Early detection of metabolic disorders in dairy cows by using sensor data

25 August 2014, EAAP, Copenhagen, Denmark

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SmartDairyFarming

This presentation

- Backgrounds
  - Smart Dairy Farming project
  - Transition period / metabolic disorders
- Material and methods
  - Literature study
  - Data collection
  - Model formulation
- Results and discussion
- Conclusions

Smart Dairy Farming project

- Mission:
  To help dairy farmers with information and technology to improve health and longevity of the cows
- Goal:
  - longevity: +2 lactations
  - production: +20,000 kg milk
- Development and testing at eight practical dairy farms

www.smartdairyfarming.nl (only in Dutch)

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Smart Dairy Farming: organisation

- Research topics:
  - Animal health
  - Fertility
  - **Feeding**
- Work packages:
  - Chain transparency
  - **Model development**
  - Sensors
  - Learning networks

Smart Dairy Farming: partners

Ministerie van Economische Zaken, Landbouw en Innovatie

Productschap Zuivel

SNN VOOR DE NOORDELIJKE ECONOMIE

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Transition period / metabolic disorders

- start of dry-off period - 60th day in lactation
- energy intake lower than energy requirement: negative energy balance
- increased risk for disorders:
  - milk fever
  - ketosis
  - left displaced abomasum
- monitoring necessity: detection model for early warning based on sensor measurements

Material & methods: literature study

	milk fever	ketosis	left displaced abomasum
milk yield	?	++	++
feed intake	++	++	++
rumination	++	+	?
body weight	-	++	++
activity	+	+	-

++ good indicator

+ indicator

? varying results found

- not useful as indicator

Material & methods: data collection

- commercial farm: 300 cows, 4 milking robots (AMS)
- sensor data: 15 months
- reference data: 26 metabolic disorders (mostly milk fever)

variable	measurement method
milk yield	AMS
milk fat & protein	AMS
milking visits	AMS
concentrates intake	AMS/concentrates feeder
concentrates leftover	AMS/concentrates feeder
feedings	AMS/concentrates feeder
feeding visits	AMS/concentrates feeder
activity	collar sensor
rumination activity	collar sensor
body weigth	AMS/concentrates feeder

Material & methods: model formulation

- level alert:
  - daily value differs from expected value (based on moving average + standard deviation)
  - one day / two successive days
  - ketosis alert based on fat & protein percentage
- trend alert:
  - decrease in milk yield in first four weeks of lactation
  - strong decrease in body weight in first 80 days
- index alert:
  - activity/rumination deviating on day of calving
  - body weight deviating at start/end of dry period

Material & methods: model formulation

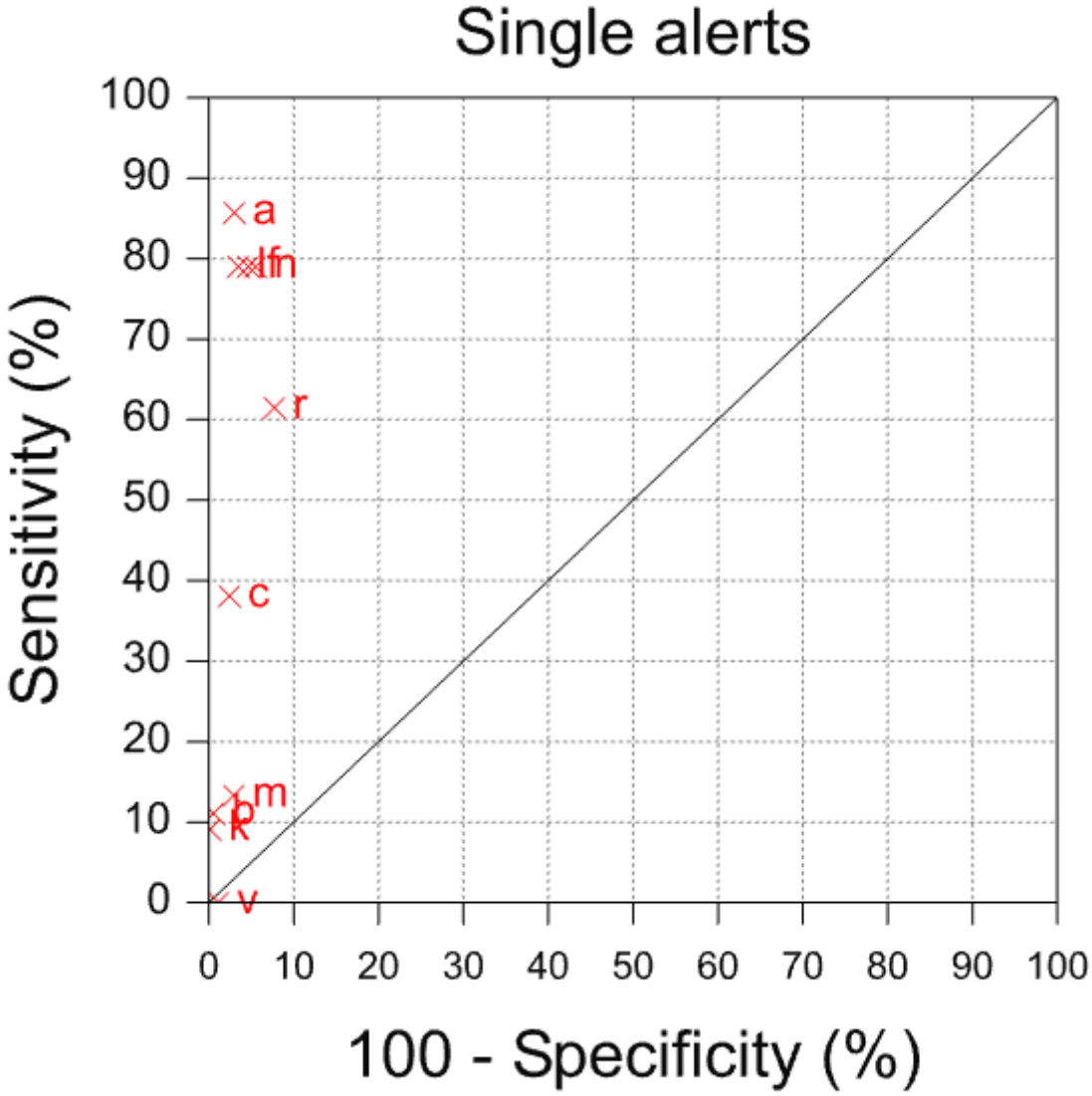
- SumAlert: number of alerts per day per cow
- SmartSumAlert: number of selected alerts per day per cow

	disease	no disease
alert	True Positive (TP)	False Positive (FP)
no alert	False Negative (FN)	True Negative (TN)

- sensitivity = percentage of detected cases
  TP/(TP + FN)
- specificity = percentage of healthy cows without alert
  TN/(TN + FP)

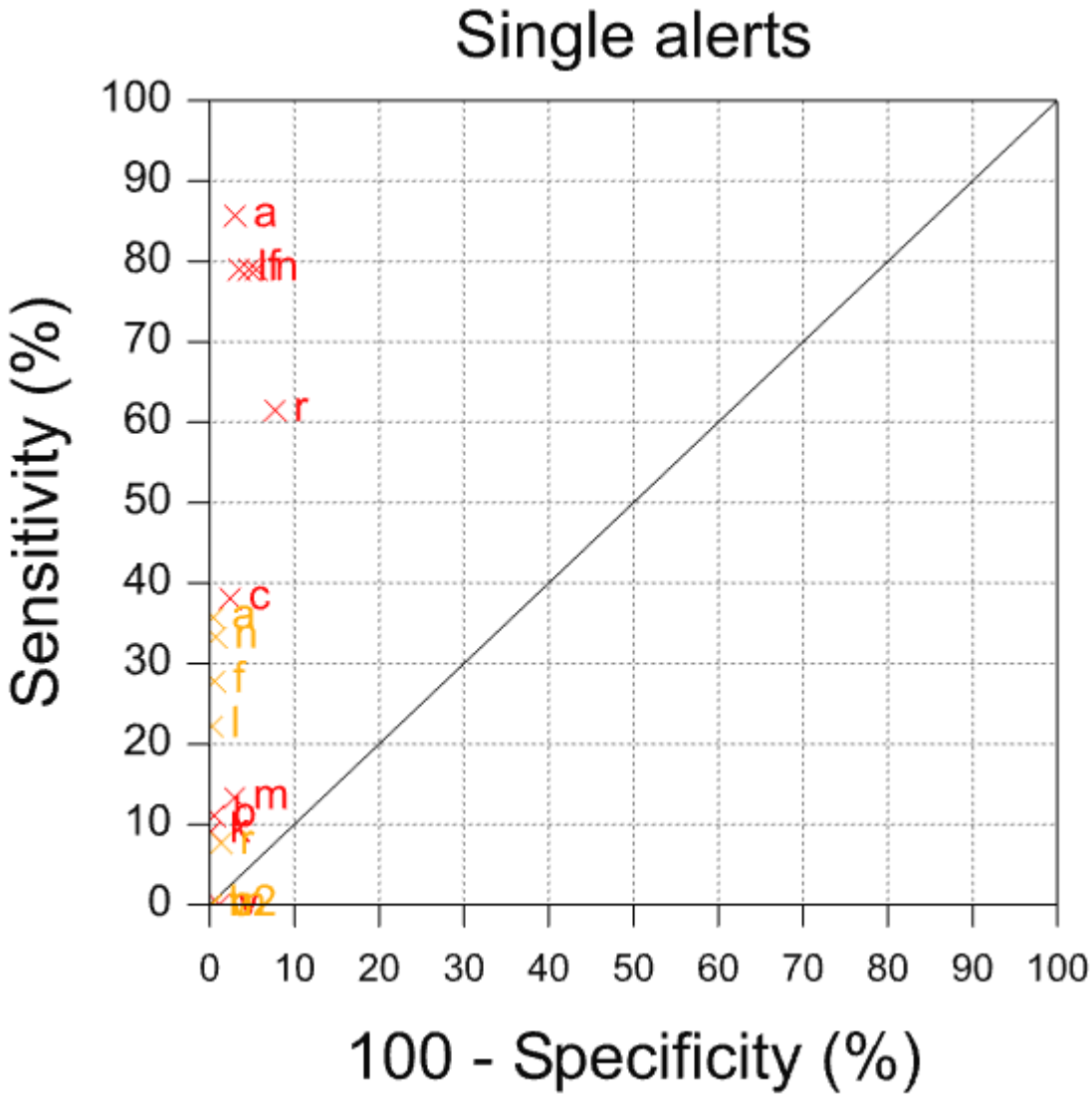
Results: one day level alerts

- ROC curve, e.g.:
  for activity a:
  sensitivity 86%
  specificity 97%



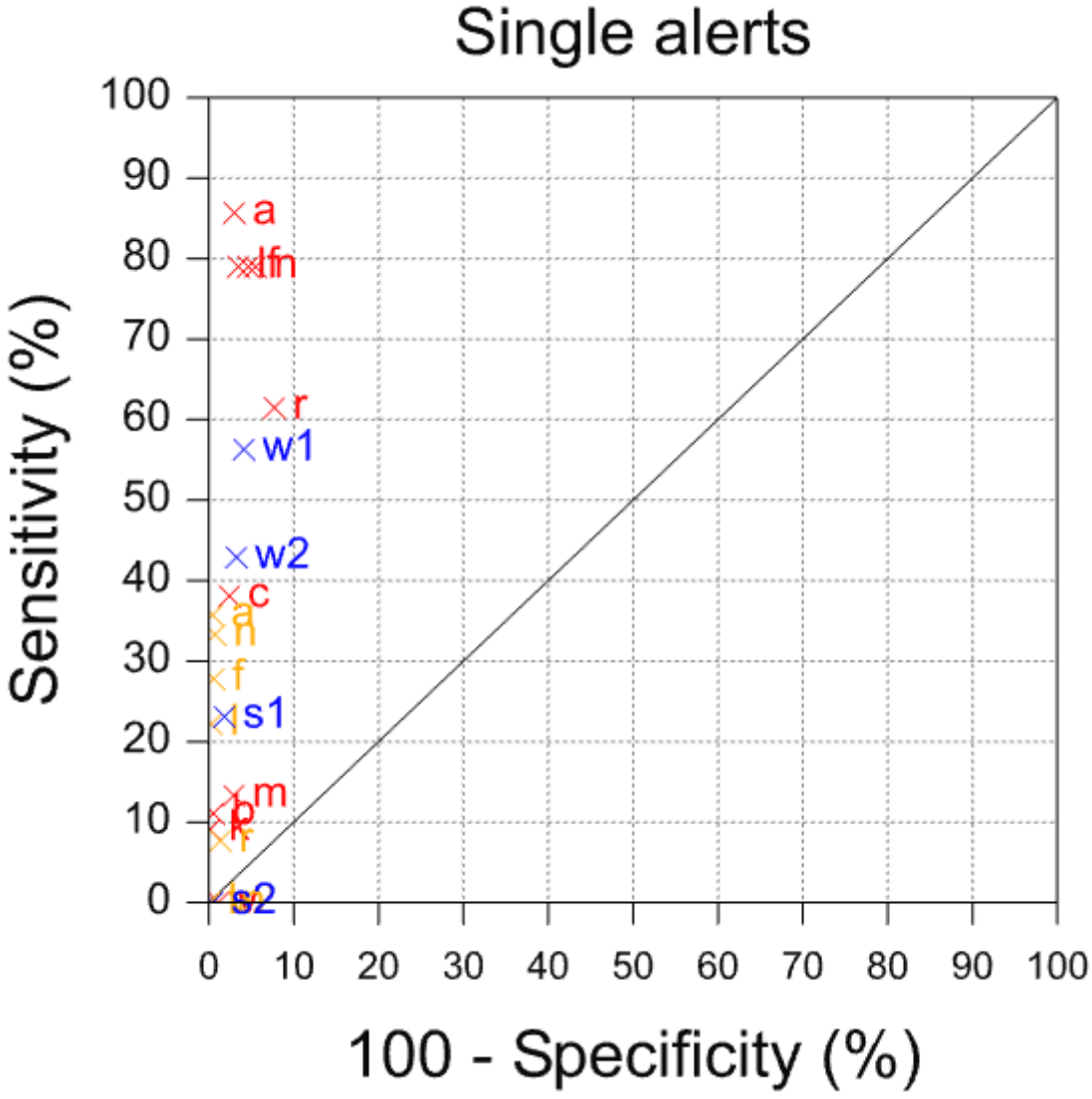
Results: ... + two days level alerts

- ROC curve, e.g.:
  for activity a:
  sensitivity 36%
  specificity 99.6%



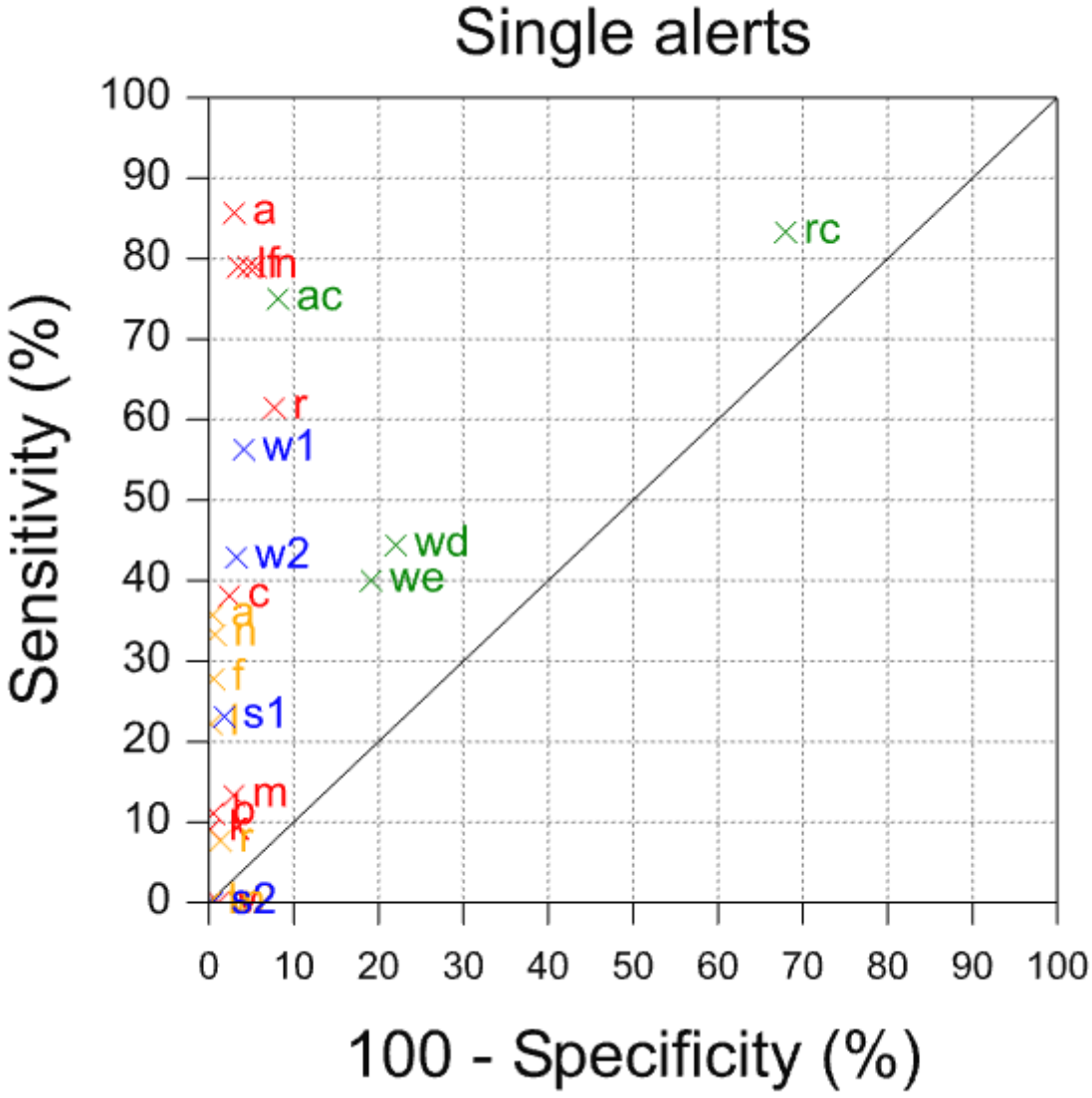
Results: ... + trend alerts

- ROC curve, e.g.:
  for weight
  one day w1:
  sensitivity 56%
  specificity 95.9%



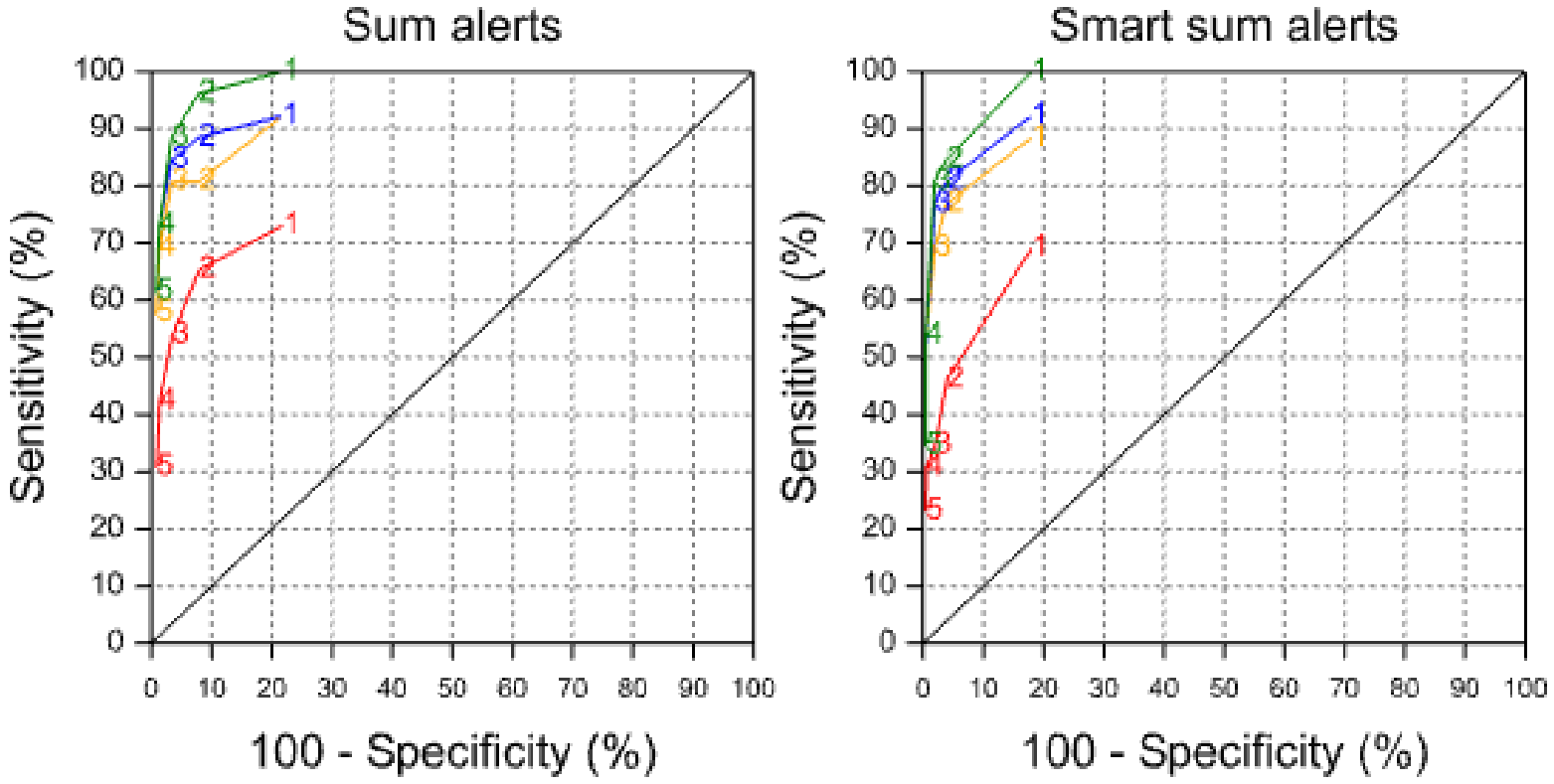
Results: ... + index alerts

- ROC curve, e.g.: for activity at calving day ac: sensitivity 75% specificity 92%



Results: sum alerts

- different sums: 1, 2, 3, 4, 5
- different periods: 0 days, 2 days, 4 days and 10 days



Discussion

- Difference in performance of variables
- Double alert not applicable
- Milk yield difficult for milk fever
- Performance of variables differs sometimes from literature
- Combination of variables needed to increase specificity
- Higher sensitivity = lower specificity (and vice versa)

Conclusions

- Detection of metabolic disorders based on sensor data possible
- But high sensitivity difficult if specificity at least 99%
- Combination of (selected) variables worthwhile!
- Detection up to 4 days prior to diagnosis
- Real-time model started recently

Questions?

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