IT-Solutions for
Animal Production

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Health traits and their role for sustainability improvement of dairy production

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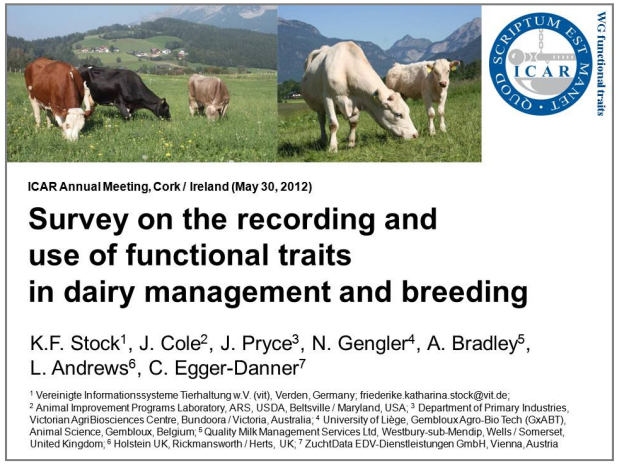
Sustainability of dairy production

- optimum use of resources
  with particular consideration of long-term effects and environmental impact
- sustainable dairy farming
  - best practices of animal husbandry and breeding
  - informed, balanced and responsible decisions
  - efficient and economically sound
  - in line with animal health and welfare demands
- sustainable dairy cow
  - reasonable input, favorable output
  - healthy and long (productive) life

Sustainability & trends in dairy breeding

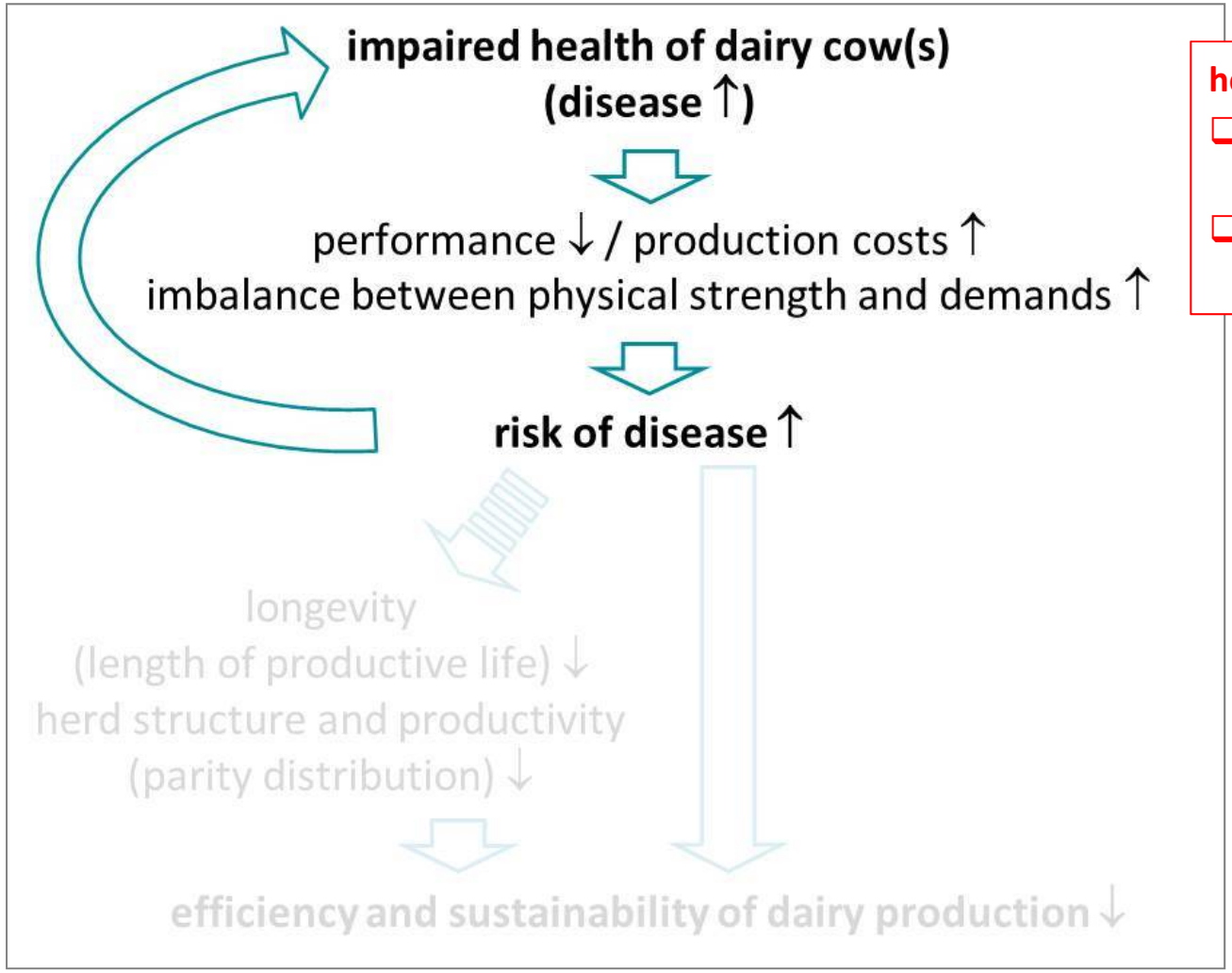
- substantial genetic progress in <u>production traits</u> of dairy cattle
  - routine performance testing
    (quantity and quality of phenotype data)
  - conventional and genomic breeding programs
- increasing importance of <u>functional traits</u>
  - integral parts of dairy breeding programs
  - increasing weights in selection indices
  - in the focus of R&D activities worldwide:
    health (direct health traits)
    >> **longevity / survival** > efficiency



relevance of sustainability aspects ↑

Sustainability aspects:

Health & longevity (I)

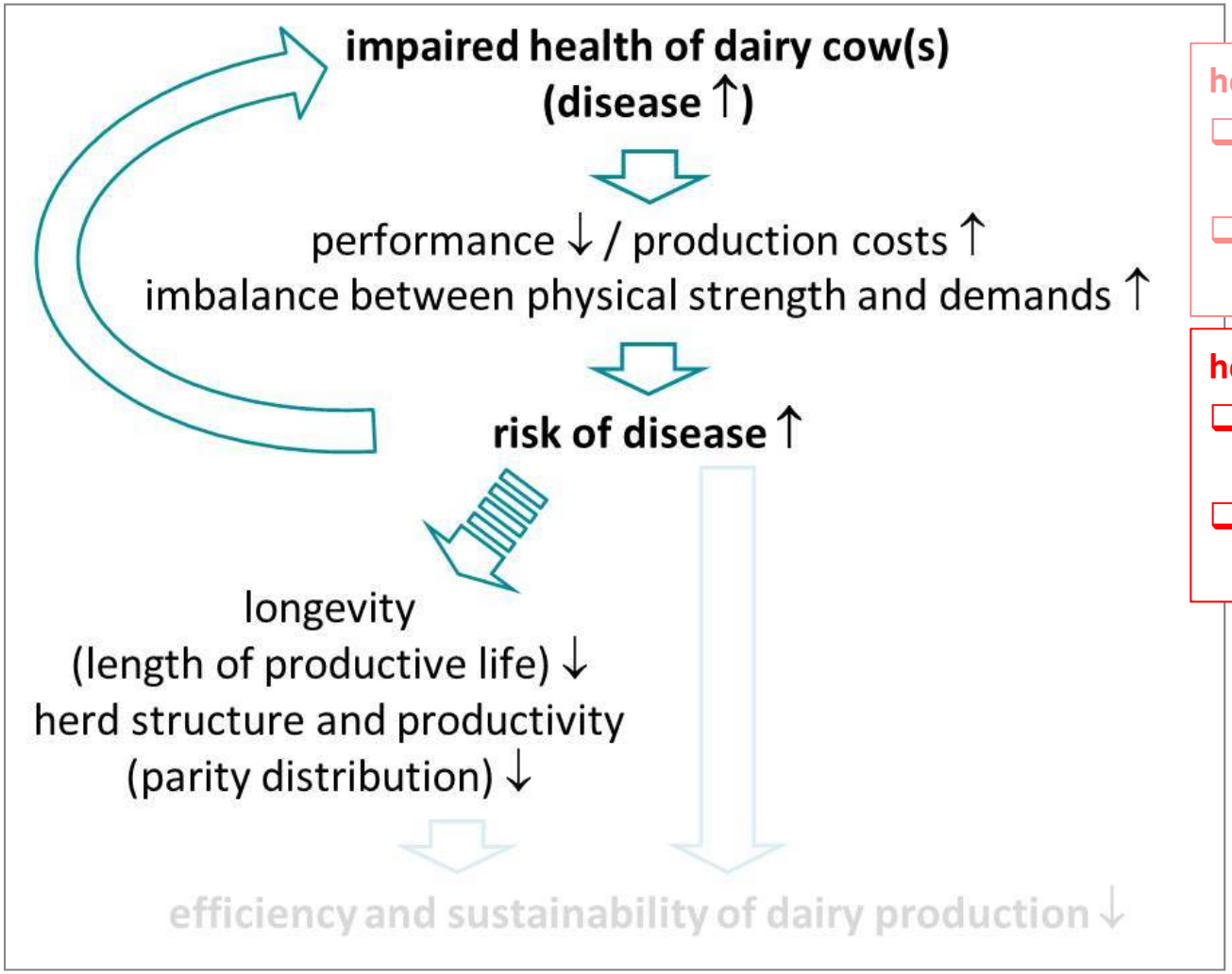


health conditions:

- ❑ **animal welfare issue (short- and long-term)**
- ❑ **detrimental for 'economic health' of dairy farming**

Sustainability aspects:

Health & longevity (II)



health conditions:

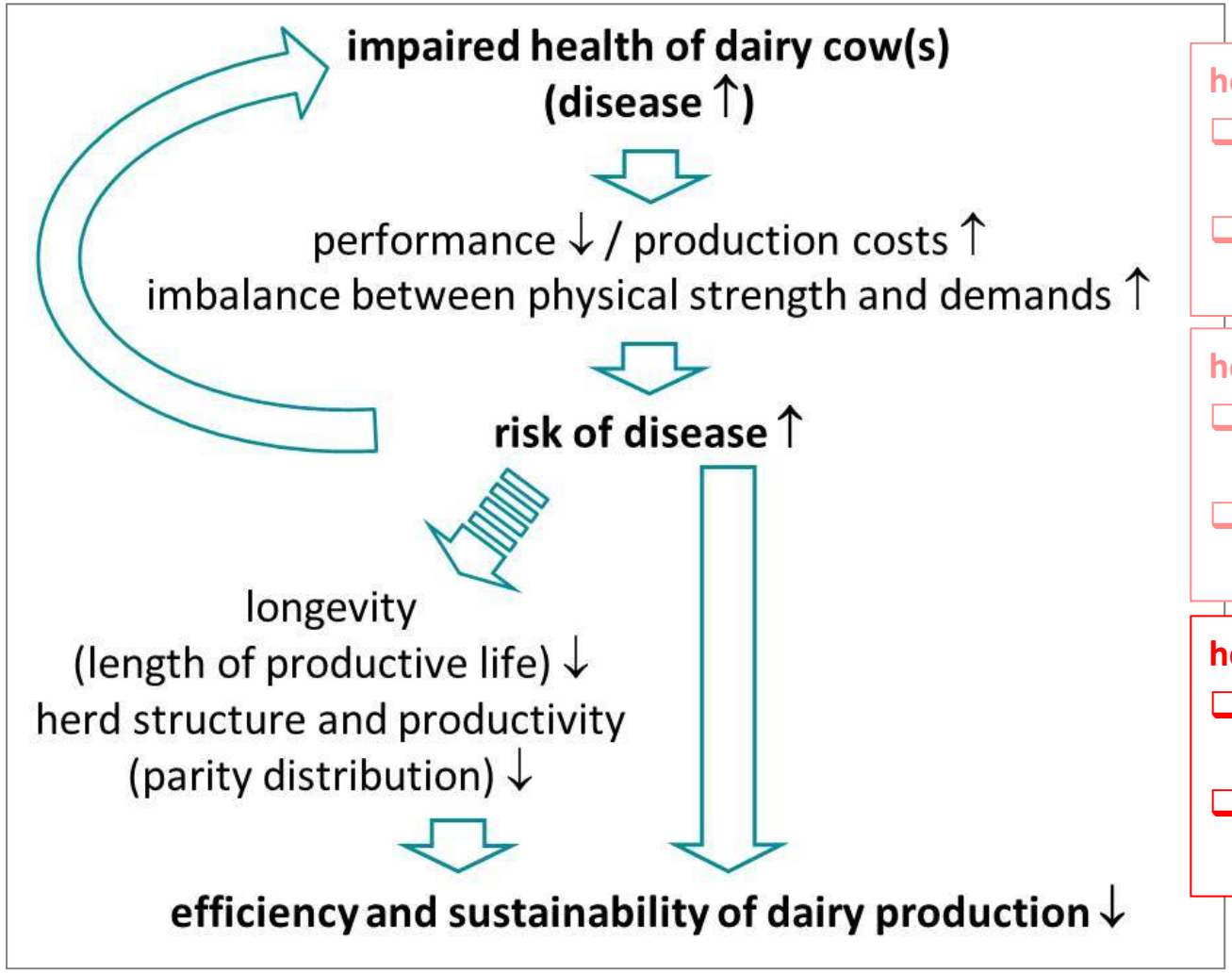
- ❑ animal welfare issue (short- and long-term)
- ❑ detrimental for 'economic health' of dairy farming

health/disease ↔ longevity:

- ❑ **heterogeneous impact on culling (decision Y/N, time)**
- ❑ **individual and herd factors (large herd effects)**

Sustainability aspects:

Health & longevity (III)



health conditions:

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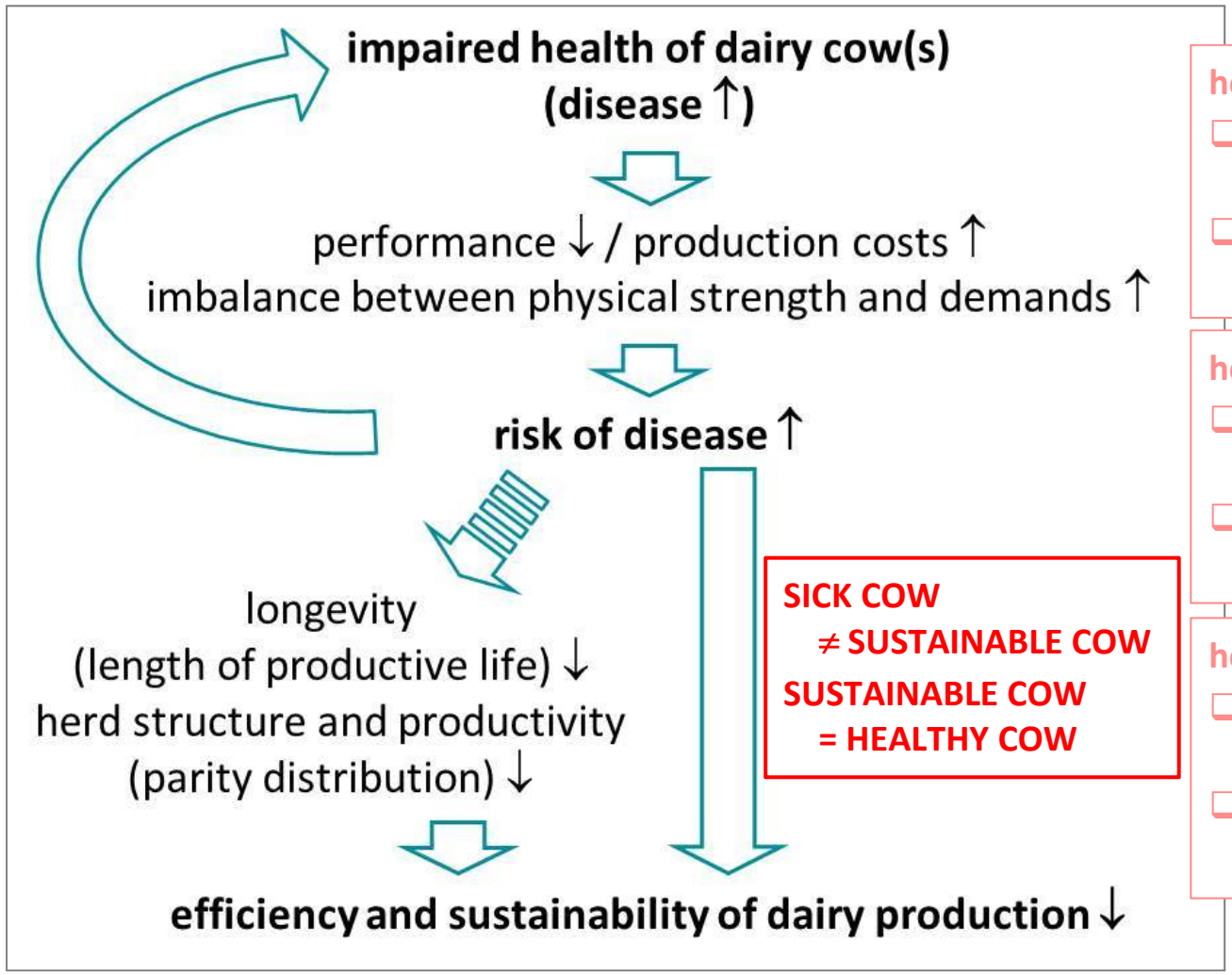
- ❑ individual and herd factors (large herd effects)

herd health management:

- ❑ disease rates and courses (short- and long-term)
- ❑ individual and specific as well as general impact

Sustainability aspects:

Health & longevity (IV)



SICK COW
≠ SUSTAINABLE COW
SUSTAINABLE COW
= HEALTHY COW

health conditions:
- ❑ animal welfare issue (short- and long-term)
- ❑ detrimental for 'economic health' of dairy farming

health/disease ↔ longevity:
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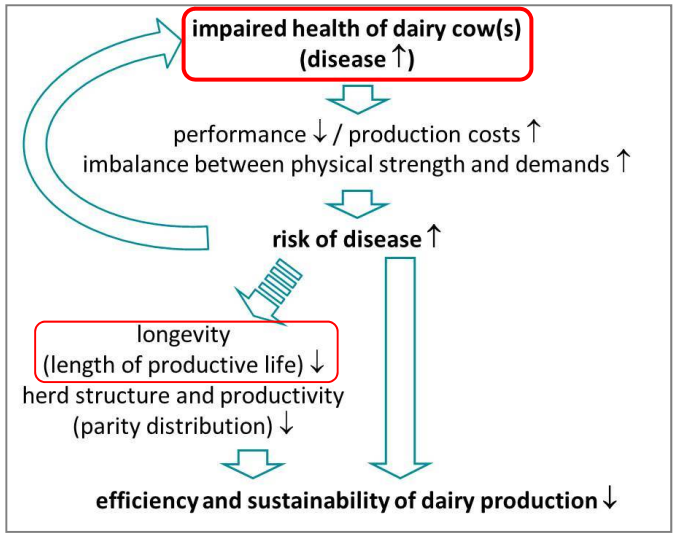
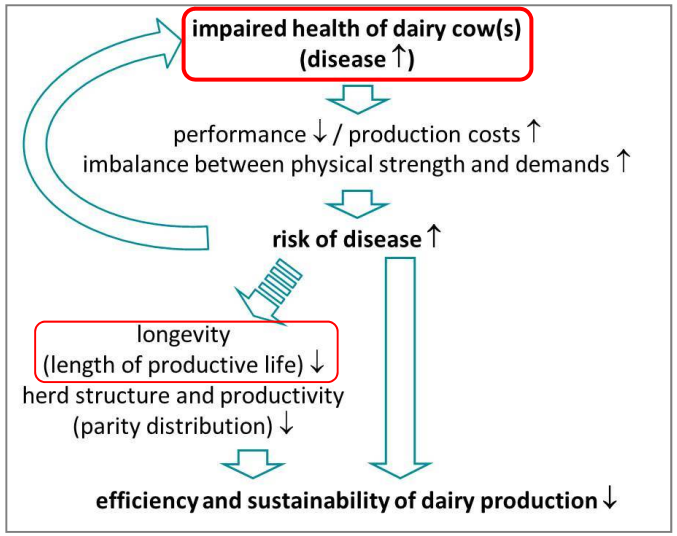
Sustainability improvement



- new goal-setting with shift
  from short-term and specific
  to long-term and global benefits
- challenges of target definition
  - identification of suitable indicators
    complex interplay of multiple factors on various levels
  - reliable and sufficiently broad information basis
    data sources (documentation routines or automated measurement vs. new recording),
    data accessibility (increase of on-farm data collection ≠ data transfer for routine analyses)

Sustainability improvement



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    data sources (documentation routines or automated measurement vs. new recording),
    data accessibility (increase of on-farm data collection ≠ data transfer for routine analyses)
- approaches
  - global measure → **longevity**
  - major determinants → **health**

PRO easy to measure, established population-wide data collection (data quantity)
CON heterogeneous causes / influences

PRO specificity (data quality)
CON difficult and expensive to measure, often insufficient population-coverage

Longevity / survival (I)

- worldwide established routines and ongoing R&D
  - longevity (length of productive life)
    impact of multiple factors on culling decisions,
    challenge of disentangling reasons for voluntary culling
  - survival
    approaches to reduce young stock mortality

no way to fully disentangle direct and indirect effects of health conditions!

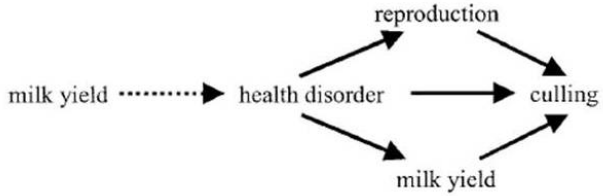

Fig.: Direct and indirect effect through milk yield and reproduction of health disorders on culling. (Beaudeau et al., 2000)

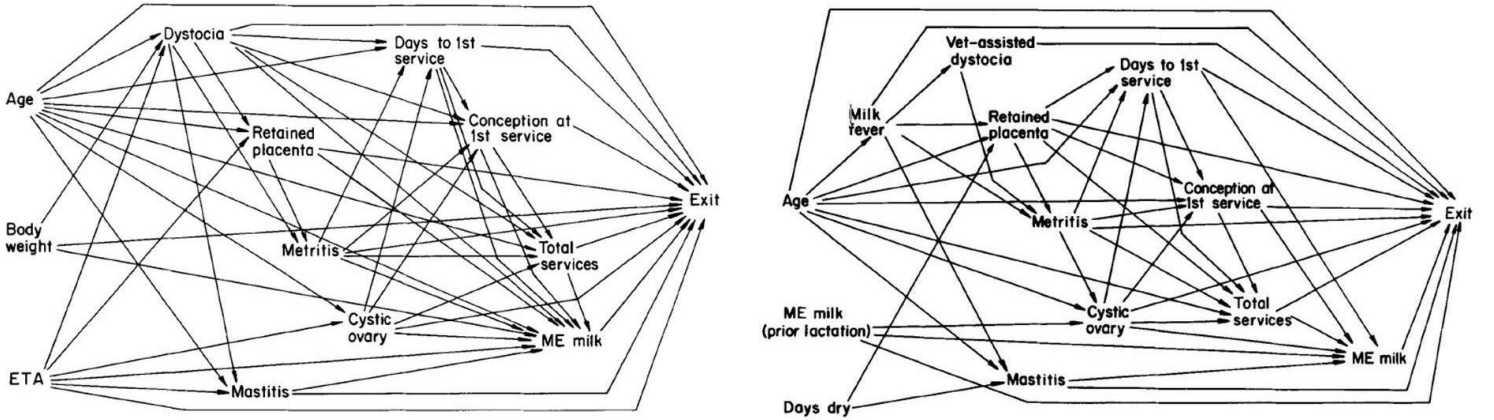

Fig.: Null path analysis model for first calf heifers (left) and multiparous cows (right). ETA = estimated transmitting ability, ME = mature equivalent (Erb et al. 1985)

Longevity / survival (II)

- worldwide established routines and ongoing R&D
  - longevity (length of productive life)
    impact of multiple factors on culling decisions,
    challenge of disentangling reasons for voluntary culling
  - survival
    approaches to reduce calf and heifer mortality

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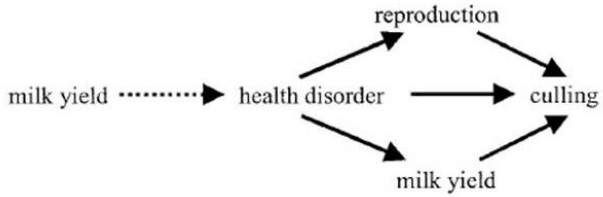
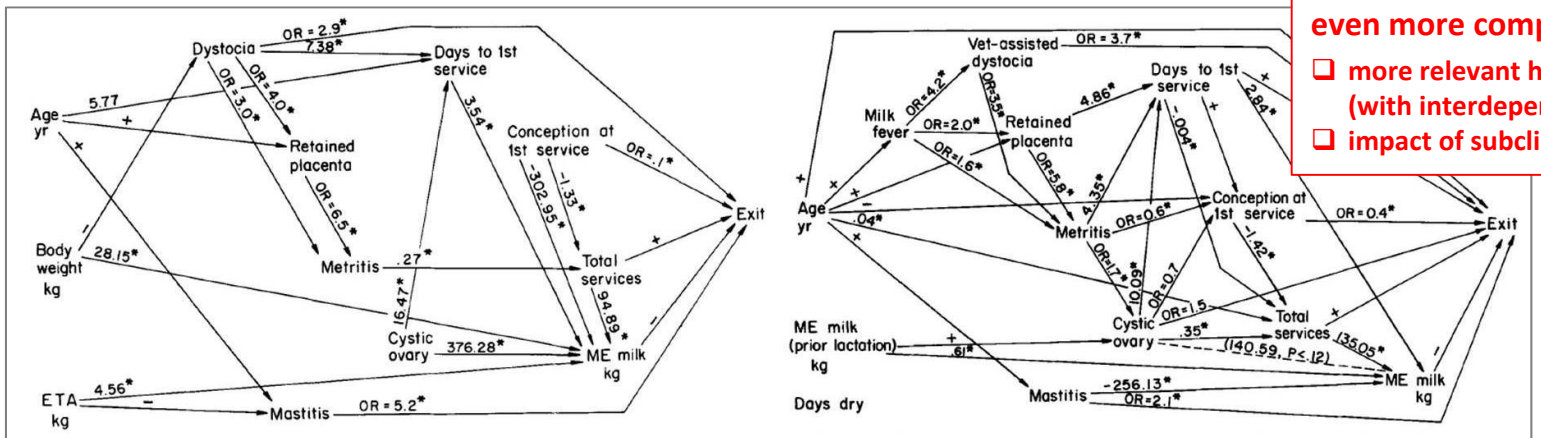


Fig.: Direct and indirect effect through milk yield and reproduction of health disorders on culling. (Beaudeau et al., 2000)

- patterns of relationships between health conditions and culling



even more complex in reality

- ❑ more relevant health disorders (with interdependencies)
- ❑ impact of subclinical conditions

Fig.: Final path analysis model for first calf heifers (left) and multiparous cows (right). ETA = estimated transmitting ability, ME = mature equivalent, OR = Odds ratio; * P<0.05 (Erb et al. 1985)

Health (I)

- international trend in dairy breeding:
  replacing indirect by **direct selection for improved health**
- framework across countries
  - increased legal requirements regarding animal health issues
    heterogeneity of regulations ↓, pressure on livestock sector ↑
  - increased awareness of the need for targeted health improvement
    new phenotypes in the context of methodological progress
    (need for new traits with specific rather than global trait definitions),
    unsatisfactory situation with few settled routines for working with disease information

Health (II)

- international trend in dairy breeding:
  replacing indirect by **direct selection for improved health**
- framework across countries
  → motivations for using health traits in breeding
  - societal demands: responsible modern livestock production
    (animal health and welfare; public reputation of agriculture, politics)
  - dairy sector demands: optimized production conditions
    (productivity, production efficiency / profitability; economics)
  - consumer demands: transparency and reliability
    (food safety, product quality)
- challenges related to working with health data
  - legislation, information / transparency, data security
  - data recording and logistics
  - data quality, validation, data processing and analysis

Health traits in dairy breeding

Current status

unsatisfactory situation with few settled routines for direct health traits, but ...

Tab.: Genetic evaluations (GE=routine, R&D=prospected) for direct health traits.

Country	UDDER HEALTH		FEMALE REPRODUCTION		METABOLIC HEALTH		HEALTH OF FEET & LEGS	
	GE	R&D	GE	R&D	GE	R&D	GE	R&D
Austria *	U1		R1,R3	R4	M1	M4		F2,F3
Canada	U1			R3,R4,R5		M1,M2,M3		F3
Denmark, Finland, Sweden	U2		R1,R2		M1,M2		F2	F1
Germany		U3,U4		R3, R4, R5, R6		M1,M2,M3		F1
France	U1							F1
Norway	U1		R4	R7	M1,M2			F1
Switzerland		U1		R7		M4		F2
The Netherlands							F1	
USA		U1		R3,R4,R5		M2,M3		F3

U1 mastitis, U2 clinical mastitis, U3 early mastitis, U4 late mastitis; R1 early reproduction disorders, R2 late reproduction disorders, R3 cystic ovaries, R4 retained placenta, R5 metritis, R6 ovary cycle disturbances, R7 fertility-related disorders / reproduction disorders; M1 milk fever, M2 ketosis, M3 displaced abomasum, M4 metabolic disorders; F1 individual claw diseases (e.g. digital dermatitis, sole ulcer), F2 feet and leg diseases, F3 lameness

* joint GE for Austrian German Fleckvieh and Brown Swiss

Health traits in dairy breeding

Current status → prospects

unsatisfactory situation with few settled routines for direct health traits, but quite a lot underway!

Tab.: Genetic evaluations (GE=routine, R&D=prospected) for direct health traits.

Country	UDDER HEALTH		FEMALE REPRODUCTION		METABOLIC HEALTH		HEALTH OF FEET & LEGS	
	GE	R&D	GE	R&D	GE	R&D	GE	R&D
Austria *	U1		R1,R3	R4	M1	M4		F2,F3
Canada	U1			R3,R4,R5		M1,M2,M3		F3
Denmark, Finland, Sweden	U2		R1,R2		M1,M2		F2	F1
Germany		U3,U4		R3, R4, R5, R6		M1,M2,M3		F1
France	U1							F1
Norway	U1		R4	R7	M1,M2			F1
Switzerland		U1		R7		M4		F2
The Netherlands							F1	
USA		U1		R3,R4,R5		M2,M3		F3

U1 mastitis, U2 clinical mastitis, U3 early mastitis, U4 late mastitis; R1 early reproduction disorders, R2 late reproduction disorders, R3 cystic ovaries, R4 retained placenta, R5 metritis, R6 ovary cycle disturbances, R7 fertility-related disorders / reproduction disorders; M1 milk fever, M2 ketosis, M3 displaced abomasum, M4 metabolic disorders; F1 individual claw diseases (e.g. digital dermatitis, sole ulcer), F2 feet and leg diseases, F3 lameness

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Crucial transition from R&D to routine

- acceptance of specialties of working with health data
  - challenging phenotyping (quality, quantity)
  - challenging analyses and interpretation of results
- current challenge of the dairy sector:
  - departure from (supported) project work
  - arrival at self-carrying routines for health data

SUSTAINABLE CONCEPTS FOR HEALTH → SUSTAINABILITY IMPROVEMENT!

- <u>needs for generating and visualizing short- and long-term benefits</u>
  - tools for optimizing herd management
  - tools for improved selection decisions
    (more farsighted, considering health and sustainability aspects)
  - direct health information as basis of new health-related phenotypes and of improved definitions / modelling of established functional traits
    (prerequisite for identification and calibration of biomarkers, validation variable)

Health → sustainability improvement

- several R&D projects (regional, joint central data analyses) in Germany with focus on health monitoring in dairy cattle

Tab.: Figures for the central bovine health data base (vit, 27 May 2014).

Farms	206
Diagnoses (Jan '09 - Mar '14)	1,011,539
Distinct disease events	497,875 (95,922 animals)
Parities at risk	~ 150,000

- genetic parameters and GE prototype for direct health traits (most relevant disease conditions of the dairy cow)
  - h^2=0.02-0.11 for mastitis, metabolic disorders, reproduction disturbances
  - h^2=0.05-0.16 for claw diseases

⇒ potential of improving animal health and welfare by breeding

→ suggested benefits for overall sustainability of dairy production

  - decrease of disease incidences
  - increase of longevity

Genetic correlation studies (I)

- aims:
  - quantifying the effects of targeted breeding measures for improved health of the dairy cow on longevity
  - comparing different definitions of longevity traits
- data basis
  1) information on direct health traits from regional pilot projects
     - standardized health records from on-farm documentation systems
       disease diagnoses from 104 German dairy farms (2009-2013, ca. 465,000 disease events), information on about 130,000 lactations of 74,000 dairy cows
     - EBV for health traits for 4,527 Holstein AI bulls

HEALTH TRAITS: single-trait repeatability linear animal model
(variance component estimation with REML / VCE6, genetic evaluation with BLUP / PEST)

$y_{ijkl} = \mu + PAR_i + hys_j + pe_k + a_k + e_{ijkl}$

with
- PAR_i = *fixed effect of parity class,*
- hys_j = *random effect of herd X year-season of calving,*
- pe_k = *random permanent environmental effect of the animal,*
- a_k = *random additive genetic effect of the animal,*
- e_{ijkl} = *random residual*

Genetic correlation studies (II)

- aims:
  - quantifying the effects of targeted breeding measures for improved health of the dairy cow on longevity
  - comparing different definitions of longevity traits
- data basis
  1) information on direct health traits from regional pilot projects
  2) longevity data from routine national milk performance recording
     - lactation records of all cows in milk recording (cow samples for test runs)
       data from 1980 onwards (GE routine 1408: 32.1 mio. records of 10.6 mio. cows),
       multiple sampling for test runs (1998-2013; 200 herds each, on average ca. 240,000 cows)
     - functional herd life (fHL) vs. survival of lactation periods
       fHL as length of productive life corrected for yield deviation within herd (vit 2014);
       survival Y/N in DIM periods 0-150, >150 to next calving for parities 1 to 3
     - EBV for 255,524 (89,329) AI bulls

Health → sustainability improvement

Results (I)

RZN correlations generally reflecting focusses of health-related cullings (global, no information on pattern)

Tab.: EBV correlations (r^2) between health and longevity traits.
(239 Holstein bulls with ≥50 daughters in the health data)

Health trait	N	LIR [%]	h^2	r^2_{RZN}
Early mastitis (-10 to 50 DIM)	122,784	18.7	0.05	**0.42**
Late mastitis (51 to 305 DIM)	100,640	28.9	0.09	**0.32**
Retained placenta	128,478	10.4	0.03	**0.28**
Ovary cycle disturbances	104.991	29.5	0.04	**0.43**
Ketosis	120,834	2.9	0.02	**0.23**
Milk fever	130,483	4.7	0.03	0.03
Abomasal displacement to the left	112,102	2.6	0.03	**0.24**
Non-purulent claw diseases	97,846	21.4	0.08	**0.35**
Laminitis	94,983	12.3	0.05	**0.30**
Interdigital hyperplasia / Corns	93,639	6.1	0.13	**0.24**
Purulent claw diseases	102,790	38.5	0.08	**0.36**
Claw ulcers	96,751	19.0	0.11	**0.34**
Digital dermatitis / Mortellaro	95,675	15.6	0.06	**0.18**
Digital phlegmon / Panaritium	94,862	10.5	0.04	**0.33**

LIR = lactation incidence rate = no. of affected lactations / no. of affected+unaffected lactations; affected lactation = lactation with at least 1 diagnosis; unaffected lactation = at risk lactation without diagnosis; standard errors of heritabilities ≤ 0.08;
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Health → sustainability improvement

Results (II)

plausible pattern of N1.1-N3.2 correlations (1st /2nd half of lactation), but also indication of needs for improvement!

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Early mastitis (-10 to 50 DIM)	122,784	18.7	0.05	**0.42**	**0.22**	**0.25**	**0.28**	**0.28**	**0.30**	**0.29**
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Health → sustainability improvement

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Conclusions (I)

- support of important role of health for longevity
  - in general, i.e. culling decision Y/N (reference to functional herd life)
  - in distinct periods of lactations, i.e. time pattern of culling decisions
- mutual support of R&D studies on functional traits
  - data quality issues regarding direct health traits
    (further) indications for under-reporting of diagnoses for early-culled cows
  - refined definitions of survival time periods within lactation
    (patho-)physiological basis; 0-49, 50-249, 250 to next calving *
- high value of information on direct health traits in dairy breeding
  - direct: new traits for more targeted selection for improved health
  - indirect: improved (functional) traits in dairy breeding programs

* Wiebelitz et al. 2014a,b

Conclusions (II)

- stronger weight on health traits in breeding requiring strengthening of health monitoring in dairy cattle
  - national rather than regional concepts
  - sustainable concepts
    - user-friendly implementations (heterogeneity of farm structures)
    - short- to medium-term benefit (management help, 'immediate reward')
    - long-term perspective (selection, 'lasting reward')

extension and improvement of systematic recording and use of health data (health monitoring) as substantial contribution to sustainability improvement of dairy production

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R&D on dairy health monitoring in Germany

Tab.: Overview of the multiple initiatives and projects on health monitoring in dairy cattle in Germany.

Federal state	Project	Data collection
Baden-Württemberg	"Gesundheitsmonitoring Rind BW"	VET+F, since 2010
Bavaria	"ProGesund"	VET+F, since 2012
Berlin-Brandenburg	RBB contract herds	F, since 2009
Hessen	"HVL-Gesundheit"	F, since 2013/2014
Mecklenburg-Vorpommern	RMV contract herds "ProFit"	F, since 2005
Lower Saxony	"GKuh"* and other farms (project-independent)	F, since 2010
Rheinland-Pfalz	"Gesundheitsmonitoring Rind RLP"	F, since 2013
Saxony	"Fitnessmonitoring Sachsen" "Zukunftsforum Veredlungsland Sachsen 2020"	F, since 2000 F, since 2011
Saxony-Anhalt	"BHNP"* and other farms (project-independent)	F, since 2010
Schleswig-Holstein	"KuhVital"	VET+F, since 2014
Thuringia	selected farms "BHNP"* und weitere Betriebe (projektunabhängig)	F, since 2007 F, since 2009

VET = veterinarian (mainly treatment receipts),
F = farmer / on-farm documentation on animal health (veterinary medical diagnoses and others)
* Innovation project of the Bundesanstalt für Landwirtschaft und Ernährung (BLE)

GKUH*plus* - preliminary studies

Heritability estimates for health traits

Genetic parameters for selected disease

(health data from dairy farms in Lower Saxony, Thuringia, Saxony-Anhalt, Saxony; 07.01.2014)

Health trait	N	LIR [%]	h^2	h^2 CAN (Koeck et al. 2012)	h^2 AUT (Fürst et al. 2011)
Early mastitis (DIM -10 to 50)	122,784	18.7	**0.047** ± 0.004	0.02 ± 0.004	0.020 ± 0.005
Late mastitis (DIM 51 to 305)	100,640	28.9	**0.090** ± 0.006		
Retained placenta	128,478	10.4	**0.034** ± 0.003	0.03 ± 0.005	0.023 ± 0.005
Ovary cycle disturbances	104,991	29.5	**0.035** ± 0.003	0.03 ± 0.005	0.046 ± 0.006
Ketosis	120,834	2.9	**0.020** ± 0.003	0.03 ± 0.008	
Milk fever	130,483	4.7	**0.029** ± 0.003		0.036 ± 0.006
Left-sided abomasal displacement	112,102	2.6	**0.028** ± 0.003	0.06 ± 0.008	
Non-purulent claw diseases	97,846	21.4	**0.077** ± 0.005	lameness: 0.01 ± 0.004	
Laminitis	94,983	12.3	**0.046** ± 0.003		
Corns (interdigital hyperplasia)	93,639	6.1	**0.133** ± 0.008		
Purulent claw diseases	102,790	38.5	**0.083** ± 0.005		
Claw ulcers	96,751	19.0	**0.109** ± 0.006		
Digital dermatitis (Mortellaro)	95,675	15.6	**0.062** ± 0.005		
Digital phlegmon	94,862	10.5	**0.039** ± 0.004		

LIR = lactation incidence rate (proportion of lactations with ≥1 diagnosis from all lactations at risk),
h^2 = heritability with standard error

relevant influence of genetic factors (usable for selection):

- **heritabilities of mostly 0.03-0.09**
- **confirmation of advantages of detailed health data recording**

GKUH*plus* - preliminary studies

Heritability estimates for health traits

Genetic parameters for selected disease

(health data from dairy farms in Lower Saxony, Thuringia, Saxony-Anhalt, Saxony; 07.01.2014)

Health trait	N	LIR [%]	h^2	N_{PRel50}
Early mastitis (DIM -10 to 50)	122,784	18.7	**0.047** ± 0.004	83
Late mastitis (DIM 51 to 305)	100,640	28.9	**0.090** ± 0.006	43
Retained placenta	128,478	10.4	**0.034** ± 0.003	115
Ovary cycle disturbances	104,991	29.5	**0.035** ± 0.003	112
Ketosis	120,834	2.9	**0.020** ± 0.003	196
Milk fever	130,483	4.7	**0.029** ± 0.003	135
Left-sided abomasal displacement	112,102	2.6	**0.028** ± 0.003	140
Non-purulent claw diseases	97,846	21.4	**0.077** ± 0.005	50
Laminitis	94,983	12.3	**0.046** ± 0.003	85
Corns (interdigital hyperplasia)	93,639	6.1	**0.133** ± 0.008	29
Purulent claw diseases	102,790	38.5	**0.083** ± 0.005	47
Claw ulcers	96,751	19.0	**0.109** ± 0.006	35
Digital dermatitis (Mortellaro)	95,675	15.6	**0.062** ± 0.005	63
Digital phlegmon	94,862	10.5	**0.039** ± 0.004	100

LIR = lactation incidence rate (proportion of lactations with ≥1 diagnosis from all lactations at risk), h^2 = heritability with standard error; N_{PRel50} = number of progeny (N_P) required for EBV reliability (r^2) of 0.5, approximated as $r^2 = N_P / (N_P + k)$ with $k = (4 - h^2) / h^2$

Distribution of bulls (N=4,527) in the health data material:

- on average 15 daughters (max. 1,750)
- ca. 75% of the bulls with ≤ 10 daughters, N=235 bulls with > 50 daughters

EBV for health traits

- **few bulls with reliable EBV (so far low average EBV reliability)**
- **good differentiation, consistent results of genetic evaluations (regional comparisons)**

Breeding use of health data (I)

1) **systematization** and **harmonization** of health data recording
   - approved comprehensive recording standard
   - optimum data integration

→ reliable data basis for relevant health traits

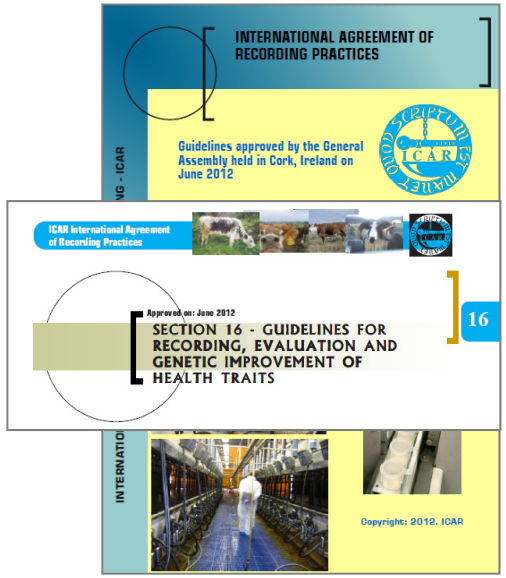
- no lack of direct health information on individual animal basis, but limited accessibility for analyses
- new phenotypes (in breeding) requiring <u>appropriate collection</u> and <u>optimized usage</u> of data

not necessarily new, but possibly adjusted

smart solutions for maximum data integration in data bases for dairy cattle

Type of data		Data source
Diagnoses of diseases	- requiring medical treatment	veterinarian, farmer
	- treated conservatively	veterinarian, farmer
Claw health information		claw trimmer, farmer
Reproduction data		inseminator, veterinarian, farmer
Outcome of special veterinary examinations		veterinarian, laboratory, farmer
Calving related disorders (cow, calf)		farmer
Culling reasons		farmer
Post mortem diagnoses		slaughterhouse

Source: Stock et al. 2014



WG functional traits

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Breeding use of health data (II)

1) **systematization** and **harmonization** of health data recording
   - approved comprehensive recording standard
   - optimum data integration

   → reliable data basis for relevant health traits

2) capable **logistics**
   for routine transfer, central storage and analysis of health data
   - strong infrastructure (milk recording)
   - advances in system integration in the dairy sector

3) delivery of valuable output

   → **added value** (visible benefit)
   - short- and long-term perspective
   - motivation as crucial factors for system performance and success