Epidemiological Tools for Herd Diagnosis

Carsten Enevoldsen, DVM, PhD, Dip. ECBHM
Professor of Cattle Health
The Royal Veterinary and Agricultural University
Denmark

ce@kvl.dk
The Cattle Vet has to Deal with Numbers

- AI-vets back in the 1950’ies realized it
- Monitoring programs were developed by e.g. Morrow and Møller back in the 60’ies
- Presenters at this meeting stressed it – e.g. Seegers, Opsomer and Da Silva
- Nothing new - everybody agrees that it is mandatory – in principle!
Training in Statistics, Epidemiology and Preventive Vet Med in DK

• Biostatistics, computer programming and epidemiology (within preventive veterinary medicine) were taught to vet students already back in 1974!

• Offered in numerous courses nationally and internationally
Do Cattle Vets then deal (properly) with Numbers?

- Lots of numbers (data) are available from the dairy herds
- Lots of key (?) indicators of performance from a wide range of software
- In the latest decade, computers have become available in almost every practice and in most large herds
- Hand held computers are becoming available

However, I will claim that very few cattle vets use the vast amount of numbers properly - even after quite intensive courses
Why so relatively few Cattle Vets deal (properly) with Numbers?

• It is truly difficult to handle the complex structure of data from a dynamic herd – animals entering and being culled all the time
• Data collection and handling is still not efficient – there are lots of technical constraints – the cattle market for software is not sufficiently attractive to developers
• Too few developers of software know the needs/problems related to herd diagnosis in detail
• There are numerous herd problems that in fact can be solved by means of common sense
• The “Clinical Eye Syndrome”!?
The “Clinical Eye Syndrome”!

• An “excuse” for not doing a proper examination?

• But, we do need to look for “patterns” that are difficult to define in few words

• We need to develop our skills to identify these patterns and communicate our findings
The “Clinical Eye” in epidemiology!

At present the use of 'pattern diagnosis' of the causes of suboptimal performance lies more in the realms of art than science, and moreover, relatively few of those who practice the art have published their findings. There is a need for skilled exponents to publish their views, and for research workers to work on converting the art into sound science

(Roger S. Morris, 1982)
Epidemiological Examination of a Herd vs Clinical Examination of an Individual

• Systems theory vs physiology/immunology/…
• Quantitative (population) vs qualitative (individual)
• Longer time horizons vs very short (days)
  – One ”herd-year” (a calving interval) is like one ”cow-day”?
• Healthy+sick individuals vs sick only
• Analysis (taking into account variability) vs norms

NOTE: There often seems to be a lack of understanding between “population medicine” and (traditional) clinical “individual medicine”. Maybe more between the herd context and the hospital context

ce@kvl.dk
A more formal Definition of Epidemiology

• the occurrence and spread (distribution) of health disorders,
• the determinants (risk-factors),
• the (biological) consequences of health disorders

in populations
Isn’t Epidemiology merely Statistics?

• Epidemiological analyses require a solid insight into the "biology" of the population of interest.

• Biological and patho-biological responses of individuals and management processes are factors that determine population structure and dynamics. For example, culling due to disease.

• However, basic knowledge about statistical analysis is necessary to perform proper epidemiological analyses.
Towards the Herd Diagnosis

Epidemiology serves two major purposes in herd (health) management:

• Monitoring (use of key indicators/trends)
• Risk factor analysis (identify high risk animals)
Monitoring Performance of the Herd (Screening)

- We need to select key indicators of health, welfare, fertility, production efficiency etc.
- Plot these key indicators vs calendar time to detect emerging trends
- Compare values of the indicators to “reference values” or “targets”
  - Compare to results obtained in other comparable herds (often called bench-marking)
  - Compare to historical results in the same herd (during a period).
  - Compare to expected results from a previous active planning process – this is often called control
# Sensitivity and Specificity - the theory

<table>
<thead>
<tr>
<th>Indicator gives alarm</th>
<th>Yes</th>
<th>No</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Pred. Value Pos. test</th>
<th>Pred. Value Neg. test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>a</td>
<td>b</td>
<td>a/(a+c)</td>
<td>XXXX</td>
<td>a/(a+b)</td>
<td>XXXX</td>
</tr>
<tr>
<td>No</td>
<td>c</td>
<td>d</td>
<td>XXXX</td>
<td>d/(b+d)</td>
<td>XXXX</td>
<td>d/(c+d)</td>
</tr>
</tbody>
</table>

- **Sensitivity** is the probability of a positive test result when the condition is present (a/(a+c)).
- **Specificity** is the probability of a negative test result when the condition is not present (d/(c+d)).
- **Predicted Value Pos. test** is the probability of the condition being present given a positive test result (a/(a+b)).
- **Predicted Value Neg. test** is the probability of the condition not being present given a negative test result (d/(c+d)).
Sensitivity and Specificity - the importance for monitoring

• We need historical data to plan the future
• But recent changes most interesting
• Uncertainty up if only most recent data is used (Var=f(N))
• More historical data will reduce the risk of getting false positive alarms
• False positives may be very important if it is costly to react to an alarm (AMS gives good demonstrations – Rasmussen today 14.00)
• Historical events may be caused by completely different factors

The continuous search for an optimal balance between sensitivity and specificity of the monitoring tools is a major issue in rational herd management!

ce@kvl.dk
Simple Moving Averages - the problem

En klinisk CMT score på 43 omsegnen til en samtale CMT-ko værdi på 12. En score på 12 vil til værdien 5-6 for den komplette cellset og 9-10 for de reelle kilder. Gør her den samlede værdien 4 eller 6, er angivet med røde stikker.

ce@kvl.dk
Simple Moving Average - The Problem

Old data out => improve!

A proper solution - Bayesian forecast (1994)
Why Disease Treatment Records are Problematic for Monitoring

• Often “targets” for incidence risks/rates of disease treatments are suggested/used

• Vaarst et al., J. Dairy Sci. 2002, describes in detail how differently farmers handle mastitis

• Consequently it does not make sense to rank herds’ udder health based on treatment data
Risk Factor Analysis

• First, we need a theory, a hypothesis
• We want to know how a response (Y) of interest (e.g. milk production, SCC or ketosis) is influenced by one or more (risk) factors (X; e.g. dry period length) that differ from cow to cow in the population
• We get estimates of the magnitude of the relations. For example:
  – Average milk loss associated with SCC
  – Relative risk of ketosis associated with metritis
• We get estimates of the uncertainty associated with the relations (usually some P-value or confidence intervals).
Risk Factor Analysis
- quantitative data - regression
# Risk Factor Analysis - binary data

<table>
<thead>
<tr>
<th>Risk factor (X) present</th>
<th>Disease (Y) present</th>
<th>Risk</th>
<th>Odds</th>
<th>Relative Risk</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>R1=\frac{a}{a+b}</td>
<td>O1=\frac{R1}{1-R1}</td>
<td>R1/R2</td>
<td>O1/O2</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>R2=\frac{c}{c+d}</td>
<td>O2=\frac{R2}{1-R2}</td>
<td>XXXX</td>
<td>XXXX</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>a</td>
<td>b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>c</td>
<td>d</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Series of W’s

• Which events occurred (e.g. diagnoses)
• Which groups of cows in the herd (e.g. parity)?
• What time of year?
• When did the events occur as related to lactation stage?
• What happened previously to the cows?
Criteria to assess the Quality and Utility of Epidemiological Tools

• Correctness of the input data
  – Underestimated importance (deliberately?)
  – Use of the information for management is the solution

• Validity

• Precision

• Transparency
  – Access to individual animal information important – especially in small populations – look for ”outliers”!

ce@kvl.dk
Validity and Precision of Measurements and ”Statements”

Valid+ Precise+

Valid- Precise+

Valid+ Precise-

Valid- Precise-
Agreement with yourself
- precision: \( \kappa = 0.57 \)

<table>
<thead>
<tr>
<th>BCS – first day</th>
<th>2.25</th>
<th>2.5</th>
<th>2.75</th>
<th>3</th>
<th>3.25</th>
<th>3.5</th>
<th>3.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCS day 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>day 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>same cows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.25</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.75</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.25</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.75</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mono-Factorial (Risk Factor) Analyses are usually Insufficient

- the example of milk fever and Jersey cows

• Many textbooks (still) claim that Jersey cows are more susceptible to Milk Fever (MF)
• If breeds are compared within parity there are no/minimal differences in risk of MF
• Similar errors can easily occur if factors are examined one-by-one

Usually we need multi-factorial analyses!
Multi-Factorial Analyses will be a routinely applied Tool for Herd Management

• First implemented on a larger scale in practice by the cooperative veterinary service (the Hachaklait) in Israel (Nir-Markusfeld, 1993).
• Used routinely in a growing number of Danish herds (www.dhd-vpa.dk)
• Substantial research and development efforts are needed to address current and future needs (e.g. OS-39-1)
• Practice-based research, development and learning contexts are being developed (e.g. KoNet Praksis)
Veterinary Production Analysis (VPA) for Monitoring and Multifactorial Risk Factor Analysis

• The main aspects of the Hachaklait system (Markusfeld, 1993) has been implemented in a system adapted to the generally smaller herd sizes in Denmark (www.dhd-vpa.dk).

• VPA contains both monitoring of numerous performance indicators and analyses of several risk factors based on linear and logistic multivariable models.

• Problems related to the smaller herd size (currently about a 100 cows on average) have been handled as described by Enevoldsen (1997).
HerdView – a Tool to handle Dynamics and Complex Patterns
The VPR System – A Web-Platform for Practicing Cattle Veterinarians

• A steadily increasing number of dairy veterinarians in DK are recording clinical findings in well defined groups of high risk cows in their dairy herds (OS23-4 - Krogh)
  – Precise definition of the population at risk is a major achievement!
• These recordings make it possible to detect disease in the individual cow earlier and intervene effectively.
• Registrations have to be merged with information about calvings, milk production etc. that are stored in the central cattle database
• VPR is an Internet portal that helps the practicing dairy veterinarians to solve these problems - [http://vpr.kvl.dk](http://vpr.kvl.dk)

ce@kvl.dk
VPR Lactation Curve Analysis
(a random coefficient regression model)
- Red line is the average lactation curve
- Horizontal lines show trend in ECM at 10, 60 and 305 DIM
- Thin lines individual cows (shows variability)
- The goal is parallel lines
Sensitive Monitoring (BCS)

The goal: Parallel lines, constant level, minimum number of drops, exams as planned
Web-Platforms the Future for Herd Management Programs(?)

• A web system allows easy implementation and updating of advanced statistical models (for example developed by PhD-students) because all changes in software and hardware are made centrally at the server

• End-users do not have to know much about the technical issues

• Band-width of internet connections will increase constantly
The Herd Diagnosis
- a summary

A synthesis of

- Results of monitoring
- Results of risk factor analyses
- General and specific knowledge about biological, technical and managerial aspects related to the entire system (including the farmer of course), issues related to data quality, and common sense.
The Herd Prognosis - The Ultimate Goal!

• Projecting the past to the future after adjustment for expected effects of the suggested/planned interventions

• Use a best guess, a simple or an advanced simulation model like SIMHERD
  http://www.agrsci.dk/content/download/23842/268779/file/SimHerd3.pdf
  – Provides targets
  – Estimates of the expected profitability of the farmer’s (and the vet’s) plans
Improvement of Herd Diagnoses
- The most Urgent Tasks for the Vet

• Learn to follow protocols (Hill, 2005)!
  – Assess and improve data quality (e.g. kappa)

• Organization of data collection/flow

• More critical attitude to various indicators
  – Documentation/evidence versus belief/perception
The Quality of The Vets’ Systematic Clinical Recordings?
- Documentation is Needed!

J. Dairy Sci. 89:JDS 5567

Within- and Across-Person Uniformity of Body Condition Scoring in Danish Holstein Cattle


*KoNet-Praksis Aps, Solsortevej 36, DK-8640 Ans By, Denmark
†Department of Large Animal Sciences, The Royal Veterinary and Agricultural University, Grønnegaardsvej 2, DK-1870 Frederiksberg C, Copenhagen, Denmark

ce@kvl.dk
The Future of Epidemiological Tools for Herd Diagnosis?

• More practice-based processes needed – “top-down” has not been very successful
• Epidemiological models/tools help to bridge practice, work-based learning and research - they promote dialogue.
  – In a herd health type situation, field research should be virtually indistinguishable from practice (Schwabe, Rieman & Franti, 1977)
  – Health promotion: The combination of educational, organizational, economic and environmental support for action conducive to health (after Meek, 1991)
  – Change does not necessarily assure progress, but progress implacably requires change (Henry S. Commager)