Item Response Theory for combining elevated somatic cell count (SCC) in cows

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Introduction

- Increase in herd size results in less labor/cow
- Problem-free cows require less labor
- Occurrence of problems, e.g. mastitis, can be summarized using Item Response Theory (IRT)
- Elevated SCC can be used to monitor mastitis

Objective:
Apply Item Response Theory to summarize elevated somatic cell count

Material & Method

- Max. 10 individual SCC/ml and milk yield from 2049 first parity cows within 305 days
- LTSCC = log(total somatic cell count)
- In absence of mastitis LTSCC is constant during lactation
- Elevated LTSCC is defined as (Heuven, 1987): LTSCC > cow's average + 0.6 (figure 1)
- Being elevated is more important than amount of elevation. Amount of elevation depends on pathogen and infection process

Figure 1. Example of elevated total SCC: cownr 1
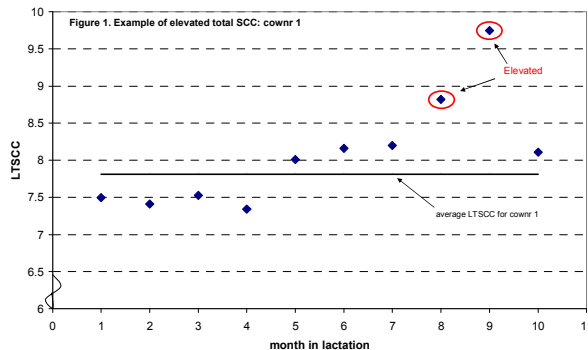
- Being elevated (0/1; no/yes) as dependent variable is analyzed using Item Response Theory with month of lactation treated as an item
- It assumes no/yes depends on the cow i's general ability and lactation month j

$$p_{ij} = \beta_j + \alpha_j * cow_i$$

- p_{ij} is prob. of elevated LTSCC for cow i in month j
- β_j is a fixed effect of month in lactation (j=1,10)
- α_j is a multiplier for month j (loading)
- cow_i is a random effect of the cow's ability (i=1,2049)

Results

Table. Data summary and parameter estimates

month	1	2	3	4	5	6	7	8	9	10
% missing	20.99	12.93	11.76	13.96	13.62	17.28	16.06	17.86	20.84	30.99
% not elev.	0.69	0.85	0.87	0.87	0.86	0.88	0.84	0.82	0.79	0.77
% elevated	0.31	0.15	0.13	0.13	0.14	0.12	0.16	0.18	0.21	0.23
logit (p/1-p)	-0.81	-1.77	-1.89	-1.93	-1.81	-1.96	-1.63	-1.50	-1.31	-1.23
β	-0.81	-1.78	-2.07	-2.18	-2.26	-3.02	-2.49	-2.44	-1.89	-1.52
α	0.14	0.17	0.70	0.84	1.22	1.95	1.86	2.10	1.65	1.13

- β measures 'difficulty', i.e. the ability where the prob. of an elevated LTSCC for the item = 50%
- α measures discrimination, i.e. how well a measurement in a specific month discriminates between cows.

Figure 2: Curves describing probability of elevated TSCC for each month
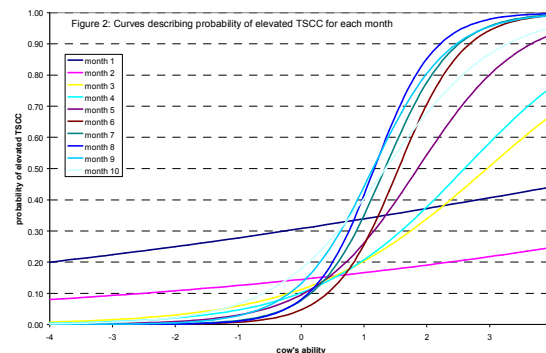
- The first two months show a different pattern as is also shown in the Table and Figure 2
- The first two months are clearly less informative about the cow's ability to have elevated total somatic cell count.
- Before peak lactation, elevated total somatic cell count might be more related to environmental factors, such as management
- Cows are best discriminated in months 6,7 and 8

Conclusions:

IRT-models allow elevated total somatic cell counts to be summarized treating cows and lactation months separately.

Different factors are important before and after peak lactation

IRT could also be applied to summarize all other problems occurring in a cow's life

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