

Development of genomic evaluations for direct measures of health in U.S. Holsteins and their correlations with fitness traits

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Introduction

- **Increasing demand for health evaluations**
 - **Consumer demand**
 - **Improve profitability → decreasing management costs**

Health trait	Direct cost estimate*
Hypocalcemia	\$38
Displaced abomasum	\$178
Ketosis	\$28
Mastitis	\$72
Metritis	\$105
Retained placenta	\$64

*Liang et al., 2017; Donnelly et al.

Objectives

- **Estimate variance components for 6 common health events recorded by producers on U.S. dairy farms**
- **Compute traditional and genomic evaluations**
- **Estimate correlations with fitness traits currently used for selection**

Phenotypic data

- **Health event data available from DRMS (Raleigh, NC) for 6 common health traits**
 - **Hypocalcemia/milk fever**
 - **Displaced abomasum**
 - **Ketosis**
 - **Mastitis**
 - **Metritis**
 - **Retained placenta**



Standardization & editing

- Account for different acronyms used in herds
- Inclusion of Holstein animals with acceptable ID
- Parities 1 to 5
- Events must occur within specified time frame after calving (e.g., retained placenta must be reported within 10 days of calving)
- Minimum/maximum constraints for herd-year reporting



Variance component estimation

- **Univariate linear animal models**
(AIREMLF90; Misztal et al., 2002):

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}_h\mathbf{h} + \mathbf{Z}_a\mathbf{a} + \mathbf{Z}_p\mathbf{p} + \boldsymbol{\varepsilon}$$

- **Fixed effects**
 - Overall mean
 - Parity
 - Year-season
- **Random effects**
 - Herd-year
 - Additive genetic
 - Permanent environmental
 - Residual

Traditional evaluation

- **Univariate BLUP repeatability animal model**
- **Similar to routine national genetic evaluations**
- **Fixed effects included**
 - **Year-season**
 - **Age at calving by parity**
 - **Regression on inbreeding**
- **Random effects the same**

Genomic evaluation

- **SNP effects estimated using model similar to BayesA**
- **Same fixed and random effects as traditional model**
- **Used 60,671 markers currently included in U.S. routine genomic evaluations**

Summary statistics

Health event	Records (no.)	Cows (no.)	Herds (no.)	Mean incidence rate (%)
Hypocalcemia	1,232,071	720,091	671	1.3
Displaced abomasum	1,880,042	1,054,244	980	2.1
Ketosis	1,288,144	741,520	671	3.9
Mastitis	2,541,411	1,428,312	1,825	10.2
Metritis	2,032,644	1,171,957	1,315	6.2
Retained placenta	1,964,950	1,120,772	1,319	3.6

Variance components

- **Observed scale (standard error)**

Health trait	Heritability	Repeatability
Hypocalcemia	0.006 (0.59×10^{-3})	0.031 (0.10×10^{-2})
Displaced abomasum	0.011 (0.46×10^{-3})	0.012 (0.48×10^{-3})
Ketosis	0.012 (0.77×10^{-3})	0.045 (0.11×10^{-2})
Mastitis	0.031 (0.95×10^{-3})	0.086 (0.75×10^{-3})
Metritis	0.014 (0.76×10^{-3})	0.053 (0.86×10^{-3})
Retained placenta	0.010 (0.62×10^{-3})	0.036 (0.86×10^{-3})

Reliability

Progeny-tested animals

Health trait	Mean reliability (%)		Improvement
	Traditional	Genomic	
Hypocalcemia	20.0	44.2	24.2
Displaced abomasum	25.7	47.1	21.4
Ketosis	24.0	46.2	22.2
Mastitis	33.3	56.3	23.0
Metritis	27.6	48.1	20.5
Retained placenta	25.6	46.7	21.1

Reliability

Young animals

Health trait	Mean reliability (%)		Improvement
	Traditional	Genomic	
Hypocalcemia	10.9	40.0	29.1
Displaced abomasum	14.6	41.8	27.2
Ketosis	13.4	41.2	27.8
Mastitis	18.3	49.4	31.1
Metritis	15.4	42.2	26.8
Retained placenta	14.2	41.6	27.4

Correlations with other traits

Health trait	Protein	Productive life	Livability	Somatic cell score	Daughter pregnancy rate	Cow conception rate	Heifer conception rate
Hypocalcemia	0.18	0.15	0.19	-0.29	0.003	0.01	0.02
Displaced abomasum	0.23	0.35	0.47	-0.13	0.32	0.28	0.24
Ketosis	0.03	0.33	0.27	-0.19	0.59	0.49	0.07
Mastitis	0.06	0.39	0.22	-0.68	0.20	0.21	0.06
Metritis	0.05	0.32	0.26	-0.09	0.46	0.41	0.23
Retained placenta	-0.03	0.17	0.13	-0.10	0.14	0.13	0.12

- Hypocalcemia & retained placenta calculated for bulls born since 1990 with reliability of $\geq 75\%$
- All other traits calculated for bulls born since 1990 with reliability of $\geq 90\%$
- Values in red are different from 0

Health merit index

- **Incorporate 6 health traits into a single measure of health**
- **Health merit = economically weighted sum of 6 health traits**
- **Ensure appropriate weighting of each trait**

Correlations with health merit index

Trait	Correlation with health merit
Protein	0.09
Productive life	0.56
Livability	0.55
Somatic cell score	-0.45
Daughter pregnancy rate	0.51
Cow conception rate	0.46
Heifer conception rate	0.34

Calculated for bulls born since 1990 with reliability of $\geq 90\%$

Conclusions

- **Genomic reliabilities**
 - 40–49% for young animals
 - 44–56% for progeny-tested animals
- **Correlations with current traits as expected**
- **Health traits will add no more than 4% improvement to lifetime net merit index (NM\$)**
- **Preparing pipeline to be ready for implementation**

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Thank you!