

# Aggregating dairy cattle welfare measures into a multicriterion welfare index

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ILVO

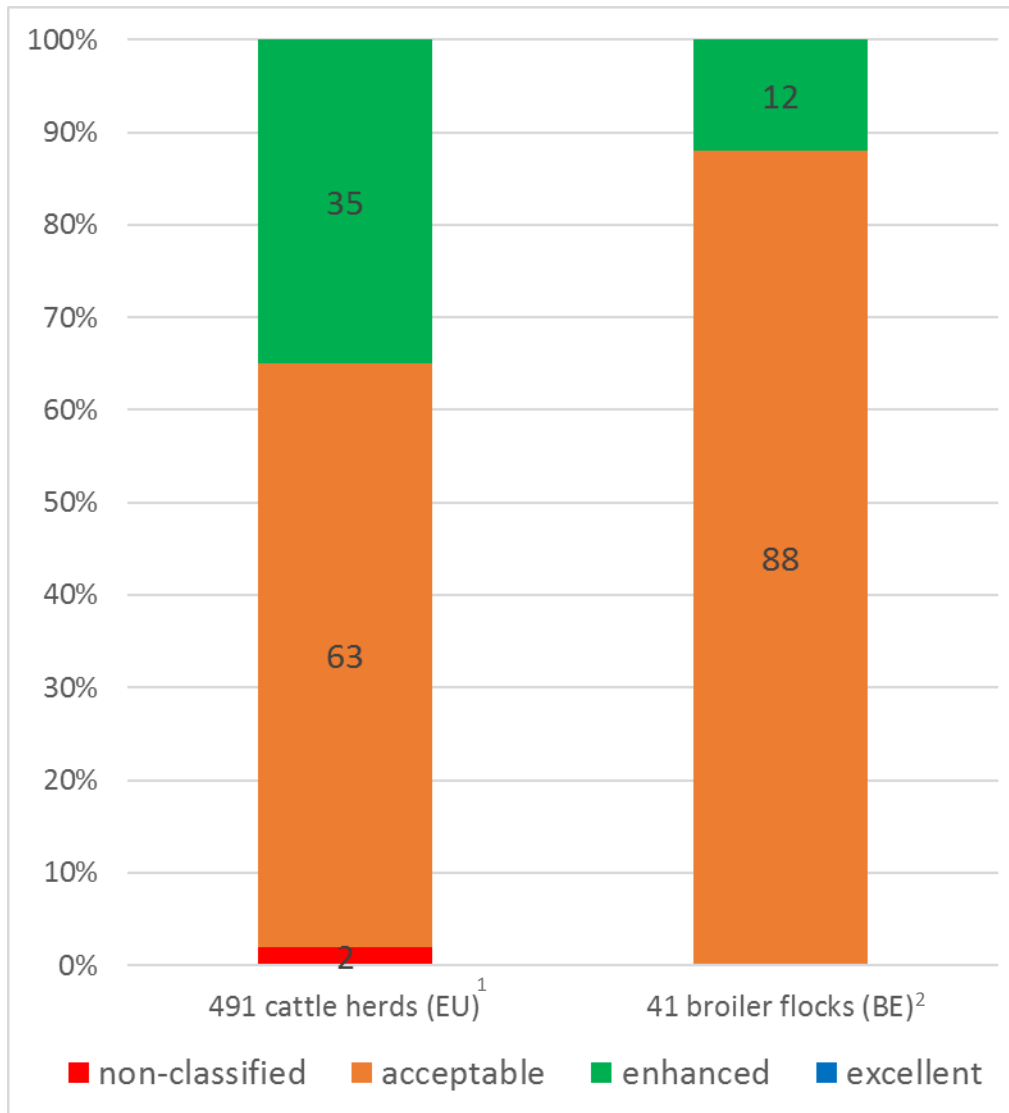
# An integrated multidimensional index for monitoring dairy cattle welfare on farm

(benchmarking, milk-label, feedback)

## Requirements:

- Animal-based
- Time & cost effective
- Key welfare issues
- Simple & intuitive integration
- Differentiating between EU-farms (attainable limits)
- Expert-based

# Why not using Welfare Quality®?



Time consuming (1d/farm)

Insufficient differentiation

Disputable categorisation

# What matters?

- Which are the key welfare impairments? → number of measures
- How severely does an animal suffer when affected by these impairments? → severity
- How many animals of the herd have these impairments? → prevalence
- How does this compare to other herds? → relative prevalence

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

$rP$  = herd prevalence / 97.5% highest prevalence of all herds in dataset

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

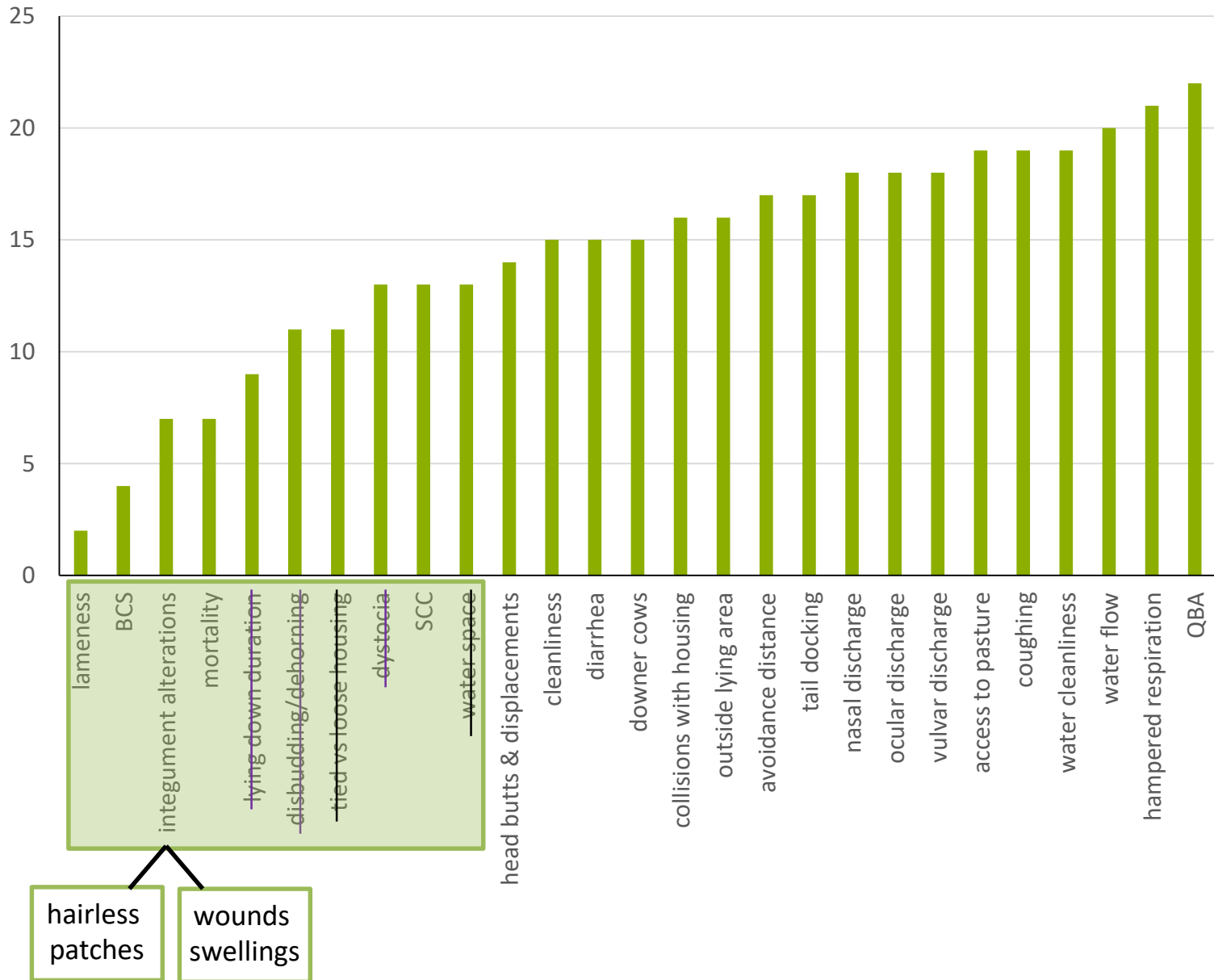
**Selected measures (m)**

- l<sub>1</sub>
- l<sub>2</sub>
- l<sub>3</sub>
- l<sub>4</sub>
- l<sub>5</sub>
- l<sub>6</sub>

- Animal-based (source: WQ)
- Unit = % (prevalence)
- Important for dairy cow welfare (experts)

17 trained users of WQ dairy cattle protocol

# Median importance rank of WQ<sup>®</sup> measures of cow welfare (n = 17 experts)



$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

**Selected  
measures (m)**

- Leanness
- Lameness
- Hairless patches
- Lesions/swellings
- Mortality
- SCC

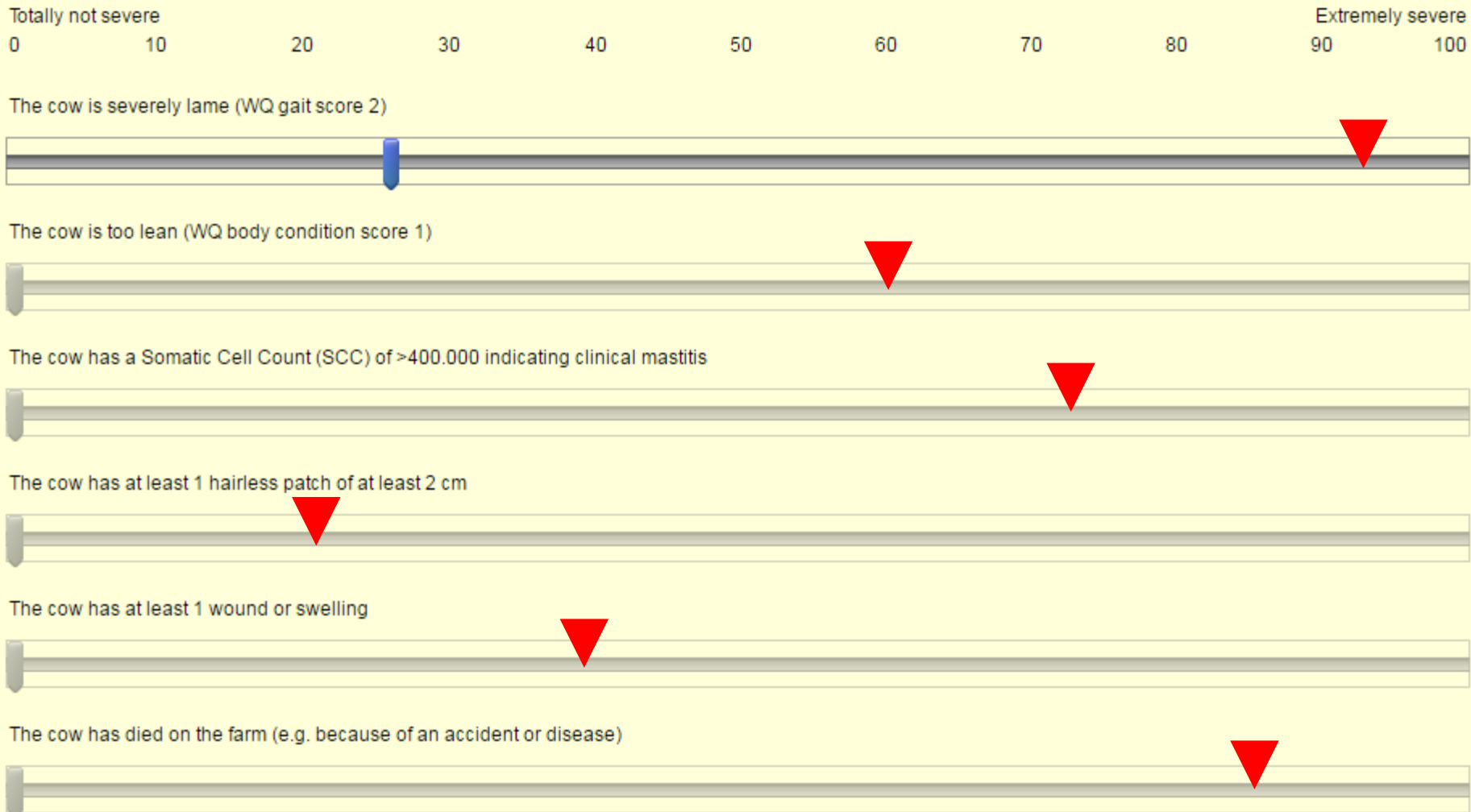
$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Selected measures (m)	Severity (S) (0-100)
Leanness	S <sub>1</sub>
Lameness	S <sub>2</sub>
Hairless patches	S <sub>3</sub>
Lesions/swellings	S <sub>4</sub>
Mortality	S <sub>5</sub>
SCC	S <sub>6</sub>

n = 14 experts



In your opinion, how severely is the welfare of an individual cow affected by the 6 welfare impairments listed below? (degree & duration of suffering)



$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Selected measures (m)	Severity (S) (0-100)
Leanness	60
Lameness	92
Hairless patches	21
Lesions/swellings	40
Mortality	85
SCC	72

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)
Leanness	60	P <sub>1</sub>	P <sub>1</sub> /97.5P <sub>1</sub>
Lameness	92	P <sub>2</sub>	P <sub>2</sub> /97.5P <sub>2</sub>
Hairless patches	21	P <sub>3</sub>	P <sub>3</sub> /97.5P <sub>3</sub>
Lesions/swellings	40	P <sub>4</sub>	P <sub>4</sub> /97.5P <sub>4</sub>
Mortality	85	P <sub>5</sub>	P <sub>5</sub> /97.5P <sub>5</sub>
SCC	72	P <sub>6</sub>	P <sub>6</sub> /97.5P <sub>6</sub>

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Ex.: Herd 51

Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)
Leanness	60	4.3	$P_1/97.5P_1$
Lameness	92	33.0	$P_2/97.5P_2$
Hairless patches	21	30.3	$P_3/97.5P_3$
Lesions/swellings	40	36.8	$P_4/97.5P_4$
Mortality	85	2.0	$P_5/97.5P_5$
SCC	72	11.0	$P_6/97.5P_6$

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

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Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)
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SCC	72	11.0	$P_6/97.5P_6$

↓  
EU-database  
N = 491 herds

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Ex.: Herd 51

Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)
Leanness	60	4.3	0.02
Lameness	92	33.0	0.90
Hairless patches	21	30.3	0.52
Lesions/swellings	40	36.8	0.40
Mortality	85	2.0	0.30
SCC	72	11.0	0.25

↓  
EU-database  
N = 491 herds

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Ex.: Herd 51

Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)	S x rP (0-100)
Leanness	60	4.3	0.02	$S_1 \cdot rP_1$
Lameness	92	33.0	0.90	$S_2 \cdot rP_2$
Hairless patches	21	30.3	0.52	$S_3 \cdot rP_3$
Lesions/swellings	40	36.8	0.40	$S_4 \cdot rP_4$
Mortality	85	2.0	0.30	$S_5 \cdot rP_5$
SCC	72	11.0	0.25	$S_6 \cdot rP_6$
				<hr/> <b>WI = mean</b>

$$Welfare\ Index\ (WI) = 100 - \frac{1}{nm} \times \sum_{m=1}^{nm} S_m \times rP_m$$

Ex.: Herd 51

Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)	S x rP (0-100)
Leanness	60	4.3	0.02	1.2
Lameness	92	33.0	0.90	82.8
Hairless patches	21	30.3	0.52	10.9
Lesions/swellings	40	36.8	0.40	16.0
Mortality	85	2.0	0.30	25.5
SCC	72	11.0	0.25	18.0

**25.7**

(lower = better)

**WI = 100 - 25.7**

**WI = 74.3**

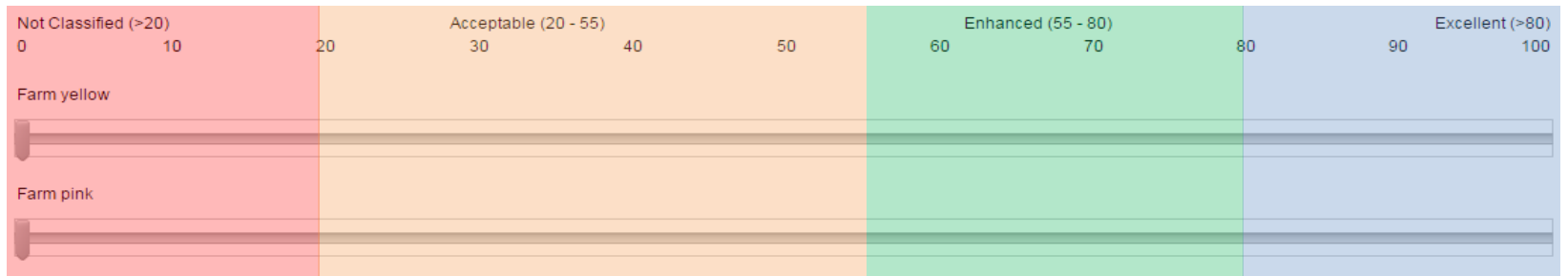
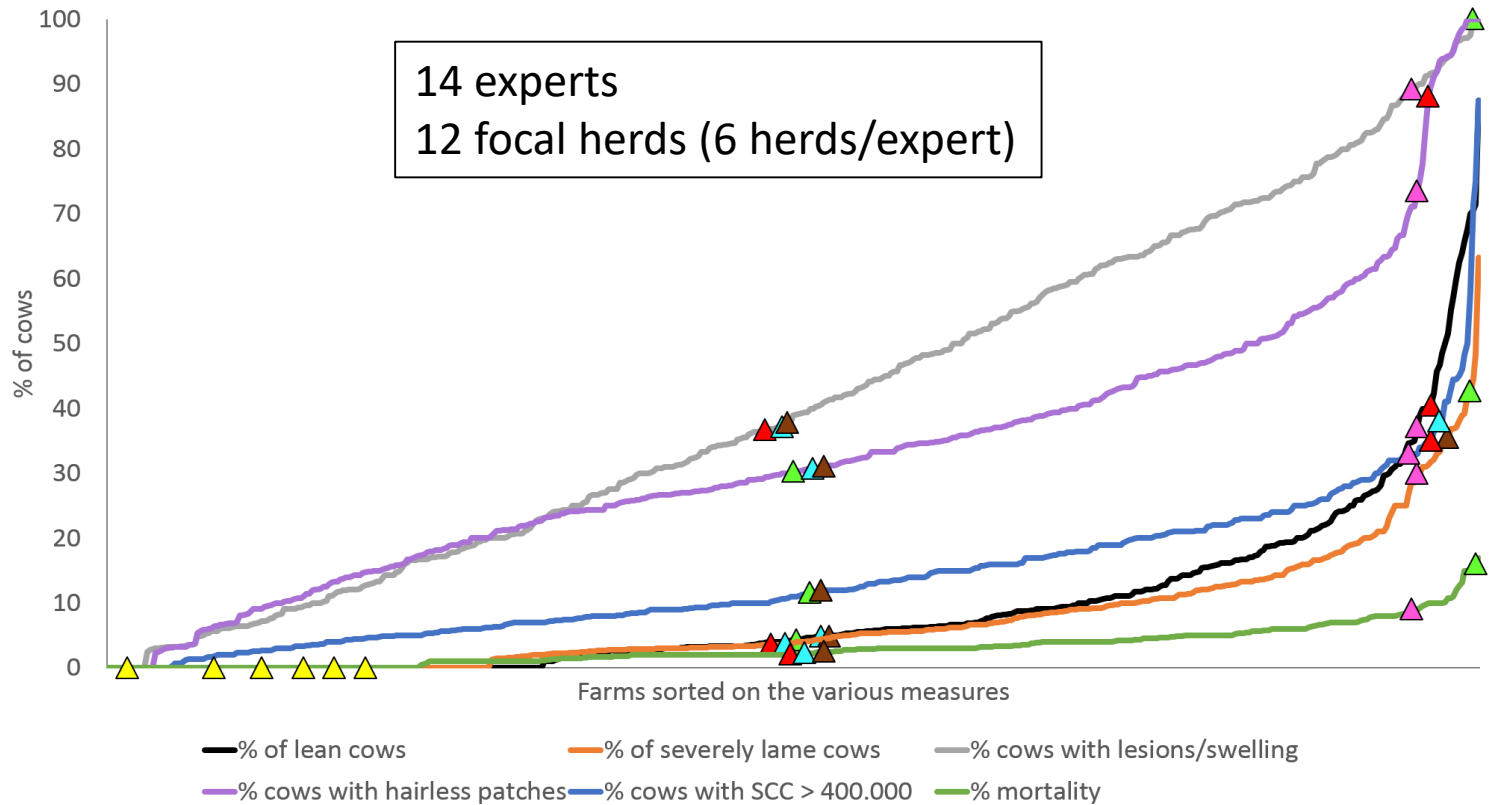
(higher = better)

Is this good/bad?  
(expert)

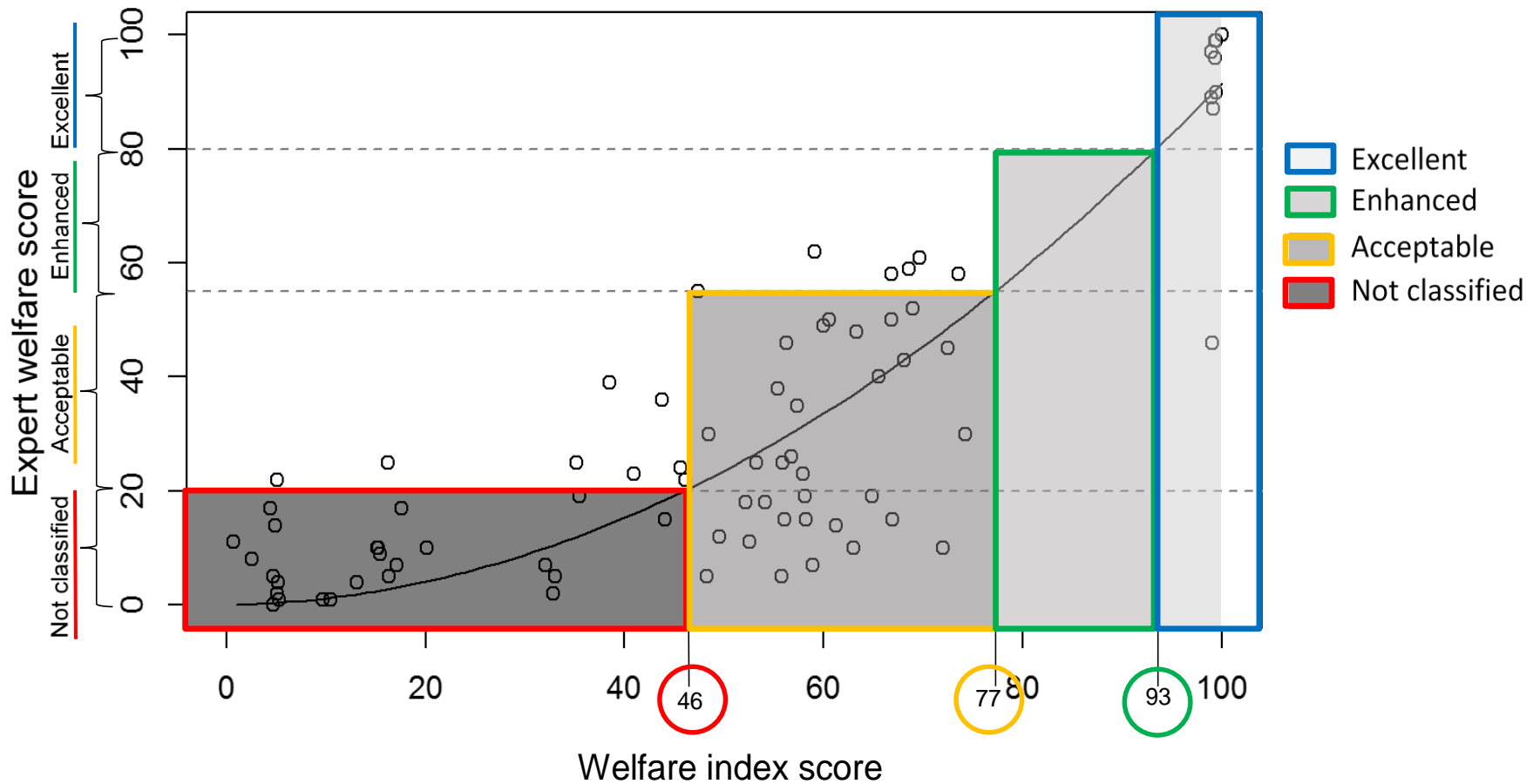


% of lean cows  
 % of severely lame cows  
 % cows with lesions/swelling  
 % cows with hairless patches  
 % cows with SCC > 400.000  
 % mortality

	Farm yellow	Farm pink	Farm red	Farm green	Farm blue	Farm brown
% of lean cows	0.0	37.1	40.5	4.0	4.3	4.3
% of severely lame cows	0.0	30.0	3.6	44.4	3.6	33.0
% cows with lesions/swelling	0.0	89.7	36.7	100.0	36.8	36.8
% cows with hairless patches	0.0	73.5	88.1	30.0	30.3	30.3
% cows with SCC > 400.000	0.0	33.0	34.8	10.7	38.0	11.0
% mortality	0.0	9.0	2.0	16.0	2.0	2.0

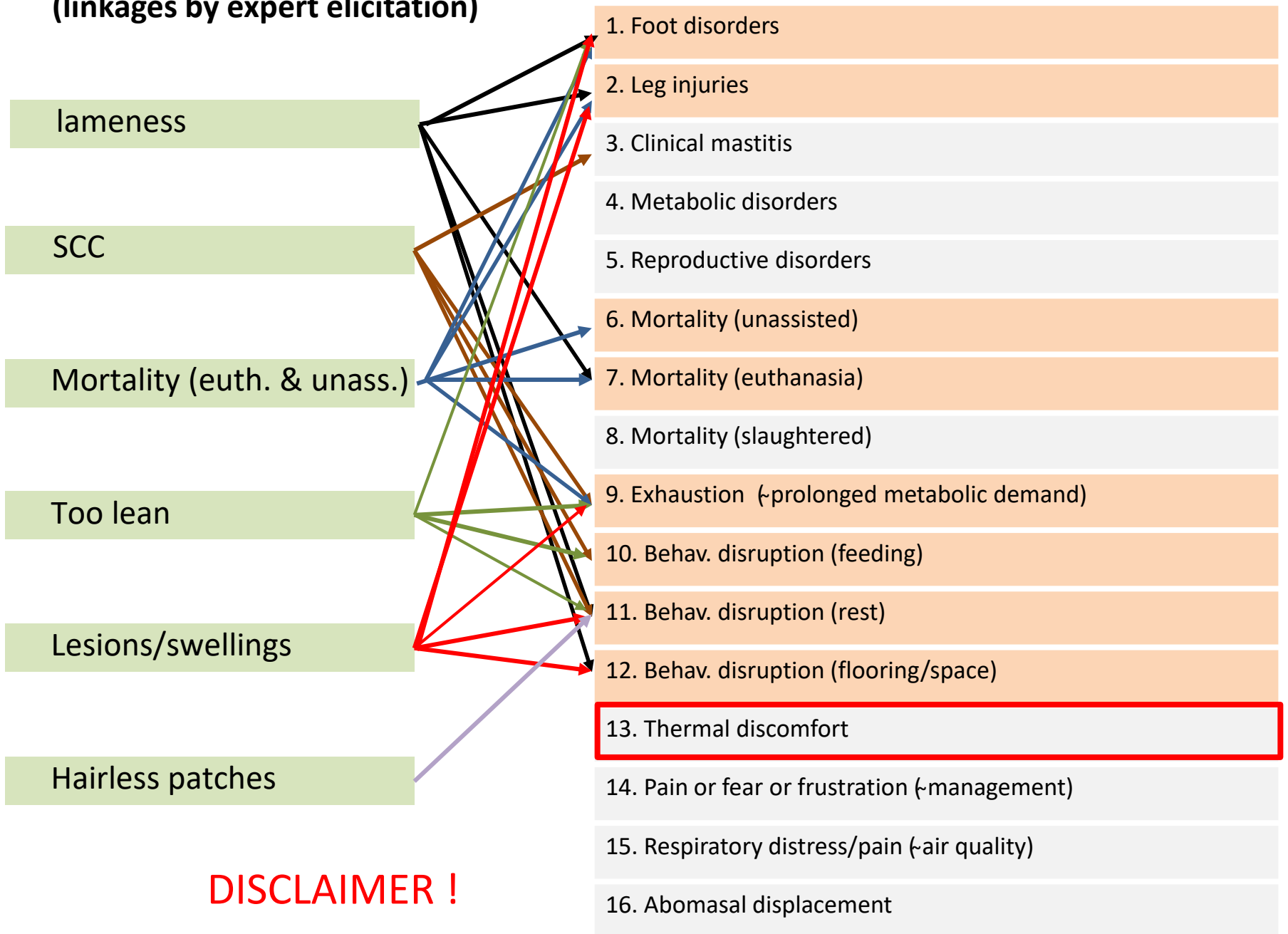


# Correspondence with experts ( $R^2 = 0.91$ ) & interpretation



**ABMs  
(linkages by expert elicitation)**

**(Worst) adverse effects (EFSA 2009, 2012a,b, 2014)**



**DISCLAIMER !**

# Conclusions

## Requirements:

- Animal-based 100%
- Time & cost effective 1-2h
- Key welfare issues EFSA's worst adverse effects  
Not exhaustive DISCLAIMER
- Simple & intuitive integration S x P
- Sensitive and differentiating (& motivating) Continuous Welfare Index
- Expert-based WQ-users: measures, S, WI  
( $R^2=0.91$ )



**Thanks for your  
attention!**

**Questions?**

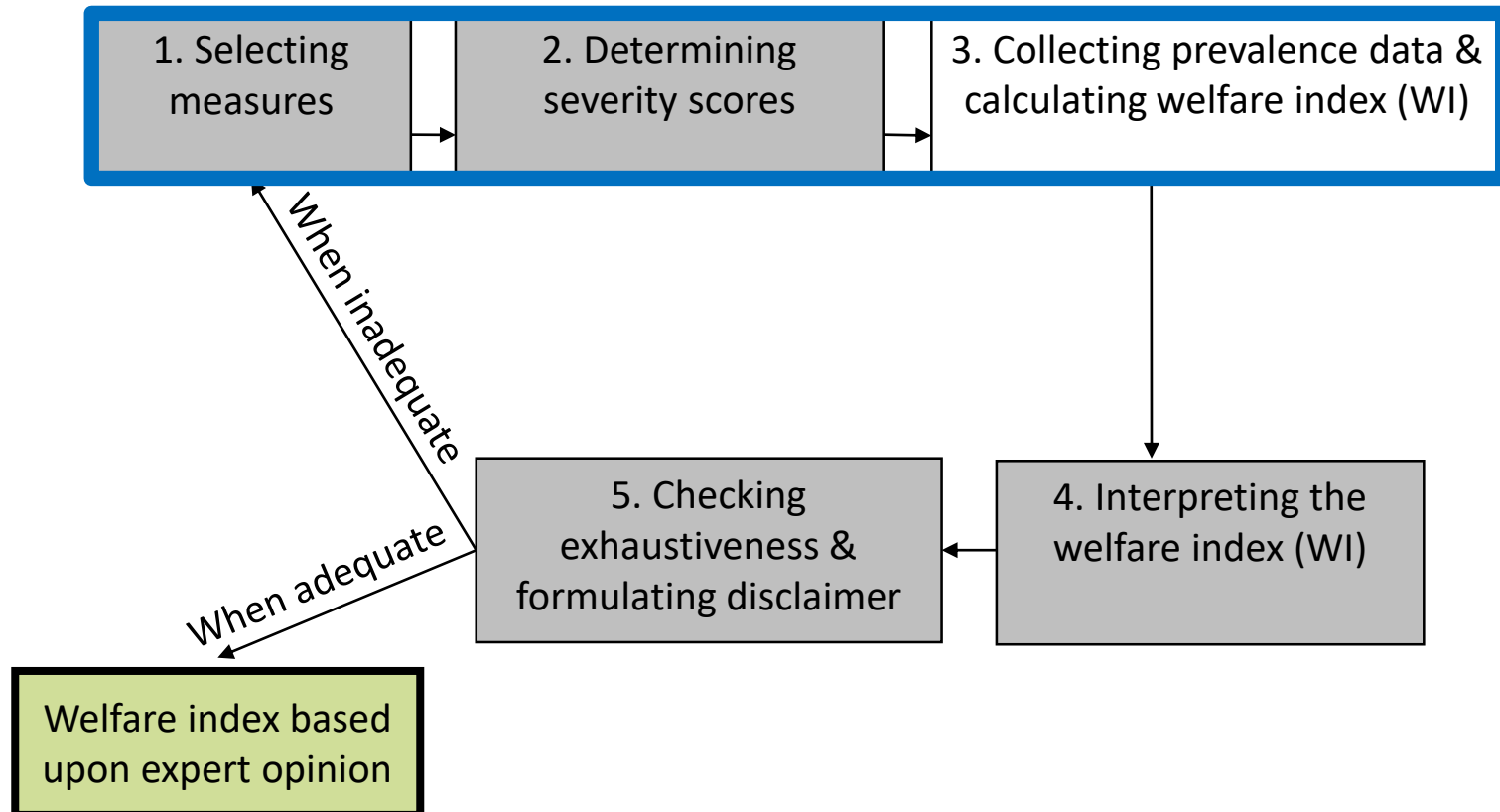
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**70th Annual Meeting of the EAAP**

# Iterative approach

## 5 Steps:



# Our approach

**Step 3: Can a major welfare problem be compensated by good/neutral scores on other indicators?**

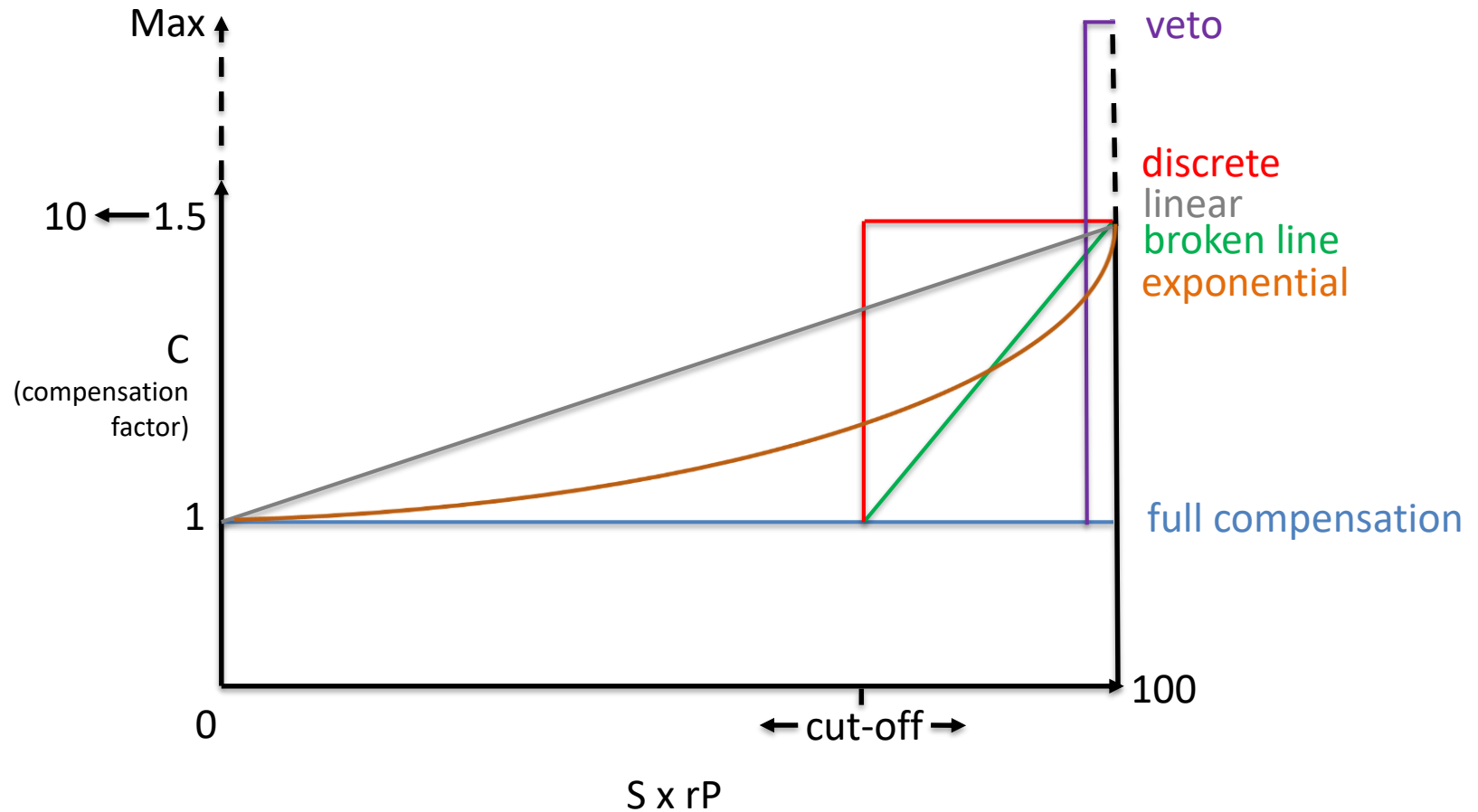
Vb: Herd 51

Selected measures (m)	Severity (S) (0-100)	Prevalence (P) (%)	rP (P/97.5P) (0-1)	S x rP (0-100)	Compensation reduction
Leanness	60	4.3	0.02	1.2	$S_1 \cdot rP_1 \times 1$
Lameness	92	33.0	0.90	82.8	$S_2 \cdot rP_2 \times 2$
Hairless patches	21	30.3	0.52	10.9	$S_3 \cdot rP_3 \times 1$
Lesions/swellings	40	36.8	0.40	16.0	$S_4 \cdot rP_4 \times 1$
Mortality	85	2.0	0.30	25.5	$S_5 \cdot rP_5 \times 1$
SCC	72	11.0	0.25	18.0	$S_6 \cdot rP_6 \times 1$
				Mean = 25.7 (lower = better)	< 39,5

# Our approach

**Step 3:** Type of compensation-reduction should match the experts' opinion

<http://survey.ilvo.vlaanderen.be:3838/DGK/>





# Our approach

None of the compensation-reduction methods gave a better fit with the experts' scores (n = 14)

compensation reduction method	R <sup>2</sup>	F-statistics
<b>Full compensation</b>	<b>0.91</b>	401
Discrete	0.90	398
Linear	0.90	369
Broken line	0.90	372
Exponential	0.90	368
Veto	0.74	117

WI =

$$100 - \frac{\sum_{m=1}^6 S_m * rPm * C / C_{max}}{6}$$

The higher the score, the better

# Why not using Welfare Quality®?

Principles	Criteria	Dairy cattle measures
Good feeding	Absence of prolonged hunger	BCS (% very lean animals)
	Absence of prolonged thirst ?	Availability & cleanliness water
Good housing	Comfort around resting	Lying down duration; % collisions; on edge of lying area; cleanliness
	Thermal comfort	-
	Ease of movement ?	Tethering
Good health	Absence of injuries	Lameness; integument alterations
	Absence of disease	Respir./reprod./digestive diseases; SCC; dystocia; downer; mortality
	Absence of pain induced by management procedures	Mutilations (dehorning; tail docking: use of anaesthesia/analgesia)
Appropri. behav.	Expression of social behaviour ?	Incidence agonistic interactions
	Expression of other behaviours ?	Access to pasture
	Good human-animal relationship	Avoidance distance at feeding place
	Positive emotional state ?	QBA

Predicts 88% of the WQ-categorisation (Heath et al 2014)

Negligible effect (de Graaf et al 2018)

Negligible effect (de Graaf et al 2018)