058
http://dx.doi.org/10.3168/jds.2012-6190

Development of protocols to evaluate in-line mastitis-detection systems

C. Kamphuis,*[1] B. Dela Rue,* G. Mein,† and J. Jago*

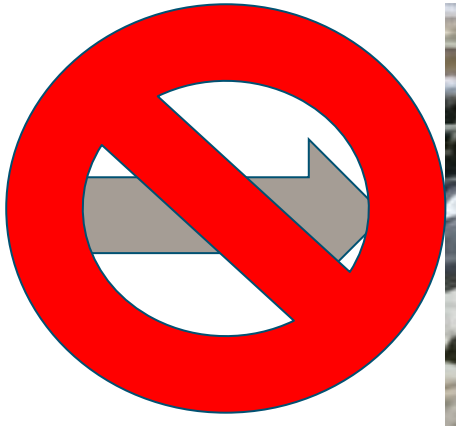
Detection results clinical mastitis

- In practise
  - Sensitivity 21% - specificity 99 %
  - Sensitivity 50 % - specificity 90 % (Mollenhorst et al., 2009)
- In theory
  - Sensitivity 57 % - specificity 98 % (Kamphuis et al., 2010)
  - Can be improved by adding SCC



WAGENINGEN
UNIVERSITY & RESEARCH

Farmers do not follow up all alerts



- Study on 7 Dutch dairy farms
- Only 3,5% of the alerts are checked by the farmer!
- High success rate: 67 %
- But 74 % of the clinical mastitis were missed

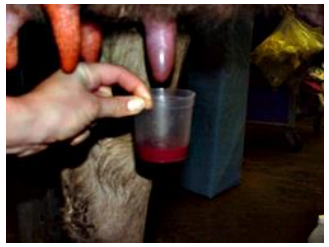
WAGENINGEN
UNIVERSITY & RESEARCH

Use and interpretation of mastitis alerts by farmers

H. Hogeveen[1,2], K.J. Buma[1] and R. Jorritsma[1]

Why so low?

- The “mastitis-is-not-black-or-white” problem



Severe clinical mastitis

Mild clinical mastitis

Healthy

Inflammatory signs (increased SCC)

Three methods for improvement

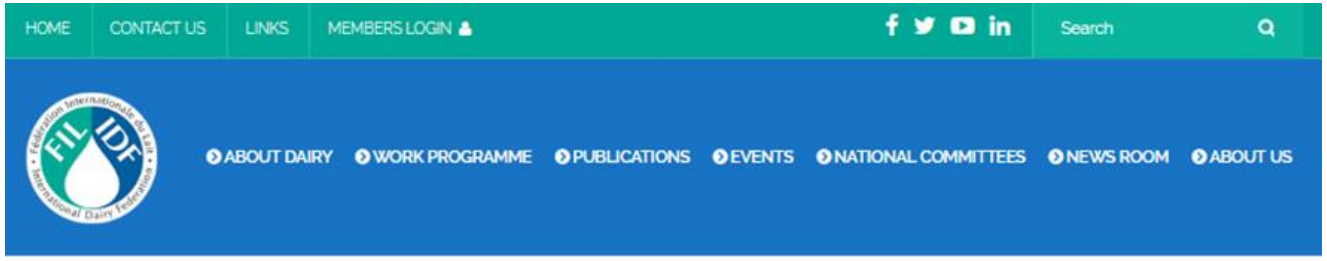
- Better sensors – has been tried
- Better algorithms – has been tried
- Add other information – has been tried

- But we are working on this since the 1990's

- Are we going to be successful?

Different approach SCAHW Action Team Sensors

- Go for a farmer-centred, management-based definition of mastitis situations
- 4 mastitis management situations:
  - Severe clinical mastitis – immediate action
  - Mild clinical/subclinical mastitis – no immediate action
  - Drying off
  - Herd-level management (monitoring & prevention)



IDF STANDING COMMITTEE ON ANIMAL HEALTH AND WELFARE

WAGENINGEN UNIVERSITY & RESEARCH

Thank you for your attention

henk.hogeveen@wur.nl

@henkhogeveen

Mastitis situation: cows needing immediate attention

Severe clinical mastitis

Ilka Klaas

Dairy Development Director, DeLaval International, Tumba, Sweden

IDF DISARM Webinar 14th October 2020

What is a cow with severe clinical mastitis that needs immediate attention?

- A cow with severe clinical mastitis has abnormal milk, ***with or without signs*** of swelling in the affected udder quarter, and she has two or more ***signs of systemic illness*** (Roberson et al. 2014).
  - Rectal temperature > 39.8°C or < 37.8°C (Wenz et al. 2001)
  - Cow is off feed/decreased feed intake/anorexia
  - Low rumen activity (less than 2 contractions/min)
  - Depression
  - Dehydration
- 5-22% of mastitis cases in herd studies were severe

  (Wenz et al. 2001; Nash et al. 2002, Pinzon and Ruegg 2011, Rodrigues et al. 2009)

Detection of cows with severe clinical mastitis in ’non-sensor world’

- Clinical examination general condition
- Abnormal signs in udder quarter or milk observed at formilking/udder prep
- Abnormal behaviour/signs observed when cow fetched for milking, during milking, staff activities in the barn

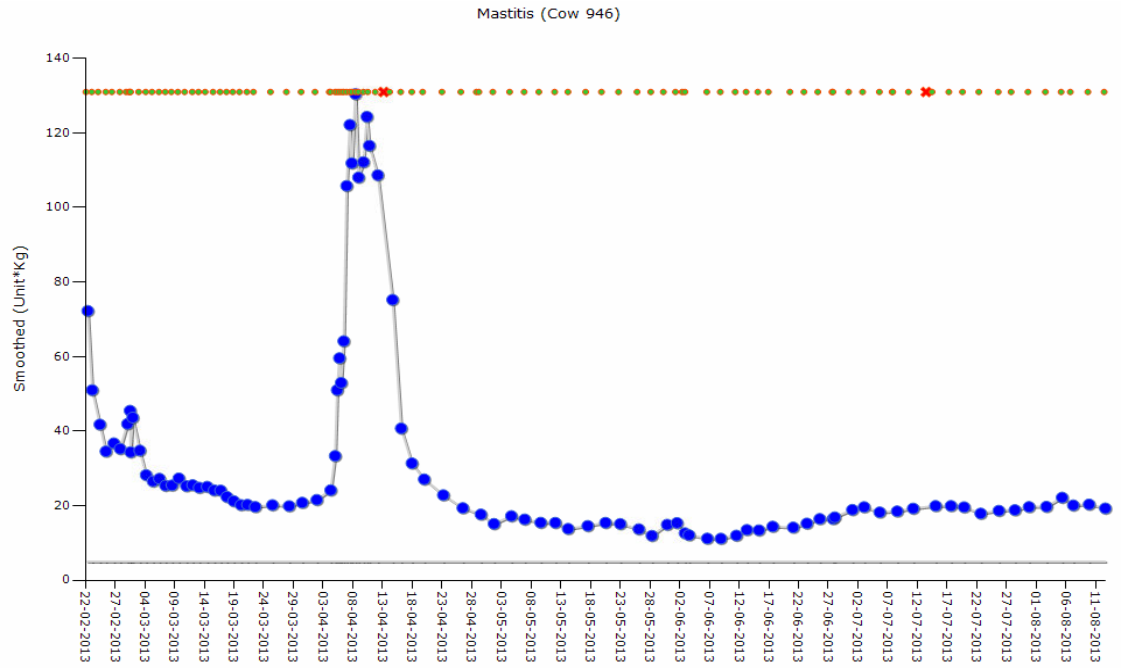
How good are farmers/staff to detect signs of mastitis?

How many severe cases are not detected (in time)?

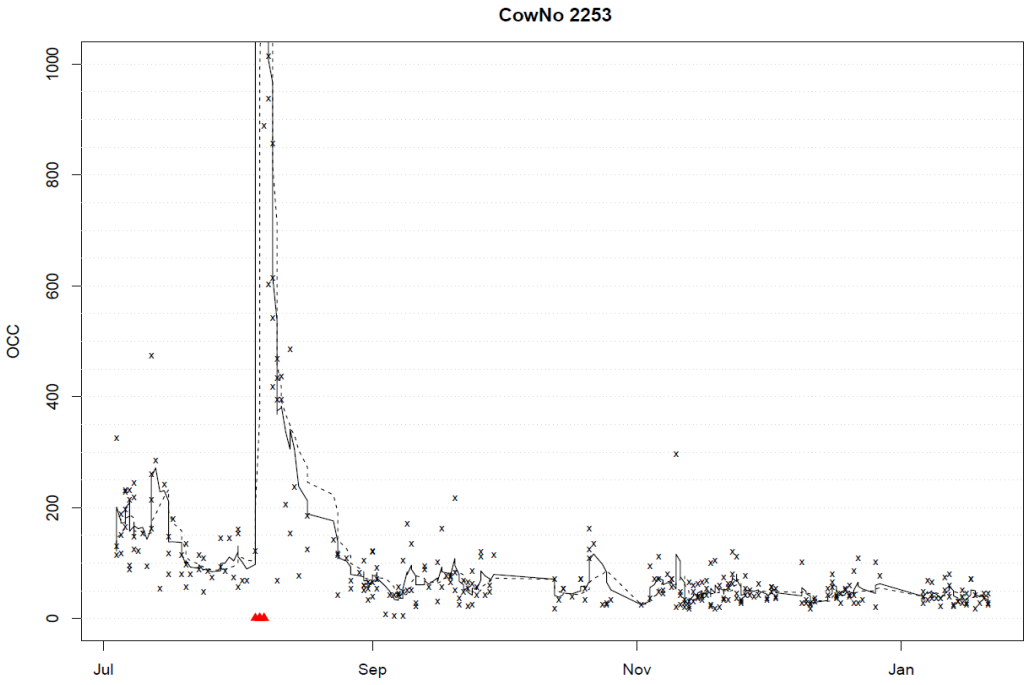
Detection or action problem?

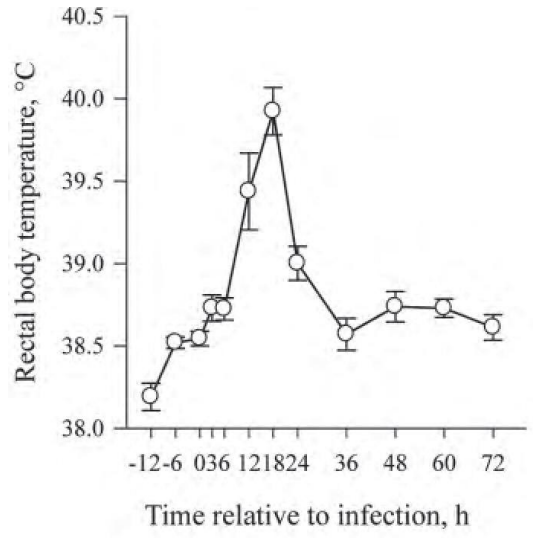
Examples of acute clinical mastitis detected by sensor systems

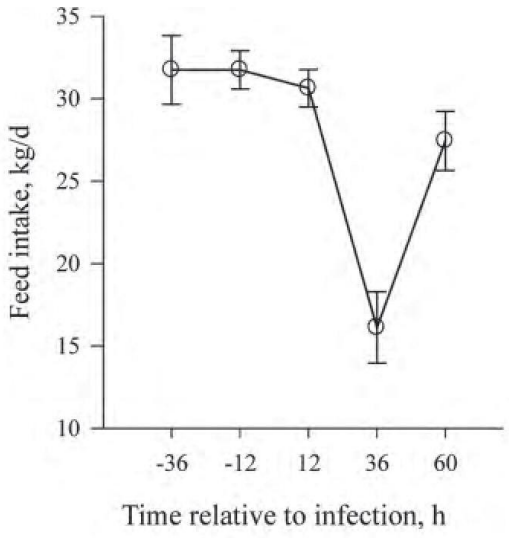
LDH measurements

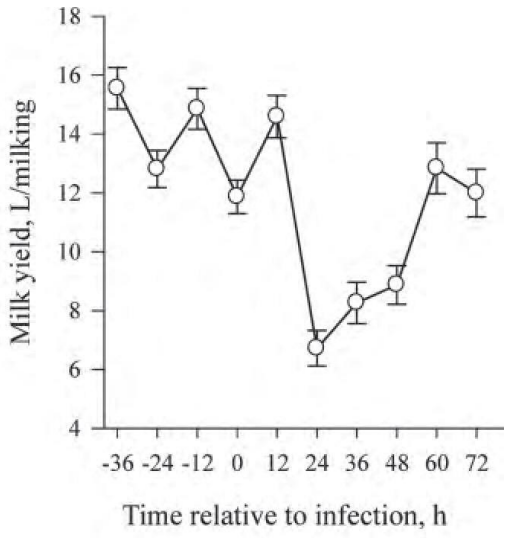


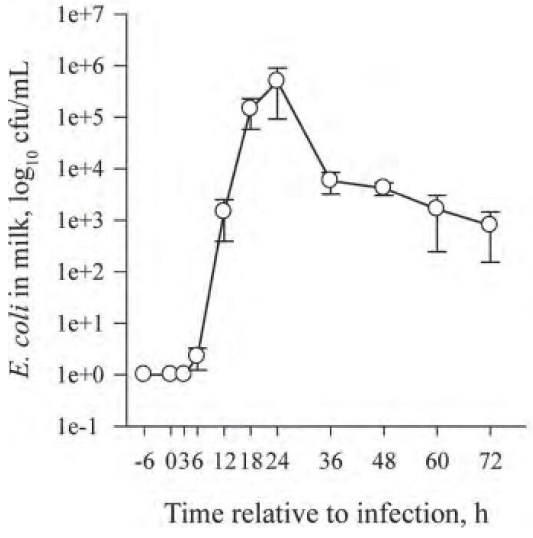
SCC measurements (OCC)

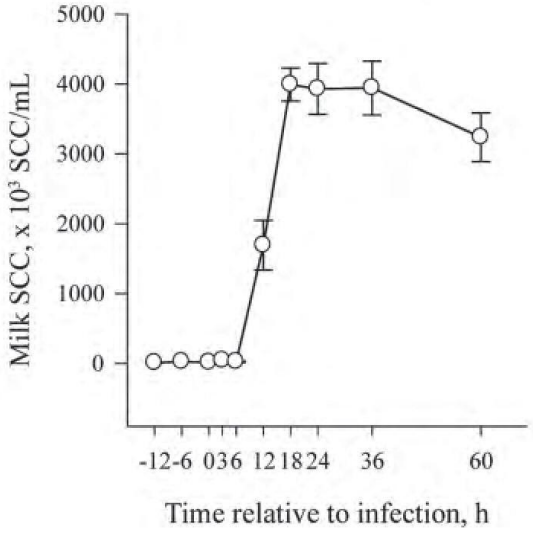












Generel signs and changes in milk in 20 cows experimentally infected by E. Coli

(Fogsgaard et al. 2012)

Different times of onset and maximum change!

Challenges for sensor systems

- Short time window
- Milk may appear normal at a stage when general condition already is compromised
- No attachment or incomplete milking of quarter, significant deviances from other quarters
- Cow may not attend a milking machine – milking based indicators may not be sufficient
- Absence of activity/measurable signs may be the important indicator
- High Se and Sp wanted – ideally, no cow should go undetected!

Where are we in the process?

Current knowledge of sensor performance for ***severe*** clinical mastitis lacking

- Performance of sensor systems to detect clinical mastitis
  - Based on 1 sensor (OCC, Dalen et al. 2019):

    at Specificity 99%: Sensitivity 60%

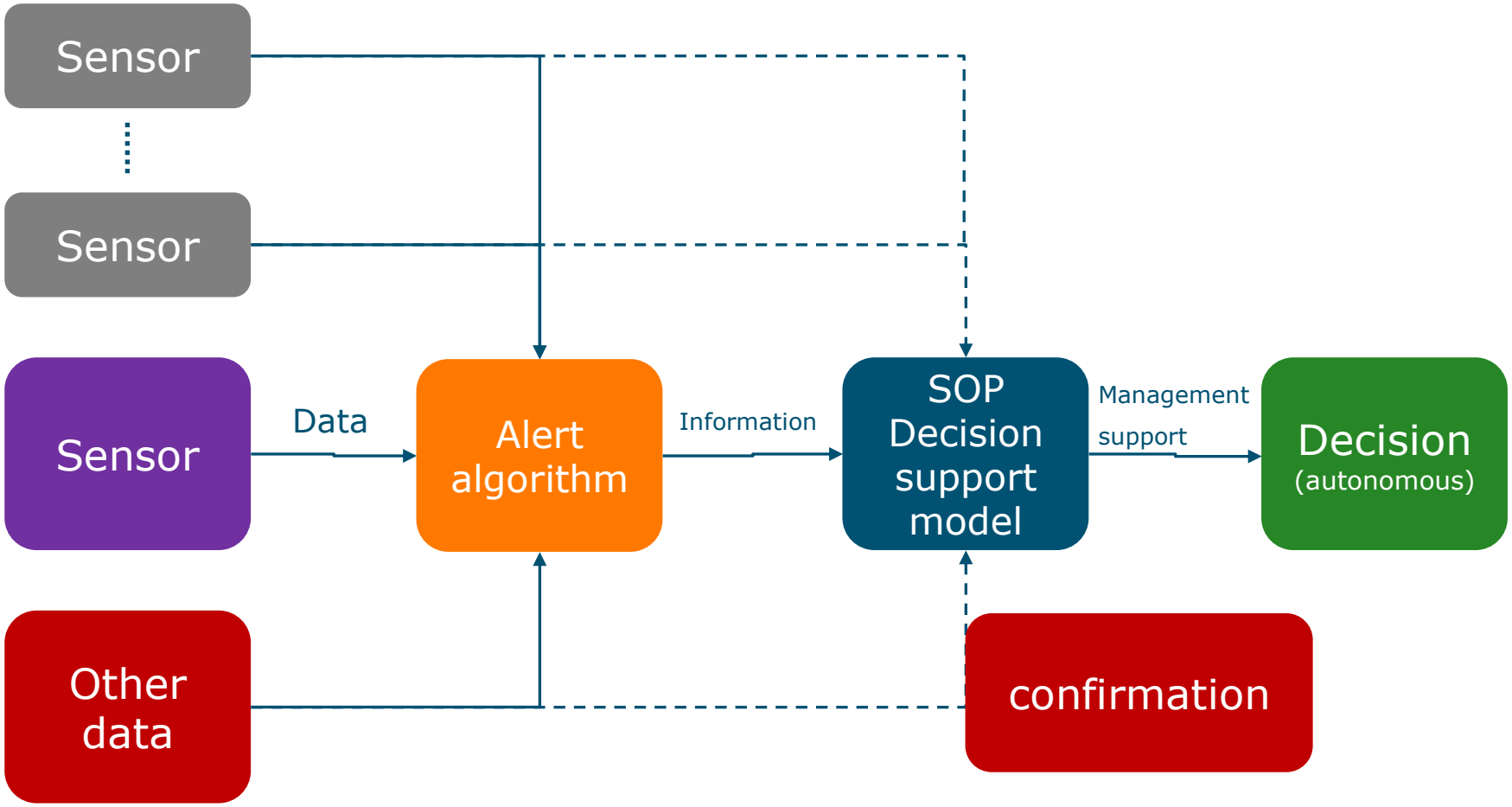
    at Specificity 90%: Sensitivity 80%
  - Based on algorithm combining 6 indicators (Khatun et al. 2018):

    Conductivity; conductivity/h; avg. milk flow, milk yield; milk yield/h and incomplete milked quarter

    best model with cow random effects 'history': Sp 91 %; Se 90 %

    model without random effects Sp 88 %; Se 84 %

Elements of a sensor system for severe clinical mastitis = cows needing immediate attention



Additional information needed to improve decision support models

WAGENINGEN UNIVERSITY & RESEARCH

Demands for a sensor system to identify cows needing immediate attention

= cows with compromised general condition

- High Se of 95 %
- High Sp of 99 %. A cow with severe compromised general condition not caused by mastitis should not be regarded as false positive
- Short time window < 12 h

- Several sensor-based and automatic milking-based indicators may need to be combined to reach the necessary demands
  - Inflammatory markers
  - Cow behavior
- Combination of sensor and non-sensor information necessary

How should farmers use sensor systems to manage subclinical and mild mastitis?

Definitions

Subclinical mastitis

Disease process not detected by physical examination of the animal. Inflammation of the mammary gland that is not visible and require a diagnostic test for detection. The diagnostic test most used is measurement of milk somatic cell count (SCC) (IDF, 2011)

Mild mastitis

Udder inflammation characterized by observable abnormalities in milk, generally clots or flakes, with little or no signs of swelling of the mammary gland or systemic illness (IDF, 2011)

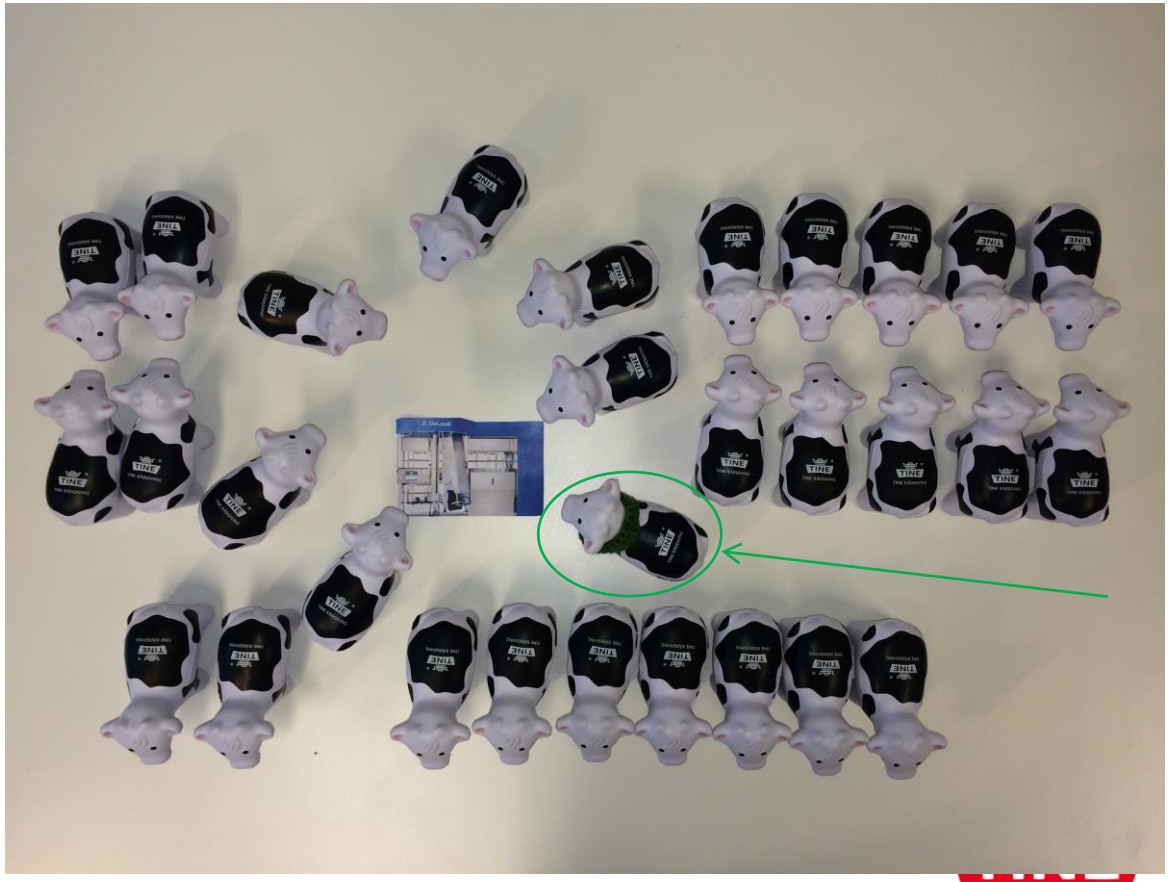
Why do we care about subclinical and mild mastitis?
Example: Automatic milking system (AMS) with a fresh start. No cows with intramammary infection (IMI).

Cow without IMI

Cow with «environmental» IMI

Cow with «contagious» IMI

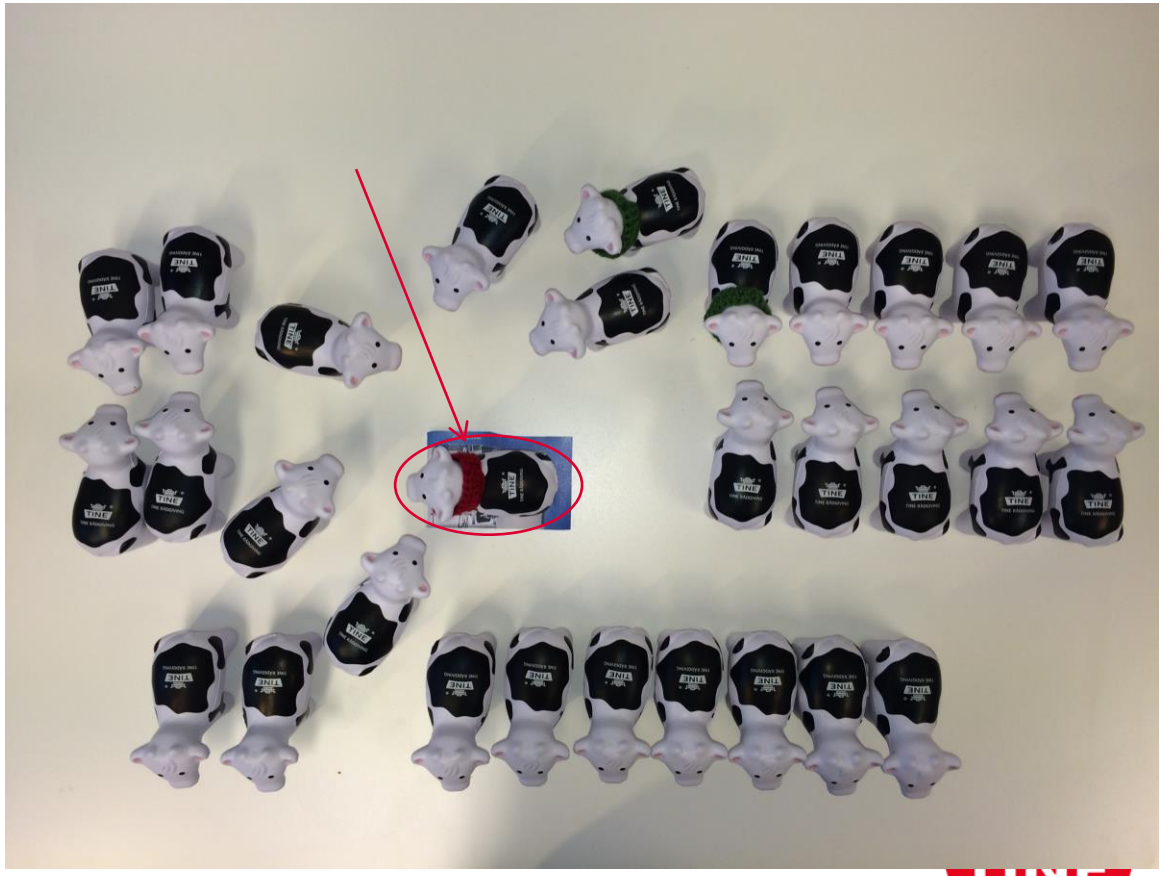
For various reasons, some cows will get an «environmental» IMI



«Environmental» IMI's usually demonstrate a low degree of direct transmission from cow to cow

Poor maintenance of the environment and/or poor management of animals can lead to more «environmental»

Introduction of cow with «contagious» IMI



Transmission of «contagious» IMI

Transmission of «contagious» IMI

Some animals get clinical mastitis and require veterinary treatment. Not necessarily the one that introduced the

More transmission of «contagious» IMI

Traditionally the farmer and the veterinarian focus on the clinical cases.

Result: Many diseased, many infected, poor health and welfare, poor milk quality, culling, frustration

Can we use sensors to classify cows into the following groups?

Or other groups?

Cows with no IMI

Cows with «environmental» IMI

Cows with «contagious» IMI

Detection of subclinical mastitis or mild mastitis

Current and widely used approaches

- Pre-stripping and checking the foremilk
  - Applicable for mild mastitis only
- DHIA (Dairy Herd Improvement Association) SCC
  - Elevated SCC is frequently associated with intramammary infection (IMI)
    - Proxy for infection (Schukken et al., 2003)
    - Se/Sp ~65%/~65% (Reksen et al., 2008)
  - Long time between testing

Various sensor systems aim to replace and improve on these approaches

- Frequent testing and huge amounts of data
- Minor improvements have been made, but nothing revolutionary
    - Se/Sp ~70%/~80% (Dalen et al. 2019)

Practical consequence of suboptimal diagnostic test properties: Detection moment

Detection moment = every milking -> high Sp

≈100 lactations per year, ≈ 2.7 milkings per day -> 63,000 milkings per year

Sp ≥ 99 -> 630 false positives -> ≈ Two false alerts per day

Sp ≥ 80 -> 12,600 false positives ≈ 35 false alerts per day

Detection moment = one evaluation before drying off -> high Se

≈ 100 lactations per year -> 100 cows to dry off per year

Sp ≥ 99 -> One false positive per year

Sp ≥ 80 -> 20 false positives per year

- Therefore:
  1. We need to adjust the use of the sensor systems for different detection moments
  2. We need to find a way to handle the challenge with suboptimal diagnostic test properties for settings with multiple detection moments (e.g. during lactation)

Demands for detection of subclinical or mild mastitis

Immediate detection is not necessary

Detection of all cases is not necessary

False alerts should be minimized

Therefore we argue for the following demands for sensor systems to detect subclinical or mild mastitis during lactation:

Sensitivity ≥ 80%

Specificity ≥ 99.5%

Time window: ~7 days

These demands are too high!

With current sensor systems – Yes

Practical implication:

- Sensor systems cannot be left alone
- Human supervision is important

Sensor systems not meeting the demands can still be useful

- Need clear instructions for optimal use

Associated management

Optimal methods of intervention upon the detection of subclinical or mild mastitis will be subject to farm specific circumstances and local regulation

Self cure vs chronicity

Secondary testing

Responsible use of antimicrobials

Immediate actions vs actions at drying off

Actions pending herd status

Using Sensor Data to Support Drying Off of Dairy Cows

IDF DISARM Webinar
October 14, 2020

David Kelton, DVM, PhD, MSc

Dairy Farmers of Ontario Chair in Dairy Cattle Health

Ontario Veterinary College, University of Guelph

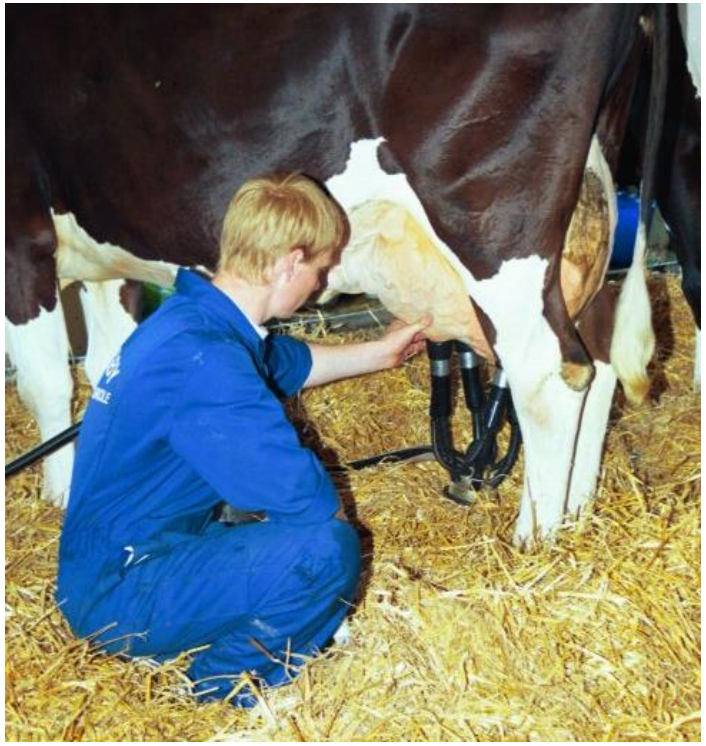
UNIVERSITY of GUELPH

DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY

Introduction – sensors and dry off

- Increasing interest in Selective Dry Cow Therapy
  - Focus on AMR and reducing AMU
  - Changes in pathogen profiles

- 2 important questions at time of dry off with a potential role for sensors and associated decision algorithms



Questions at dry off

1. How much milk is the cow producing?
   - Do we need to do something to decrease milk production prior to dry off?

2. In a herd using selective dry cow therapy (SDCT) is this cow a candidate for NOT treating with antibiotic?
   - Is she at LOW risk of having an intramammary infection? MAJOR or MINOR pathogen?

Questions at dry off - #1

How much milk is the cow producing?

- Do we need to do something to decrease milk production?

DAILY MILK WEIGHTS

LESS than 15 Kg of milk/day

J. Dairy Sci. 99:4005–4017
http://dx.doi.org/10.3168/jds.2015-10348

Intramammary infections and milk leakage following gradual or abrupt cessation of milking

P. N. Gott,* P. J. Rajala-Schultz,*[1] G. M. Schuenemann,* K. L. Proudfoot,* and J. S. Hogan†
*Department of Veterinary Preventive Medicine, The Ohio State University, Columbus 43210
†Department of Animal Sciences, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster 44691

DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY
UNIVERSITY of GUELPH

Questions at dry off - #2

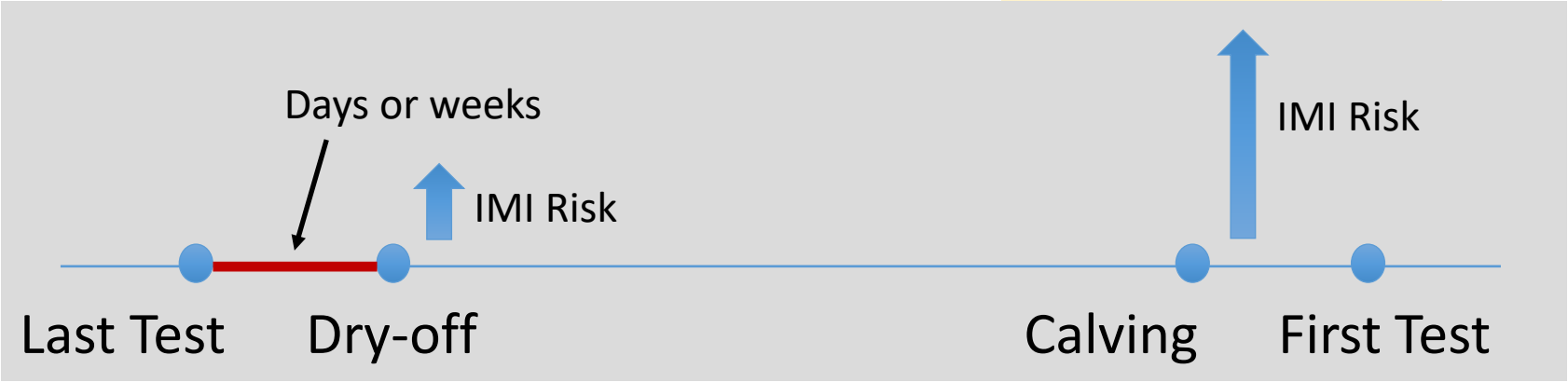
- In a herd using selective dry cow therapy (SDCT) is this cow a candidate for NOT treating with antibiotic?
  - Is she at LOW risk of having an intramammary infection? Can we distinguish between MAJOR & MINOR pathogens?
  - When do we want to know it?
  - Do we have sensors to provide the information?
  - How good are those sensors for this purpose?

Selective Dry Cow Therapy

- Selecting herds and cows: **Many protocols….no consensus**!

- Selecting **cows**……(and in some cases **quarters**)
  - DHI individual cow SCC +/- Clinical Mastitis Cases
  - SCC at last or multiple tests…..usually the last 3 tests
  - Selection 'Index' = weighted SCC from last three DHI tests
    - (weighted as 20% for 3rd last test; 30% for 2nd last test; 50% last test)

- Challenge:



DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY
UNIVERSITY of GUELPH

Selective Dry Cow Therapy

- CMT and culture can provide information closer to the time of dry-off, but are rarely used in most commercial herds!
- Some ‘tools’ have been evaluated for this purpose

Preventive Veterinary Medicine 179 (2020) 104982

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

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

Evaluation of rapid culture, a predictive algorithm, esterase somatic cell count and lactate dehydrogenase to detect intramammary infection in quarters of dairy cows at dry-off

Sam Rowe[a,*], Sandra Godden[a], Daryl V. Nydam[b], Patrick Gorden[c], Alfonso Lago[d], Amy Vasquez[b], Erin Royster[a], Jennifer Timmerman[a], Mark Thomas[e]

DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY
UNIVERSITY of GUELPH

Selective Dry Cow Therapy

- Sensors are another option:
  - We are not aware of any studies that have evaluated the performance of sensor systems for the identification of cows with IMI at dry-off

- Considerations:
  - Planned event…so we can use more data to ‘get it right’
  - Want a sensor/algorithm with ‘reasonable accuracy’
  - Higher Sensitivity….more False Positives….more antibiotic use
  - Higher Specificity….more False Negatives….untreated IMI’s with Major pathogens
  - Will vary among herds/regions with underlying prevalence of IMI

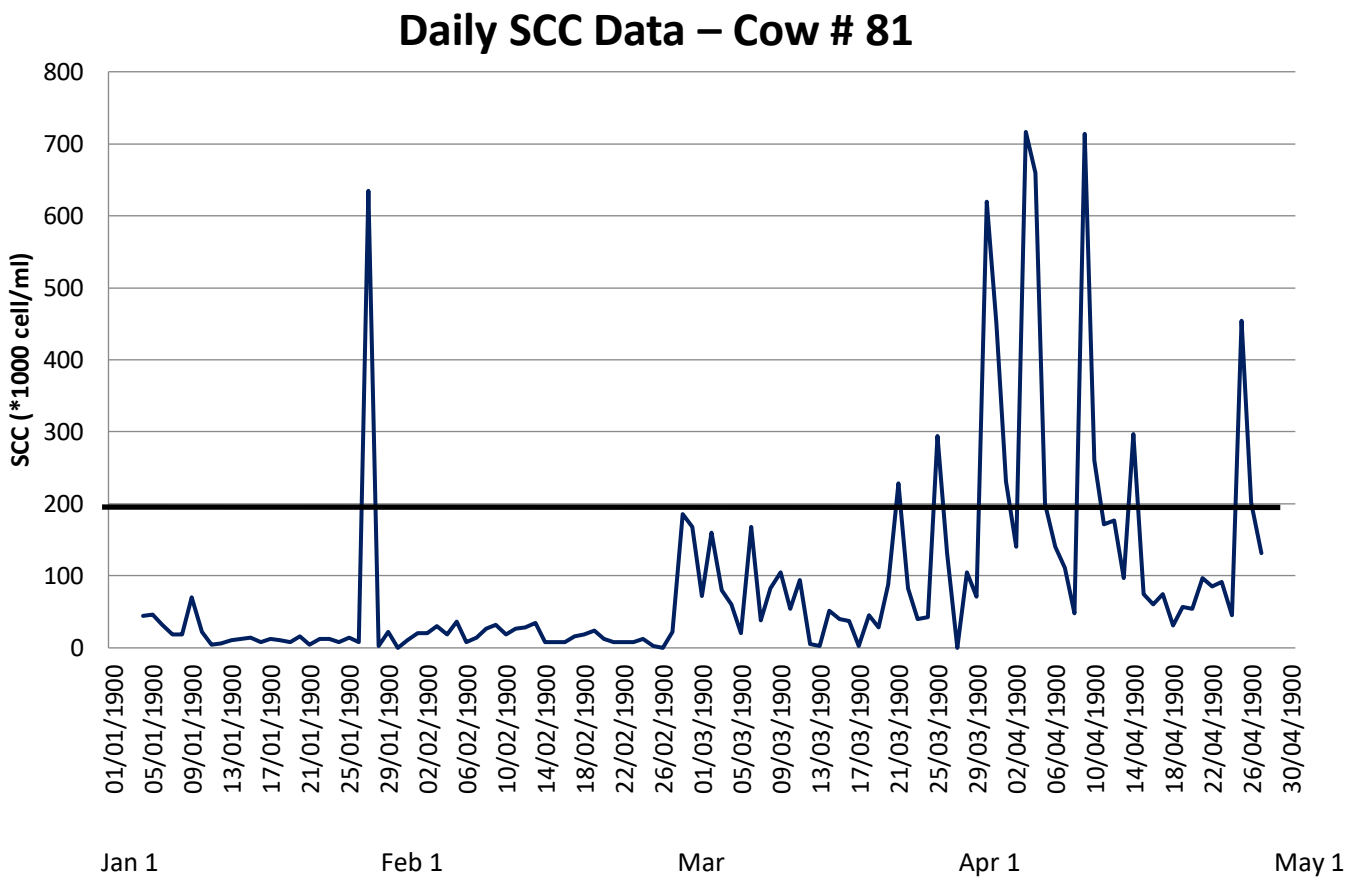
Desired Test (sensor/algorithm) performance

- THEREFORE – sensor performance is herd specific and influenced at least in part by the underlying prevalence of IMI in the herd

- It is not clear what it possible….but we would like to see a system with
  - Sensitivity at least 95%
  - Specificity at least 95%

- Are there advantages to having more data points (more days/milkings) to improve our decision making?

The challenge with more frequent SCC/LDH/EC



Indicators of **Inflammation** – not necessarily **Infection**

We can use data generated over a longer time period

How many days? How many sensors? In what format?

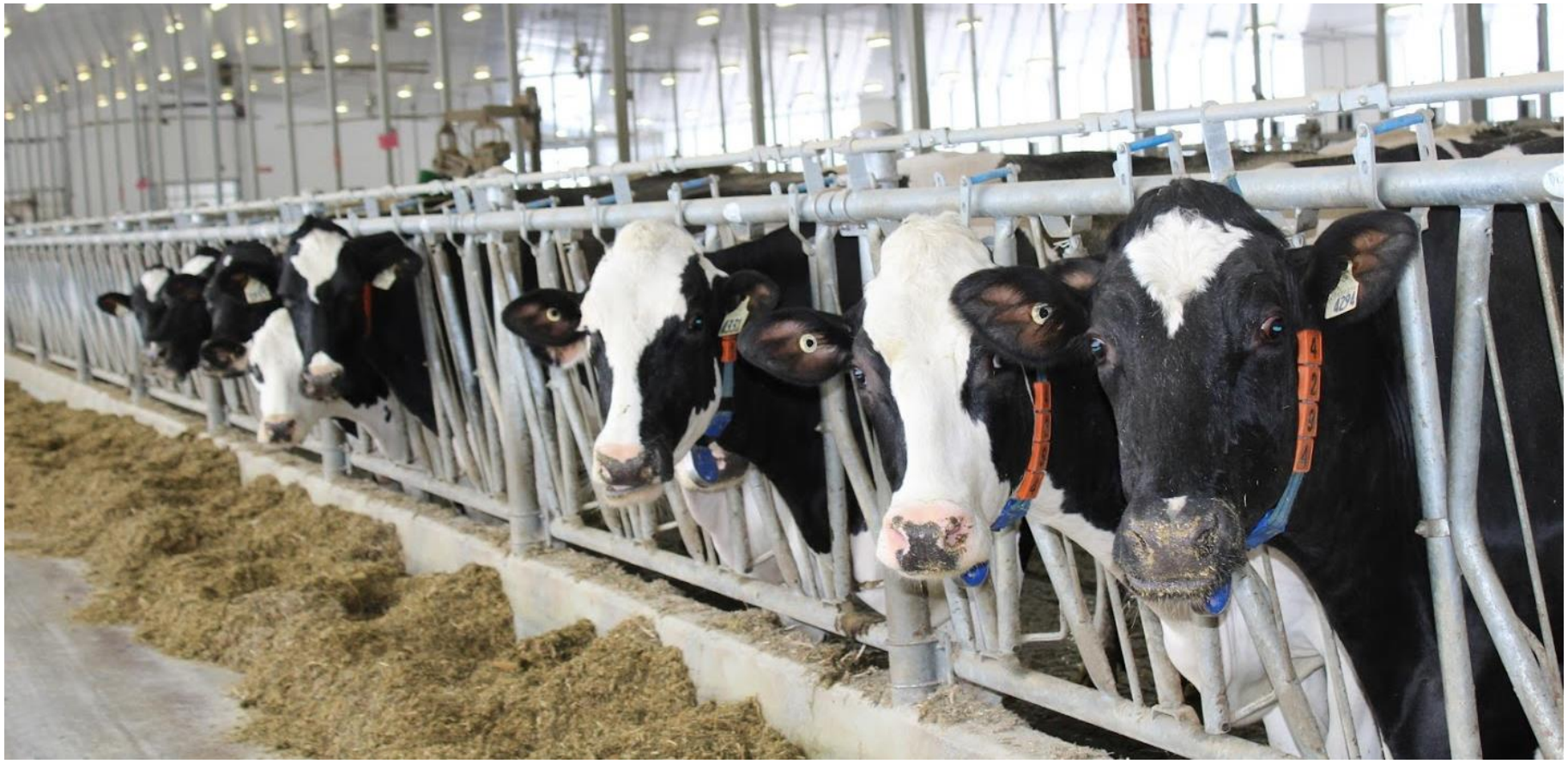
Conclusion – sensors and dry off:

- In our experience farmers could use sensor data to decrease production prior to dry off – but DON’T

- We have sensors that could inform Treat/Don’t Treat decisions, but we have not developed or validated the algorithms

- Overall we do a poor job in evaluating the **outcomes** of our treatments, and sensors could provide valuable information here as well

Thank You!



UNIVERSITY of GUELPH

DAIRY at GUELPH
CANADA'S DAIRY UNIVERSITY

How can the management of clinical and subclinical mastitis be supported by sensor systems?

Detection of herd level mastitis problems

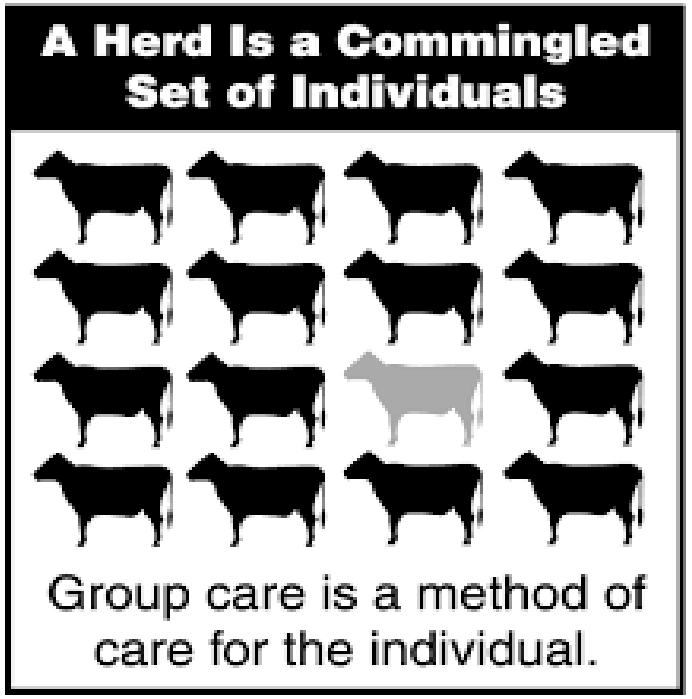
DISARM webinar IDF14th October 2020

Hen Honig, DVM, Dip. ECAWEL

Sensor system on the herd level

The sensor systems can give a day-to-day overview of the **herd-level mastitis situation.**

This feature can be used to continuously monitor udder health



Keep in mind!

Contagious pathogens and **multifactorial** nature of mastitis, **herd's mastitis situation may change fast**, leading to:

- **Severe production losses**.
- **Increase use of antimicrobials.**
- **Reduced animal welfare**.

Early detection of a change in herd-level mastitis situation

An adequate response

Quick adjustment of the management

Prevention of mastitis cost.

Key Performance Indicators (KPIs) - support the process of herd-level monitoring

- KPIs are used to detect any deviances from the farm's expected or planned level of udder health.

KPI's current - herd's mastitis monitor

- Incidence of clinical mastitis.
- Bulk milk SCC.
- Average cow milk SCC and cows with a new high SCC

Disadvantage:

- Interpretation of these KPIs are based upon statistics

Demands from sensor system in KPI

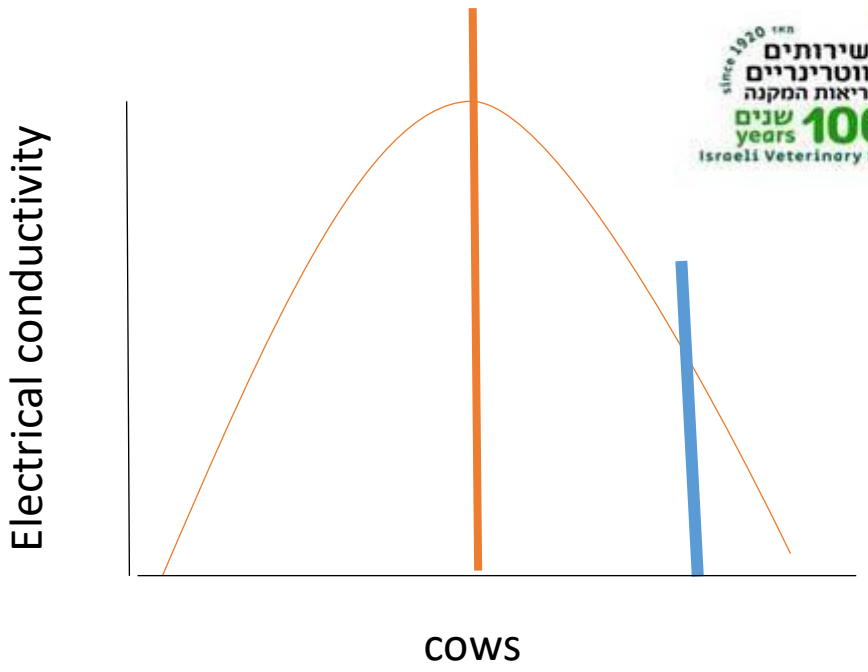
Aimed:

- **Finding the individuals' mastitis**

- **Different aspects** of the herd's mastitis situation.
- **Most critical** is the **herd's overall situation**

Example of KPI:

E.g. Milk electrical conductivity



1. Farm's average
2. Distribution within farm
3. Percentage above predefined threshold
4. Indirect Indicator for herd health

- Potentially, **individual's cow mastitis** alert could be based on a **multi-sensor system**
- Research and development of **herd's level mastitis** evaluation system **is in demand**.

Specificity Vs Sensitivity

- Sensitivity measures the proportion of positives that are correctly identified
- Specificity - measures the proportion of negatives that are correctly identified

Herd level mastitis problems should be identified as quickly as possible

Specificity

- **High specificity**
- at the herd's level
- avoid time consuming false positive alerts

Sensitivity

- **High sensitivity**
- Crucial for **early detection** and prevention of mastitis

The goal of preventive mastitis management - **prevent new infections**

Economic perspective:

Expenses weighed against the **reduction in productivity**

Animal welfare:

Important benefits of good udder health

Difficulty in defining Standard Operating Procedures (SOP) on the herd level

- Preventive plans for the **general dairy** farms.

Vs

- Preventive plans - **adjusted to the specific farm**:
  - Multifactorial nature of mastitis
  - Large differences between farms on management aspects (barn, field, feeding, management capacity of the farmer).
  - Conventional/automatic milking systems

Recording system

- **Proper and consistent recording system** are the most **important** requirement for evidence based actions aimed at reducing the risk of clinical (CM) or sub-clinical Mastitis (SCM).
- Recording system should **report** a “warning” for any suspected cow (showing KPI deviation).

Future directions

- Advance decision processes
- The prudent mastitis treatment requires that definition of health status of the cows based on sensor data, combined with other frame data, will be accurate and acceptable also by the Health Authorities

Thank you! Question ?

Conclusions

- Sensor systems in clinical mastitis detection are performing satisfactory
- No improvement of udder health
- Developing sensor systems for different mastitis situations provide potential
    - Address specific management issues
    - Are optimized in performance (sens. & spec.)
    - Will lead to improved udder health
    - Better use of antibiotics
    - Reduced losses mastitis
- But work should be carried out into these types of algorithms

SEE OUR VIDEO ON YOUTUBE

Type your questions in the chat box

www.fil-idf.org

@FIL_IDF

Disseminating Innovative Solutions for Antibiotic Resistance Management

www.disarmproject.eu

@ProjectDisarm