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Epidemiology of Reproductive Disorders in Dairy Cattle: Associations Among Host Characteristics, Disease and Production.

YRJÖ T. GRÖHN[1]*, HOLLIS N. ERB[1], CHARLES E. McCULLOCH[2], and HANNU S. SALONIEMI[3]

[1]Section of Epidemiology, Department of Clinical Sciences, New York State College of Veterinary Medicine, Cornell University, Ithaca, 14853 (USA)

[2]Biometrics Unit, College of Agriculture and Life Sciences

[3]College of Veterinary Medicine, Helsinki, Finland.

*Reprint requests

ABSTRACT

Logistic regression was used to investigate the effects of host characteristics, production, and 23 veterinary diagnoses on the risks of ten reproductive disorders. For each reproductive disease in each lactation record, all prior disease events in that lactation were examined as possible risk factors. All 61,124 Finnish Ayrshire cows were from milk-recorded herds and calved during 1983. Each cow was

under observation from 2 days before calving to the following calving or to removal from the herd.

Twenty % of the cows were treated by a veterinarian for reproductive disorders. Lactational incidence rates (%) were: dystocia 1.2, prolapsed uterus 0.2, retained placenta 4.4, early metritis 2.3, silent heat 4.9, cystic ovary 6.8, prolapsed vagina 0.1, late metritis 1.1, other infertility 2.1, and abortion 0.4.

Silent heat and other infertility decreased and dystocia (after the first calving), retained placenta, and cyst increased with increased parity. Parity did not explain the incidences of the other reproductive disorders. The cows calving during the dark season (September-February) had higher risks of early metritis, silent heat, cyst, and other infertility than those calving during the light season. Higher herd milk yield in the previous lactation increased the risks of retained placenta, early metritis, and late metritis; higher herd yield in the current lactation increased risks of dystocia and of cyst. The risks of retained placenta, early metritis, silent heat, cyst, other fertility, and abortion also increased with increased individual-cow's milk yield.

Most reproductive disorders were interrelated. Six non-reproductive disorders (non-parturient paresis, udder edema, indoor and outdoor hypomagnesemia, rumen acidosis, and chronic mastitis) were not risk factors for any of the reproductive disorders. Of the other non-reproductive disorders, clinical parturient paresis was a risk factor for dystocia, prolapsed uterus, retained placenta, and early metritis; clinical ketosis was associated with silent heat, cystic ovary, and other infertility; disorder of the abomasum, traumatic reticuloperitonitis, acute mastitis, and foot or leg injury also contributed to early metritis. No disorders were protective.

INTRODUCTION

Several previous studies examined the epidemiology of reproductive disorders in dairy cows. Many of these studies had only small or modest sample sizes (n = 343 to 2875) (Coleman et al., 1985; Curtis et al., 1985; Dohoo and Martin, 1984; Erb et al., 1981a,b; Erb et al., 1985; Sandals et al., 1979). Also, most studies explored disease interrelationships only between reproductive disorders (Coleman et al., 1985; Erb et al., 1981b; Sandals et al., 1979) or between reproductive disorders and a few metabolic diseases (and sometimes mastitis) (Bendixen et al., 1986; Bendixen et al., 1987; Curtis et al., 1985; Erb et al., 1985; Saloniemi et al., 1986).

A large data set with information on demographics, previous-lactation and current-lactation cow and herd milk yields, and 23 veterinary diagnoses was available to use for 2 objectives. Our first objective was to generate hypotheses regarding risk factor-disease relationships not previously studied. Our second objective was to re-examine "known" relationships under conditions of maximum practical (for an observational study) statistical control of potential confounding by other disorders.

MATERIALS AND METHODS

Data

The data are from 61,124 Finnish Ayrshire cattle who calved during 1983, and from whom data on 23 veterinary diagnoses were collected from 2 days before calving to either a subsequent calving or removal from the herd (whichever came first). All cows were pedigreed, were bred by artificial insemination, and were in herds that recorded milk. The herds were from the 76 (out of 461) communities that were judged to have the best record-keeping (Gröhn et al., 1986). The data included only those diagnoses treated by veterinarians during farm visits. The diagnoses were made according to ordinary clinical methods in field conditions. Only the first diagnoses of each disease in a lactation were considered; repeated treatments or treatments by telephone prescription (i.e., the farmer described the symptoms to the veterinarian, and the veterinarian -- without seeing the cow -- diagnosed the case and gave a prescription) were excluded. These data were examined previously for the effects of parturient paresis, retained placenta, metritis, mastitis, and ketosis on risks of dystocia, retained placenta, metritis, silent heat, and cyst (Saloniemi et al., 1986).

The reproductive disorders studied were: dystocia, prolapsed uterus, retained placenta, early metritis (metritis diagnosed within 42 days postpartum), silent heat (anestrus or subestrus), cyst (ovulatory dysfunction including cystic ovaries), prolapsed vagina, late metritis

(metritis diagnosed later than 42 days postpartum), other infertility (reproductive disorders which were not included in the former diagnoses), and abortion.

Time-ordering of variables

We wanted to examine each reproductive disease in turn as the dependent (outcome) variable in a multivariable model in which all other preceding or concurrent events were potential risk factors. To do this, we copied the edited data set of 61,124 lactations once for each disease. Within each such data set, that one disease became the dependent variable which determined "case" or "control" status for each lactation record. Because every diagnosis had a day in milk (DIM) of diagnosis, it was then a simple matter to recode potential risk factor diseases to code = 0 ("absent") if the DIM of the putative risk factor was greater than the DIM of the designated outcome disease of the data set.

However, a potential bias existed for control records, because in them there was no recorded "cut-off" DIM for counting or not counting the risk factor diseases. If the entire control lactation were "at risk" for the occurrence of risk factor diseases, then the controls could have "too many" occurrences of disorders such as mastitis, which then would have biased odds ratios (ORs) towards the null. Therefore, prior to copying the data set and recoding risk factors to reflect proper time sequences, the entire data set was randomized once. Then, if a particular record did not have a particular disease, the DIM variable for that disease in that record was assigned the same value as the DIM for that disease in the previous record that did have that particular disease in the randomized list. This meant that the controls for each disease were assigned a DIM cut-off that was random but in proportion to the distribution of the DIM for the cases of that disease. After the data set was copied once for each "disease-as-outcome", putative risk factor diseases in each control record were recoded to code= 0 if their DIMs were greater than the randomly-assigned, dummy DIM for the outcome disease (just as had been done in case records). Thus, there was equal "opportunity" for risk factor diseases to be counted as present in both cases and controls.

Statistical Analysis

All statistical analyses were carried out using the Statistical Analyses System (SAS Institute, Inc., 1985). The occurrences of diseases were expressed as lactational incidence rates (Erb and Martin, 1980).

A 3-stage process was used to model each outcome disease. In the first stage, 2 x 2 chi-square tests were done to relate each outcome to each potential risk factor disease. Only risk factor diseases associated at $P \leq .10$ with the outcome in these unconditional chi-square tests were advanced to the second stage.

The second modelling stage tested (for each outcome disease) a multiple logistic regression model that included all the risk factor diseases that passed the first screening stage, plus parity, season, cow's milk-yield class, and herd milk-yield class. Parity classes were 2, 3-4, 5-6, and >6; for dystocia and cyst there was also a class for first lactation. If the parity classes included first lactation, the entire edited set of 61,124 records was used and the milk yield classes for both cow and herd were from the current lactations; otherwise, records from first lactations were excluded, the sample size was 41,989, and the milk yields were from the previous lactation. Calving season had 2 classes (March - August and September - February) for most disorders; for early and late metritis there were 3 classes (fall = September - December, spring = January - April, summer = May - August). Wald's test (the ratio of the logistic regression coefficient and it's standard error related to the Z-distribution with 1 d.f.) was used to test the significance of the terms in the model. Any variables not significant at $P \leq .10$ were removed and the logistic regression was rerun with the more parsimonious set of risk factors. Wald's tests were done again and the process was continued until a model was obtained in which all variables were significant at $P \leq .10$.

In the third stage of the modelling, community was forced into all logistic multiple regression models and the level of significance was lowered to 5%. Any predictor variable (except community) with $P > .05$ by Wald's test was removed and the reduced model was rerun until final models were obtained in which the only variables were community plus those with coefficients significant at 5%. (For prolapsed uterus, prolapsed vagina, and abortion it was not possible to obtain solutions when the models included community; community was removed for these 3 outcomes but the 5% level of significance still was used.)

RESULTS AND DISCUSSION

The likelihood ratio statistics (G^2) for all models were non-significant, implying good fits to the data.

Occurrence

There were 61,124 Finnish Ayrshire dairy cattle in the study population. One-third (20,384) of the cows were treated at least once by a veterinarian for some kind of disease (Table I). These 20,384 cows had 30,188 first treatments. Twenty % of all of the cows were treated for at least one reproductive disorder; reproductive disorders made up 46.9 % of first treatments by a veterinarian. The lactational incidence rates are typical of those observed in other epidemiologic studies, even though most other studies were of Holstein-type or Friesian-type cattle. Even with such a large data set, however, the number of cases of some diseases (especially prolapsed uterus, prolapsed vagina, and indoor hypomagnesemia) was limited.

The median days in milk at diagnoses were similar to those found by Dohoo and Martin (1984) and Erb et al. (1984) (Table I).

Host characteristics

The risks of dystocia (after the first lactation), retained placenta, and cyst increased with increasing parity (as has been noted before: Bartlett et al. 1986, Bendixen et al., 1986; Bendixen et al., 1987; Coleman et al., 1985; Dohoo et al., 1984; Erb and Martin, 1980; Erb et al., 1985; Markusfeld, 1987; Thompson et al.; 1983) (Tables II, III, VI). Contrary to some reports (Dohoo et al., 1984; Erb and Martin, 1980; Markusfeld, 1987) but consistent with others (Coleman et al., 1985; Curtis et al., 1985; Erb et al., 1985; Etherington et al., 1985; Martinez and Thibier, 1984), risk of neither early nor late metritis was related to parity (Table IV,VII). Parity was also a significant risk factor for silent heat and other infertility, which decreased with increasing parity (Tables V, VIII). Parity did not influence the risks of prolapses or of abortion (Table IX), although Markusfeld (1987) reported that parity was related (.05 < P < .10) to prolapsed uterus in Israeli Friesian cows.

The cows who calved during the dark, stabling season (September-February) had higher risks of early metritis, silent heat, cyst, other infertility, and perhaps late metritis than those calving during the light season. There was no influence of season for the other reproductive diagnoses. However, previous studies suggested increased risk of dystocia for winter calvings (Bendixen et al., 1986; Erb and Martin, 1980; but not Dohoo et al., 1984). Risk of retained placenta was increased in the fall in Erb and Martin (1980), decreased in the fall in Muller and Owens (1974) and also in Bendixen et al. (1987) (but only in Swedish Red cattle -- not in Swedish Friesians), and was not related to season in Dohoo et al. (1984). Increased fall risk of metritis was found in Erb and Martin (1980) but not Dohoo et al. (1984). Increased risk of cystic ovary among cows who calved in the winter was reported before (Bane, 1964, Dohoo et al., 1984; Erb and

Martin, 1980; but not Bartlett et al., 1986 or Hackett and Batra, 1985). No seasonal patterns of risk were found for the prolapses or for abortion; the latter agrees with Dohoo et al. (1984).

Increased herd milk yield in the previous or current lactation increased the risks of dystocia, retained placenta, early and late metritis, and cyst; other studies did not examine herd yield. The risks of retained placenta, early metritis, silent heat, other infertility, and abortion also increased with an increase in individual-cow's previous-lactation milk yield. However, previous studies found no relationship between previous milk yield (or genetic potential) and retained placenta (Curtis et al., 1985; Dohoo et al., 1984; Erb et al., 1981a; Shanks et al., 1978), early metritis (Curtis et al., 1985; Dohoo et al., 1984; Shanks et al., 1978), late or unspecified metritis (Dohoo et al., 1984; Erb et al., 1981b; Erb et al., 1985), or ovarian cyst (Dohoo et al., 1984; Erb et al., 1981b; Johnson et al., 1966; Shanks et al., 1978; Whitmore et al., 1974; Wiltbank et al., 1953; but not Erb et al., 1985). The differences between the results of the cited studies and the results reported here could be due to the increased power in this study, to breed, or to country.

Prior studies reported increased total services or incidence of repeat breeder cows with higher previous- or early-lactation milk yield or genetic potential (Erb et al., 1985; Hamudikuwanda et al., 1987; Hewitt 1968; Shanks et al., 1978). If a large percentage of cows in our diagnostic category "other infertility" are repeat breeders, then all these reports are consistent.

Disease

Relationships among the reproductive disorders are combined in Figure 1 from the ten logistic regression models. Exogenous variables (parity, calving season, cow and herd milk yield in previous lactation, and community) and non-reproductive diseases were excluded from the figure. For each arrowhead there is an odds ratio that gives a likelihood of diagnosing that particular outcome disease (comparing the cows with the history of the risk factor disease to those without the history of the risk factor disease). One has to consider that the arrows come from ten different populations in which diagnoses of risk factor diseases had been removed if the time sequencing was inappropriate (Tables II - IX). Therefore, it is possible to see e.g., that the cows with silent heat had increased odds of (earlier) cyst and that cows with cyst had increased odds of (earlier) silent heat.

Seventeen out of 23 veterinary diagnoses were the risk factors for at least one reproductive disorder.

There is a growing body of literature which indicates that parturient paresis is a risk factor for several reproductive disorders; our data are in agreement. Parturient paresis is related to dystocia (Erb et al., 1985; Thompson et al., 1983; but not Dohoo and Martin, 1984), retained placenta (Bendixen et al., 1987; Erb et al., 1985; Markusfeld, 1987; Thompson et al., 1983; but not Dohoo et al., 1984), metritis (Dohoo et al., 1984; Erb et al., 1985; Markusfeld, 1987), and uterine prolapse (Markusfeld, 1987). Also, hypocalcemia is more common in dairy and beef cows with uterine prolapse and in beef cows with dystocia than in controls (Richardson et al., 1981; Risco et al., 1984). These associations are independent, because of all the cited analyses except Bendixen et al. (1987) and those for hypocalcemia controlled for the effects of (at least some of) the other reproductive disorders while examining the associations involving parturient paresis.

Similarly, other studies have shown (as we have with these results) that dystocia, retained placenta, metritis, and cystic ovary occur as a complex. Specifically, dystocia is a risk factor for retained placenta (Bendixen et al., 1987; Coleman et al., 1985; Thompson et al., 1983; but not Dohoo and Martin, 1984; or Erb et al., 1981), dystocia is a risk factor for metritis (Coleman et al., 1985; Dohoo and Martin, 1984; Erb et al., 1981; Erb et al., 1985), and dystocia is a risk factor for cystic ovary (direct effect in Dohoo and Martin, 1984; indirect effects in Erb et al., 1985; Etherington et al., 1985; but no effects in Coleman et al., 1985; Erb et al., 1981b). Retained placenta is a risk factor for metritis (Callahan et al., 1971; Coleman et al., 1985; Dohoo and Martin, 1984; Erb et al., 1981b; Erb et al. 1985; Etherington et al., 1985; Sandals et al., 1979), and metritis is a risk factor for cystic ovary (Erb et al., 1981b; Erb et al., 1985; Etherington et al., 1985 for pyometritis but not for early metritis; but not Coleman et al., 1985; Dohoo and Martin, 1984). Some of these studies (Dohoo and Martin, 1984; Erb et al., 1985; Markusfeld, 1987; Thompson et al., 1983) explicitly controlled for parturient paresis, so the interrelationships are not due merely to common-causal association.

Etherington et al. (1985) reported that anestrus was predicted by late metritis (consistent with our results), but not by retained placenta, early metritis, or cystic ovary. Cystic ovary was a risk factor for late metritis in our data and in Dohoo and Martin (1984).

Ketosis was not a risk factor for early metritis in our data (<42d) or in Curtis et al. (1985; <30d) but was related to metritis from 22d to 60d in Dohoo and Martin (1984). Also in Dohoo and Martin (1984), parturient paresis, late metritis, and foot or leg (but not dystocia, retained placenta, cystic ovary, abomasal displacement, ketosis, traumatic reticuloperitonitis, mastitis, or teat injury) were risk factors for abortion; our results (except for retained placenta) are in disagreement with their results.

Ketosis was a risk factor for 3 non-parturient reproductive disorders: silent heat, cyst, and other infertility. Interestingly, cow milk yield in the previous or current lactation also was significant in each of these models (Tables V, VI, VIII).

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TABLE I

Incidences of veterinary diagnoses in 61,124 (including 41,989 multiparous) Finnish Ayrshire cows (calvings in 1983 in 5,661 herds)

Diagnosis	Lactational incidence rate(%) All	Lactational incidence rate(%) Multiparous	Median day postpartum of diagnosis
Dystocia	1.2	1.0	0
Prolapsed uterus	0.2	0.2	0
Retained placenta	4.4	5.3	2
Early metritis	2.3	2.2	16
Silent heat	4.9	4.5	89
Cyst	6.8	7.5	89
Prolapsed vagina	0.1	0.1	94
Late metritis	1.1	1.1	104
Other infertility	2.1	2.0	129
Abortion	0.4	0.4	--
Parturient paresis	4.0	5.3	1
Udder edema	0.4	0.3	14
Non-parturient paresis	0.9	1.2	43
Disorder of the Abomasum	0.5	0.6	21
Hypomagnesemia, indoor	0.1	0.2	22
Ketosis	6.0	6.6	28
Hypomagnesemia, outdoor	0.4	0.4	44
Rumen acidosis	0.3	0.3	56
Traumatic reticuloperitonitis	0.6	0.5	113
Acute mastitis	6.2	7.0	44
Teat	2.9	3.1	95
Chronic mastitis	1.7	2.0	103
Foot or leg injury	1.9	1.8	65

TABLE II

Final logistic regression model for dystocia (61,124 Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
Parity				
1	0.44	0.07	2.1	1.7 - 2.7
2	-0.32	0.10	1.0	
3-4	-0.12	0.08	1.2	0.9 - 1.6
5-6	-0.08	0.09	1.3	0.9 - 1.7
>6	0.08	0.11	1.5	1.1 - 2.1
Cow milk yield in current lactation (305 day, 4% FCM, kg)				
<4740	0.23	0.07	1.3	0.7 - 2.3
4740 - 5899	0.01	0.07	1.2	1.0 - 1.6
5900 - 7059	-0.20	0.08	1.0	
≥7060	-0.04	0.10	1.2	0.9 - 1.6
Herd milk yield in current lactation (305 day, 4% FCM, kg)				
<4870	-0.16	0.10	1.0	
4870 - 6149	-0.02	0.06	1.2	0.9 - 1.5
≥6150	0.19	0.07	1.4	1.0 - 1.9
Parturient paresis	2.28	0.13	9.7	7.5 - 12.6
(76 communities)				

TABLE III

Final logistic regression model for retained placenta (41,989 multiparous Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
Parity				
2	-0.29	0.04	1.0	
3-4	-0.09	0.03	1.2	1.1 - 1.4
5-6	0.07	0.04	1.4	1.2 - 1.6
>6	0.31	0.04	1.8	1.6 - 2.1
Cow milk yield in previous lactation (305 days, 4% FCM, kg)				
<4740	-0.20	0.06	1.0	
4740 - 5899	-0.03	0.04	1.2	1.0 - 1.4
5900 - 7059	0.02	0.04	1.2	1.0 - 1.5
≥7060	0.20	0.05	1.5	1.2 - 1.8
Herd milk yield in previous lactation (305 days, 4% FCM, kg)				
<4870	-0.04	0.07	1.1	0.9 - 1.3
4870 - 6149	-0.12	0.04	1.0	
≥6150	0.16	0.05	1.3	1.2 - 1.5
Dystocia	1.41	0.13	4.1	3.1 - 5.3
Abortion	2.98	0.23	19.8	12.6 -31.0
Parturient paresis	0.87	0.08	2.4	2.0 - 2.8
(76 Communities)				

TABLE IV

Final logistic regression model for early metritis (41,989 multiparous Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
Calving season				
January-April	0.12	0.05	1.6	1.3 - 1.9
May-August	-1.33	0.06	1.0	
September-December	0.21	0.05	1.7	1.4 - 2.1
Cow milk yield in previous lactation (305 days, 4% FCM, kg)				
<4740	-0.18	0.10	1.0	
4740 - 5899	-0.14	0.06	1.1	0.8 - 1.4
5900 - 7059	0.06	0.06	1.2	1.0 - 1.5
≥7060	0.26	0.07	1.5	1.2 - 2.1
Herd milk yield in previous lactation (305 days, 4% FCM, kg)				
<4870	-0.50	0.13	1.0	
4870 - 6149	0.10	0.07	1.7	1.1 - 2.4
≥6150	0.49	0.08	2.7	1.8 - 4.0
Dystocia	1.16	0.19	3.2	2.2 - 4.6
Retained placenta	1.49	0.10	4.4	3.7 - 5.3
Cyst	1.69	0.42	5.4	2.4 -12.4
Abortion	1.31	0.33	3.7	2.0 - 7.1
Parturient paresis	0.38	0.12	1.5	1.2 - 1.8
Disorder of the abomasum	1.45	0.29	4.3	2.4 - 7.6
Traumatic reticuloperitonitis	1.86	0.48	6.4	2.5 -16.5
Acute mastitis	1.09	0.12	3.0	2.3 - 3.8
Foot or leg injury	1.81	0.23	6.1	3.9 - 9.6
(76 communities)				

TABLE V

Final logistic regression model for silent heat (41,989 multiparous Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
Parity				
2	0.28	0.04	1.6	1.4 - 1.9
3-4	0.06	0.04	1.3	1.1 - 1.5
5-6	-0.21	0.05	1.0	
>6	-0.12	0.06	1.1	0.9 - 1.3
Calving season				
Sept.-Feb./ March-August	0.66	0.12	1.9	1.5 - 2.4
Cow milk yield in previous lactation (305 days, 4% FCM, kg)				
<4740	-0.49	0.06	1.0	
4740 - 5899	-0.18	0.04	1.4	1.2 - 1.6
5900 - 7059	0.14	0.04	1.6	1.4 - 1.9
≥7060	0.67	0.05	3.2	2.7 - 3.9
Retained placenta	0.27	0.10	1.3	1.1 - 1.6
Early metritis	0.38	0.13	1.5	1.1 - 1.9
Cyst	0.46	0.09	1.6	1.3 - 1.9
Late metritis	1.09	0.20	3.0	2.0 - 4.4
Abortion	0.72	0.29	2.1	1.2 - 3.7
Ketosis	0.42	0.08	1.5	1.3 - 1.8
(76 communities)				

TABLE VI

Final logistic regression model for cyst (61,124 Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
Parity				
1	-0.24	0.04	1.0	
2	-0.05	0.03	1.2	1.1 - 1.3
3-4	0.04	0.03	1.3	1.2 - 1.4
5-6	0.07	0.04	1.4	1.2 - 1.5
>6	0.16	0.05	1.5	1.3 - 1.7
Calving season				
Sept.-Feb./ March-August	0.50	0.04	1.6	1.5 - 1.8
Cow milk yield in current lactation (305 days, 4% FCM, kg)				
<4740	-0.50	0.03	1.0	-
4740 - 5899	-0.29	0.03	1.2	1.1 - 1.4
5900 - 7059	0.18	0.03	2.0	1.8 - 2.1
≥7060	0.62	0.05	3.1	2.6 - 3.6
Herd milk yield in current lactation (305 days, 4% FCM, kg)				
<4870	-0.32	0.06	1.0	-
4870 - 6149	0.12	0.03	1.5	1.3 - 1.8
≥6150	0.20	0.04	1.7	1.4 - 2.0
Early metritis	0.39	0.09	1.5	1.2 - 1.8
Silent heat	0.37	0.09	1.5	1.2 - 1.7
Prolapsed vagina	1.20	0.46	3.3	1.3 - 8.2
Late metritis	1.05	0.15	2.9	2.1 - 3.8
Other infertility	1.03	0.13	2.8	2.2 - 3.6
Ketosis	0.37	0.06	1.4	1.3 - 1.6
(76 communities)				

TABLE VII

Final logistic regression model for late metritis (41,989 multiparous Finnish Ayrshire cows).

Parameter	β	SE(β)	OR	95% C.I. (OR)
Calving season				
January-April	-0.37	0.07	1.0	-
May-August	0.10	0.07	1.6	1.3 - 2.0
September-December	0.26	0.07	1.9	1.5 - 2.4
Herd milk yield in previous lactation (305 days, 4% FCM, kg)				
<4870	-0.13	0.13	1.0	
4870 - 6149	-0.22	0.08	0.9	0.6 - 1.4
≥6150	0.35	0.08	1.6	1.1 - 2.4
Retained placenta	0.90	0.15	2.5	1.8 - 3.3
Early metritis	0.50	0.22	1.6	1.1 - 2.5
Cyst	0.80	0.15	2.2	1.7 - 3.0
Other infertility	1.28	0.27	3.6	2.1 - 6.1
Abortion	1.24	0.41	3.5	1.5 - 7.8
(76 communities)				

TABLE VIII

Final logistic regression model for other infertility (41,989 multiparous Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
Parity				
2	0.35	0.06	1.7	1.4 - 2.1
3-4	-0.04	0.06	1.2	1.0 - 1.4
5-6	-0.19	0.07	1.0	-
>6	-0.12	0.09	1.1	0.8 - 1.4
Calving season				
Sept.-Feb./ March-August	0.26	0.07	1.3	1.1 - 1.5
Cow milk yield in previous lactation (305 days, 4% FCM, kg)				
<4740	-0.55	0.09	1.0	
4740 - 5899	-0.23	0.06	1.4	1.1 - 1.8
5900 - 7059	0.13	0.06	2.0	1.5 - 2.5
≥7060	0.65	0.07	3.3	2.5 - 4.4
Early metritis	0.55	0.17	1.7	1.2 - 2.4
Cyst	0.97	0.10	2.6	2.2 - 3.2
Late metritis	0.88	0.26	2.4	1.4 - 4.1
Ketosis	0.34	0.12	1.4	1.1 - 1.8
(76 communities)				

TABLE IX

Final logistic regression models for prolapsed uterus, abortion and prolapsed vagina (41,989 multiparous Finnish Ayrshire cows)

Parameter	β	SE(β)	OR	95% C.I. (OR)
	Outcome = prolapsed uterus			
Parturient paresis	3.06	0.25	21.3	13.1 - 34.6
	Outcome = prolapsed vagina			
Teat injury	1.43	0.60	4.2	1.3 -13.5
	Outcome = abortion			
Cow milk yield in previous lactation (305 days, 4% FCM, kg)				
<4740	0.05	0.16	1.0	
4750 - 5899	-0.25	0.13	1.4	1.1 - 1.8
5900 - 7059	-0.14	0.06	2.0	1.5 - 2.5
≥7060	0.34	0.07	3.3	2.5 - 4.4
Retained placenta	2.43	0.18	11.4	7.9 -16.2
Early metritis	0.83	0.36	2.3	1.1 - 4.7

LEGEND FOR FIGURE

Figure 1. Relationships among reproductive disorders (Tables II-IX). Numbers near arrowheads are odds ratios from ten separate logistic regressions; the arrowheads impinge upon the dependent variables of the relationships summarized by the odds ratios.

* Parturient paresis also was a risk factor.
** Ketosis also was a risk factor.

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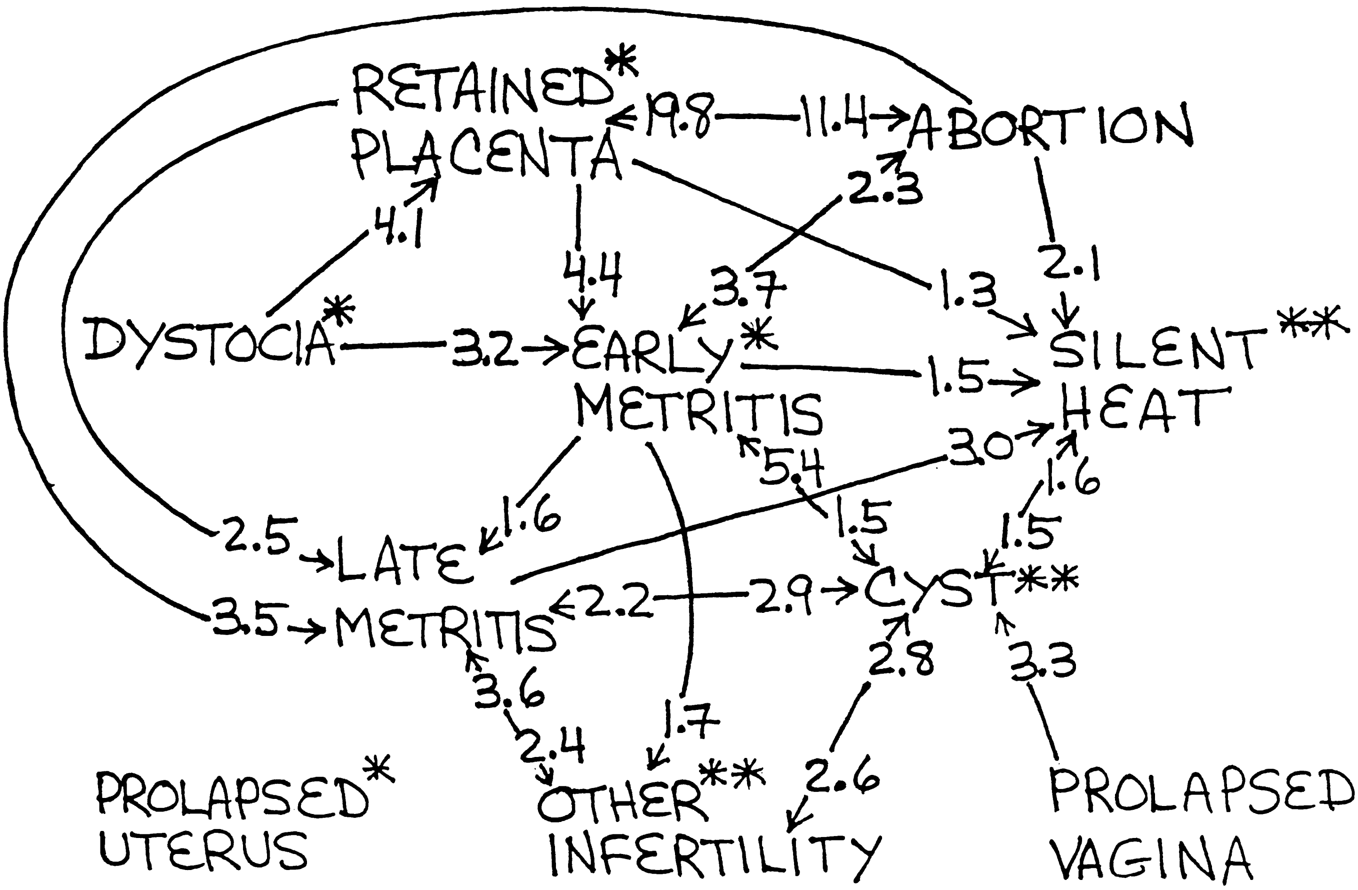

Grohn et. al. This is a photocopy of Figure 1. After a professional artist has redrawn the figure, we will send a photograph of it to the Editor-in-Chief.