Key Performance Indicators for the UK national dairy herd

A study of herd performance in 500 Holstein/Friesian herds for the year ending 31st August 2019

Dr. James Hanks
&
Dr. Mohamad Kossaibati

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Veterinary Epidemiology & Economics Research Unit (VEERU),
School of Agriculture Policy & Development,
University of Reading,
P.O.Box 237
Reading,
RG6 6AR
panveeru@panveeru.net

University of Reading

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Executive Summary

This is the tenth annual study of Key Performance Indicators (KPI) from a cross-section of 500 dairy herds that milk record with National Milk Records (NMR). Starting in 2010, each study covers over 70 different parameters describing aspects of fertility, production and health. The principal objective of the studies is to provide farmers and their technical advisers with accurate and current descriptions of performance levels as the basis for discussion and target setting at herd level.

The method of calculation for the majority of the 38 parameters described in this study is identical in all studies. Consequently the studies provide both a description of current performance of the national dairy herd and how this has changed over the 10 year period.

For each parameter the 500 herds are arranged in ascending/descending order. The median is then the average of the middle two herds (herds in position 250 and 251). It follows that 50% of herds fall above and 50% of herds fall below this median value.

Herd size:
- Median **herd size** in 2019 is 169 cows. One herd in four has more than 249 cows and one herd in four has less than 118 cows.
- While the median herd size has increased by 40 cows since 2010, the herd sizes have not changed markedly in the last 3 years.

Longevity:
- The median **age at first calving** in 2019 is 2.3 years. The median **age at exit** is 6.0 years giving 3.7 years of productive life. Both age at first calving and age at exit are lower than in 2010, but have remained relatively constant since 2017.
- The median **lactations per cow at exit** in 2019 is 3.6 lactations. This is 0.3 less than in 2010 but has been relatively constant since 2016.
- The median **culling rate** in 2019 is 27%. This has increased from 24% since 2010 but remained relatively constant since 2016.

Fertility:
- The median **calving interval** in 2019 is 401 days. There has been a steady reduction from 424 days in 2010.
- The median **conception rate** in 2019 is 35%. There has been a gradual increase of 3% since 2010 but the rate is unchanged from 2018. There remains a wide variation in conception rate between herds. One herd in four has a conception rate of 29% or less.
- The median % of inter-service intervals at 18-24 days (**heat detection)** in 2019 is 37%. This continues an upward trend of 7% since 2010. However, one herd in four still detects under 28% of service returns at the next available oestrus.
- The median **submission rate** in 2019 is 39%. This has steadily increased from 27% in 2010.
- The median **pregnancy rate** in 2019 is 14%. This has steadily increased from 9% in 2010.
- The median **% cows served by day 80** (after calving) in 2019 is 58%. This is 12% higher than in 2010 with most improvement occurring before 2014. In 2019 one herd in four served less than 44% of cows at least once by day 80 after calving.
- The median **% conceived by day 100** (after calving) in 2019 is 34%. This is 8% higher than in 2010 although there has been no change since 2017.

Milk production:
- The median **Lifetime milk per cow per day** (since birth) in 2019 is 13.0kg. This has increased by 2.5kg since 2010 with annual increases every year since 2013.
- The median **Milk per cow per year** (milk per cow place) in 2019 is 8,737kg. There was a 3.8% increase of 291kg since the 2018 study. Since 2010 the median milk/cow/year has increased by 14% (1,072kg).
- The median **protein %** content of milk has increased from 3.27% in 2010 to 3.32% in 2019.
- The median **fat %** content of milk has increased from 3.96% in 2010 to 4.02% in 2019.

Somatic Cell Counts (SCC):
- The median **herd SCC** in 2019 is 171,000 cells / ml milk. This is 39,000 less than in the 2010 study. The median herd SCC has followed a steady downward trend since 2010. The median herd SCC in 2010 (214,000) was bettered by 375/500 (75%) of herds in 2019.
- 346 (69%) of the 500 herds had a herd SCC below 200,000 cells in 2019. This contrasts with 218/500 (44%) herds in the 2010 study.
- The median level of **chronic high SCC cows** in 2019 is 9%. There has been a consistent improvement (decline) from 14% in 2010. The strong association ($R^2 > 0.7$) between the % chronic high SCC cows and herd SCC occurred in every study. In 2019, 65/500 (13%) herds recorded over 15% chronic cows, down from 207 (41%) in the original 2010 study. In 2019, 310/500 (62%) herds recorded less than 10% chronic cows, up from 121 (24%) in 2010.
- The median **% cows completing lactations with no high SCC recordings** in 2019 is 46%. This has increased steadily since 2010 when 33% of lactations recorded no high SCCs.

Mastitis: Cases are not consistently recorded across all 500 herds. Since 2016 a subset of the 500 herds (recording 5 or more cases/100 cows/year) has been included for analysis of mastitis incidence.
- Median mastitis incidence in the 2019 subset is 30 cases per 100 cows per year.
- Since 2016, the incidence rate has reduced by 6 cases per 100 cows per year although there is a wide range between the best and worst herds.

Johne's disease (JD): Two subsets of the 500 herds were analysed: 233 herds that have regular quarterly JD testing for the previous 2 years, and; 105 herds that have regular quarterly testing for at least the previous 7 years.
- In the sample of 233 herds, the median percentage of cows present on 1st October 2019 that had multiple (more than one) high JD test result is 3.2%. The equivalent figure in the 2018 analysis was 3.5%. There were 21 herds (9%) that had no cows with more than one high test.
- In the sample of 233 herds, the median percentage of cows with any high test result(s) is 9.1% of cows. This has risen from 8.6% of cows in 2018. There were just two herds (<1%) that had no cows with any high test result(s).
- Among the 105 herds regularly testing for at least 7 years, the percentage of cows with more than a single high test result peaked close to 7% between August 2015 and July 2016. Since then the prevalence has more than halved to the current level below 3.5%.

The data paint a picture of the UK dairy sector showing continuing increases in milk production KPIs (milk per cow per year and milk per cow per day of life) and steady improvements in fertility parameters and SCC parameters. Herd size appears to have stabilized in recent years, after increasing in the first half of the current decade. Along with this, the productive life of cows appears static at just over 3½ lactations, with herd turnover replacing over ¼ of cows every year (culling rate 27%).

Section 1: Description of the study and methods used

Introduction

This is the 10th annual study describing key indicators of production, fertility and health in commercial black and white dairy herds in the United Kingdom. The Key Performance Indicators (KPIs) are based on milk recording data from 500 commercial black and white herds for the 12 month period ending on 31st August 2019. Herd selection used random numbers to ensure a representative cross-section of all herds (good, bad and indifferent) that milk record with National Milk Records (NMR).

The range in performance across these herds is described for 38 parameters clearly showing the wide differences in performance, as well as huge potential for improvement, in commercial dairy herds. This includes six additional parameters (including mastitis rate/100 cows in milk/year) shown since the 2016 study. The principal objective throughout has been to provide farmers and technical advisers with accurate and up-to-date information on the variation in performance of commercial dairy herds.

The calculations used to generate these parameters are identical to those used by the InterHerd+ program allowing farmers and technical advisers to compare the performance of any milk recording herd directly with the 500 herd sample that is representative of the national performance. In other words, for each parameter: ***"Is the performance of my herd typical/outlying, good/acceptable/poor when compared to the 500 herds?"***. This prompts discussion around: ***"Why is a parameter where it is? Which parameters could/should we prioritise/improve and what are the likely implications?"*** If this promotes discussion between farmers and their technical advisers into the different causes and options for improvement then the study has served its primary purpose.

Following the analysis of individual parameters there is a section on trends since 2010 for a selection of the KPIs. Further sections discuss their practical use by farmers and advisers. A KPI template of 80 parameters for use in InterHerd+ is also available for users to update the KPI parameters to the target values from the 2019 study.

Parameter description

For 35 parameters described in this study (out of total of 38), the performance level of each of the 500 herds (252 herds for mastitis rate) is presented as a bar chart. The herds are displayed from "best" to "worst", in ascending or descending order depending on whether it is generally preferable to have a low value (e.g. SCC, calving interval) or a high value (e.g. dry period cure, conception rate). The "best" is always on the left side, nearest the vertical Y axis. For each parameter, a median (middle) value and inter-quartile range values (the level achieved by the middle 50% of herds) are also derived.

The **target** value proposed for each parameter (and included in the KPI template) is the level achieved by the **"best" 25%** of the herds for that parameter. In other words, **the target is set at a level that is currently achieved (or exceeded) by one in four dairy herds** over the last year.

The sample of herds

The source of data is the monthly milk records obtained by National Milk Records (NMR). The 500 herds used in the study all fully milk record on a monthly assisted basis and are approximately 10% of herds recorded by NMR. Herds were selected using random numbers to ensure a representative cross-section of the sample. The herds are all predominantly comprised of black and white breeds (Holstein, Holstein-Friesian, Friesian) and have recorded for a minimum of two years. Where possible the same herds used in the 2018 study were maintained for the 2019 herds' sample. Herds with poorly recorded fertility data (inadequate recording of services and pregnancy diagnoses), as well as herds no longer recording, were replaced with new herds, again selected using random numbers. In total 454 herds (91%) were in both the 2018 and 2019 studies.

Herd size for the 500 herds in the 2019 study ranged from minimum 45 to maximum 938 cows, with a median value of 169 cows, as shown in Figure 1. In the sample 61% of herds were comprised of less than 200 cows, with 36 herds containing over 400 cows.

Figure 1. Herd size of the 500 herds in the 2019 study
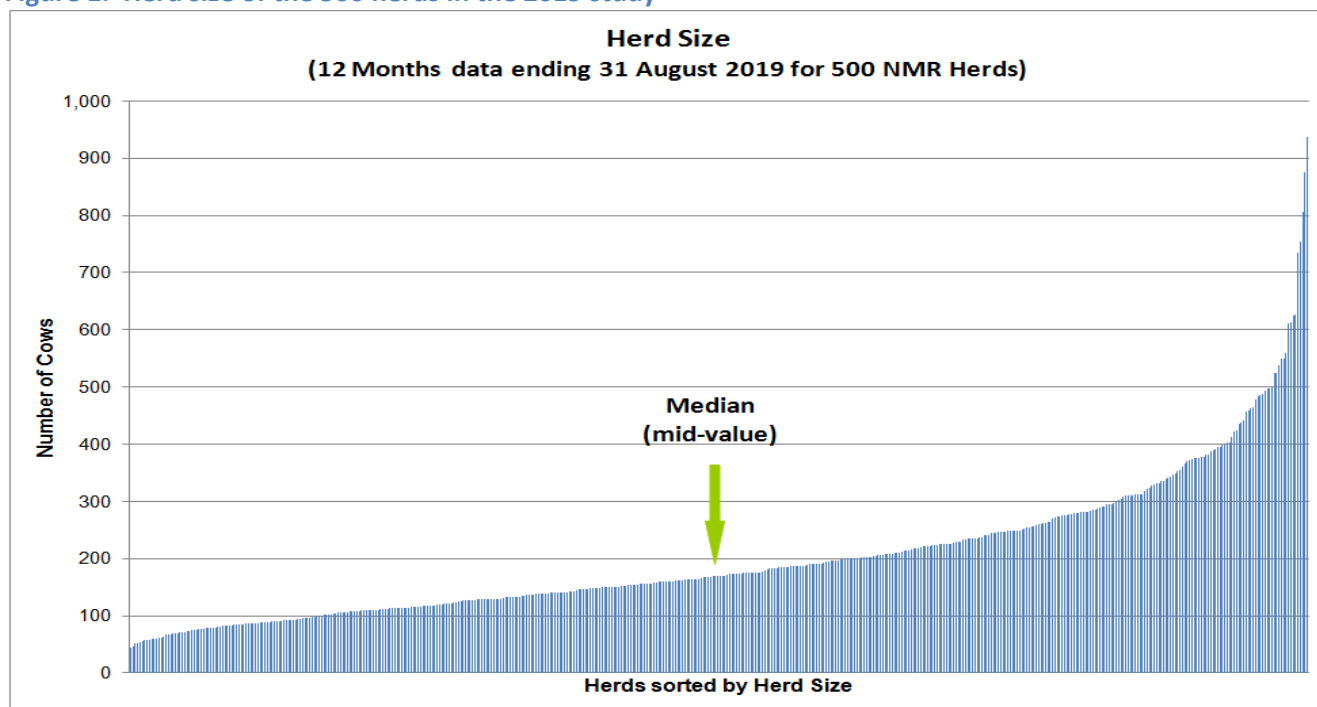
The parameters

To minimize the impact of short term seasonal variations, the key performance indicator values are calculated using data recorded over a full 12 month period. They represent the consolidated or average performance levels achieved by each herd for the period from 01 September 2018 to 31 August 2019. The definitions of each parameter are detailed in Appendix 2.

The results of the study are summarized in Tables 1(a) & 1(b).
For each parameter, four statistics are presented:

1. The **median**: The middle value. If the performance levels of all herds are arranged in ascending order, the median is the performance of the middle herd (or the average of the middle two herds in an even number of herds). Half the herds do better and half do worse than the median value.
2. The **first quartile (25% value) and third quartile (75% value)**. With the median, these split the herds into four equal groups. The first and third quartile values are the lower and upper limits of performance achieved by the middle 50% of herds. 25% achieve "better" and 25% achieve "worse" than the limits for that parameter.
3. The **target** value used by InterHerd+ is the level achieved or bettered by 25% of the herds in the study. This value is the "**better**" of the **first quartile (25%) or third quartile (75%) values.** For parameters like somatic cell count, culling % and calving interval the target will be the 25% (lower) value, while for others (conception %, protein %, dry period cure %) it will be the 75% (higher) value.
4. The **inter-quartile range** is the difference between the performance of the best and worst 25% of herds (i.e. the difference between the **first quartile (25% value) and third quartile (75% value)**. This gives an impression of how widely herds in the middle 50% differ.

The position of these values is graphically displayed in Figure 2.

Throughout this report the parameter value is displayed on the vertical Y axis and bars representing the study herds are arranged along the horizontal X axis. The "best" performing herd is nearest the vertical Y axis with the worst performing herd furthest away.

The parameter described in Figure 2 is the herd average SCC so the target value is at the lower end of the inter-quartile range (as a low average SCC is preferable to a high average SCC).
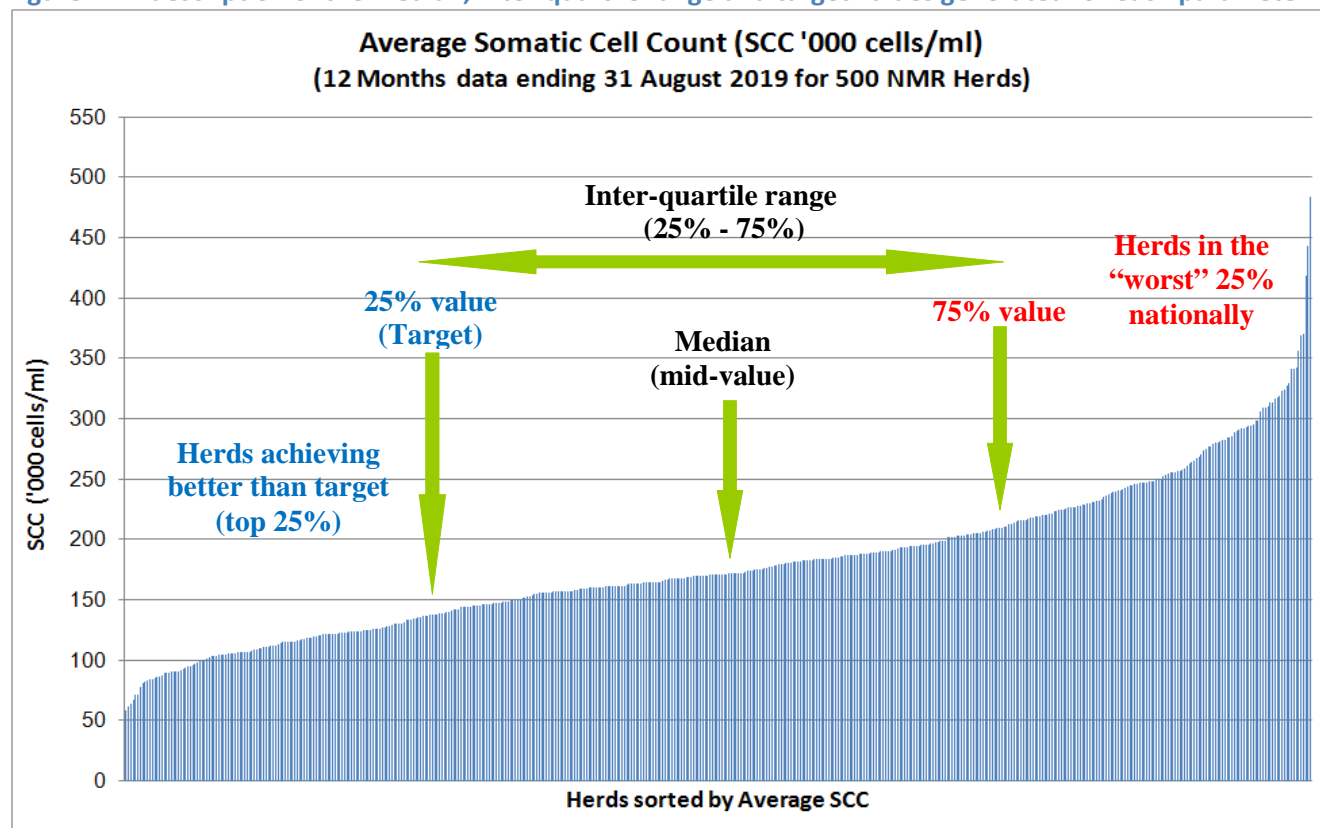
Changes to studies from earlier years

1. **Mastitis Key Performance Indicators:** The results of the study summarized in Tables 1(a) & 1(b) include 4 parameters relating to mastitis, including the herd overall Mastitis rate (cases/100 cows in milk/year). This is the fourth year that mastitis related parameters have been derived from the survey herds, reflecting the significant improvement in the level of reporting of mastitis by farmers in recent years. While in 2012 less than 20% of herds reported any mastitis, this has risen to over 50% of herds in 2019. For the purpose of this study any herd that recorded over 5 cases/100 cows in milk/ year was considered to record mastitis. The mastitis KPIs in this report are calculated based on 252 of the 500 herds (50%) that qualified this year.

2. **305 day milk/protein/fat yields:** In previous reports up to that of 2015, 305 day yield parameters were calculated from all lactations, including lactations that were shorter than 305 days. In this report, as in all years since 2016, the lactation must be at least 305 days long for inclusion in the calculation. This report also details the 305 day yields (total yield up to and including the 305th day of lactation) of fat and protein. As with the milk yield, these parameters are calculated from lactations that were at least 305 days in length. Note that the exclusion of lactations shorter than 305 days does not apply to the calculation of the **overall lactation yield**. In some herds, when many cows have lactation lengths below 305 days, this can result in lactation yields smaller than the 305 day yields.

3. This is the second year the report presents new 'KPIs' related to the sero-prevalence of Johne's disease, shown in Appendix 1. These are based on results from a sub-group of 233 herds from the 500 herds which have been regularly (quarterly) 'whole herd' tested using the milk ELISA over at least the previous 2 years.

Acknowledgements

Section 2: KPI results for the year ending 31 August 2019

Table 1(a)   Summary of Key Performance Indicators derived from analysis of 500 NMR milk recording herds for the year ending 31 August 2019 – Culling, fertility & milk parameters.

Parameter	Median (1)	1st - 3rd quartile (25% - 75%) (2)	Target (3)	Inter-quartile range (4)
A. Culling rate	27%	22% - 33%	**22%**	11%
B. Percentage culled (off take) 100 days after calving	5%	3% - 7%	**3%**	4%
C. Age at exit (years)	6.0	5.4 - 6.7	**6.7**	1.3
D. Age at exit by lactations	3.6	3.2 - 4.0	**4.0**	0.8
E. Percentage Served by day 80	58%	44% - 68%	**68%**	24%
F. Percentage conceived 100 days after calving	34%	25% - 41%	**41%**	16%
G. Calving to 1st service interval (days)	81	71 - 98	**71**	27
H. Calving interval (days)	401	387 - 417	**387**	30
I. Age at 1st calving (years)	2.3	2.1 - 2.5	**2.1**	0.4
J. Conception rate	35%	29% - 42%	**42%**	13%
K. %Service intervals at 18-24 days (Heat detection)	37%	28% - 44%	**44%**	16%
L. Percentage service intervals >50 days	21%	15% - 31%	**15%**	16%
M. %Cows eligible for service served (Submission rate)	39%	28% - 51%	**51%**	23%
N. %Eligible for service that conceived (Pregnancy rate)	14%	10% - 18%	**18%**	8%
O. Lifetime milk / cow / day (kg)	13.0	10.9 - 14.9	**14.9**	4.0
P. Milk / cow / year (kg)	8,737	7,571 - 9,761	**9,761**	2,190
Q. Average protein%	3.32%	3.26% - 3.39%	**3.39%**	0.13%
R. Average fat%	4.02%	3.87% - 4.17%	**4.17%**	0.30%
S. 305-day milk yield (kg)	9,078	7,910 - 10,040	**10,040**	2,130
T. 305-day protein yield (kg)	296	260 - 327	**327**	67
U. 305-day fat yield (kg)	361	318 - 401	**401**	83

(1)   The median is the middle value (so 250 herds were better and 250 were worse than this value).
(2)   The **first quartile (25% value) and third quartile (75% value)** describe the lower and upper limits of performance achieved by the middle 50% of herds. 25%, or one in four, herds achieve "better" and 25% "worse" than the limits for that parameter.
(3)   The **Target** is set at the level achieved or bettered by the **"best" 25% of herds**. **One in four of the 500 herds in the sample achieved this level or better**.
(4)   The inter-quartile range is the difference between the **first quartile (25% value) and third quartile (75% value)**. This gives an impression of how widely herds in the middle 50% differ.

Table 1(b) Summary of Key Performance Indicators derived from analysis of 500 NMR milk recording herds for the year ending 31 August 2019 – Somatic Cell Count (SCC) and mastitis parameters.

Parameter	Median (1)	1st - 3rd quartile (25% - 75%) (2)	Target (3)	Inter-quartile range (4)
V. Herd SCC ('000 cells/ml)	171	136 - 214	136	78
W. % milk samples with **High** SCC (*)	17%	13% - 22%	13%	9%
X. % milk samples with SCC ≥500,000 cells/ml	7%	5% - 9%	5%	4%
Y. % cows with **High** SCC at 1st record in lactation (*)	16%	12% - 21%	12%	9%
Z. % **Chronic** milk samples (**)	9%	6% - 12%	6%	6%
ZA. Dry period cure (High:Low) (***)	77%	69% - 85%	85%	16%
ZB. Dry period protection (Low:Low) (***)	85%	80% - 90%	90%	10%
ZC. % Low at last recording of previous lactation (*)	74%	66% - 81%	81%	15%
ZD. % samples New SCC category (**)	6%	5% - 8%	5%	3%
ZE. % cows dried-off with no High SCC samples in the lactation (*)	46%	37% - 54%	54%	17%
ZF. Threshold Index new high / new low (****)	1.25	1.12 - 1.40	1.12	0.38
ZG. % of cows with New/First/Repeat sample that are Low SCC at next recording (**)	55%	50% - 60%	60%	10%
ZH. % of cows with Chronic sample that are low SCC at next recording (**)	21%	17% - 25%	25%	8%
ZI. Percentage drying off with no mastitis cases[+]	80%	72% - 87%	87%	15%
ZG. Mastitis rate (cases/100 cows in milk/year)[+]	30	18 - 48	18	30
ZK. Cows with Index mastitis case by Day 30[+]	5%	2% - 7%	2%	5%
ZL. Index mastitis rate after Day 30[+]	20%	12% - 29%	12%	17%

(*)   **HIGH** SCC is a milk sample with ≥200,000 cells/ml milk;
      LOW SCC is a milk sample with below 200,000 cells/ml milk
(**)   **CHRONIC** / **NEW** / **FIRST** and **REPEAT** are the Herd Companion categories describing high SCC cows. See Appendix 2 for definitions.
(***) **Dry period protection (High:Low):** The percentage of cows finishing a lactation with a HIGH SCC sample that starts the new lactation with a LOW SCC sample;
      Dry period cure (Low:Low): The percentage of cows finishing a lactation with a LOW SCC sample that starts the new lactation with a LOW SCC sample.
(****) **Threshold Index:** The total cows changing from Low to High SCC divided by the total cows changing from High to Low SCC at consecutive milk recordings.
(1) The median is the middle value (so 250 herds were better and 250 were worse than this value).
(2) The **first quartile (25% value) and third quartile (75% value)** describe the lower and upper limits of performance achieved by the middle 50% of herds. 25%, or one in four, herds achieve "better" and 25% "worse" than the limits for that parameter.
(3) The **Target** is set at the level achieved or bettered by the **"best" 25% of herds**. **One in four of the 500 herds in the sample achieved this level or better**.
(4) The inter-quartile range is the difference between the **first quartile (25% value) and third quartile (75% value)**. This gives an impression of how widely herds in the middle 50% differ.
 +   **The mastitis parameters are derived from a group of 252 herds (within the 500 herds in the study) where mastitis rate >5 cases per 100 cows in milk / year.**
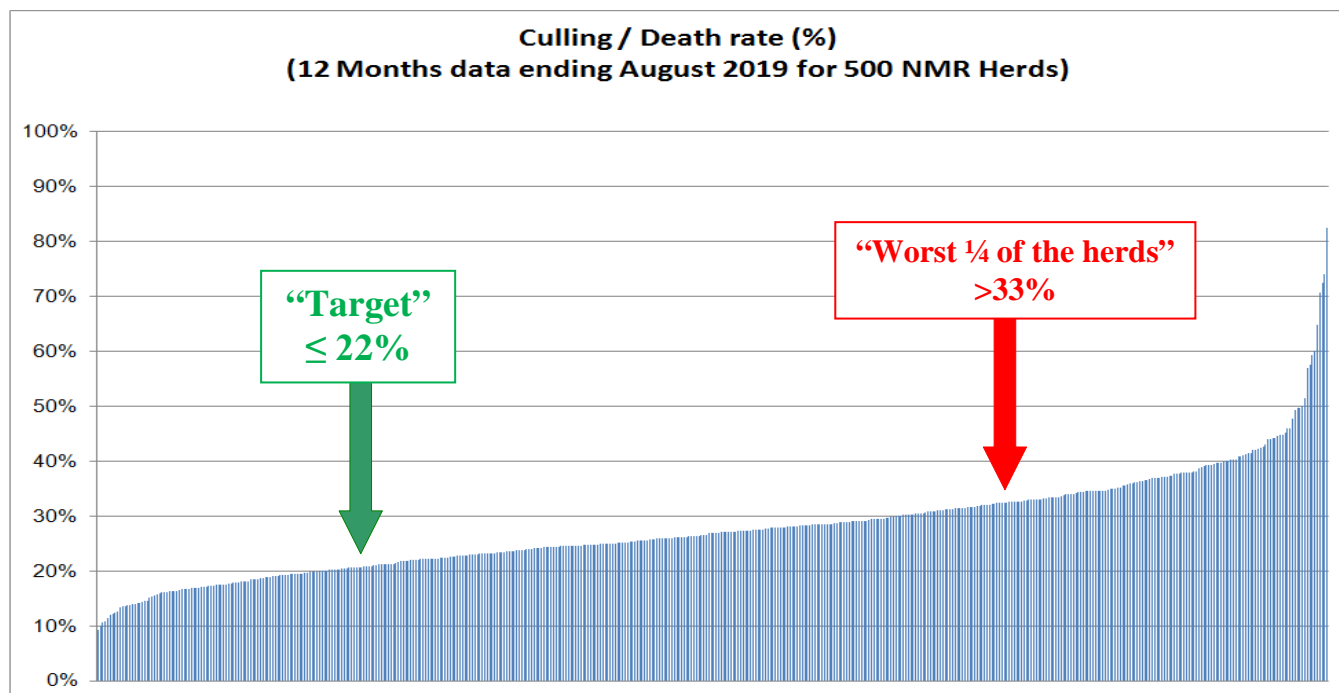
A. Culling/death rate: The % of cows that left the herd (culled/sold/died) in the last 12 months.

<div align="center">

Target (top ¼ of herds' level):   **22%**

Median: 27%

75% level: **33%**

Inter-quartile range: 11%

</div>

Culling / Death rate (%)
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" ≤ 22%
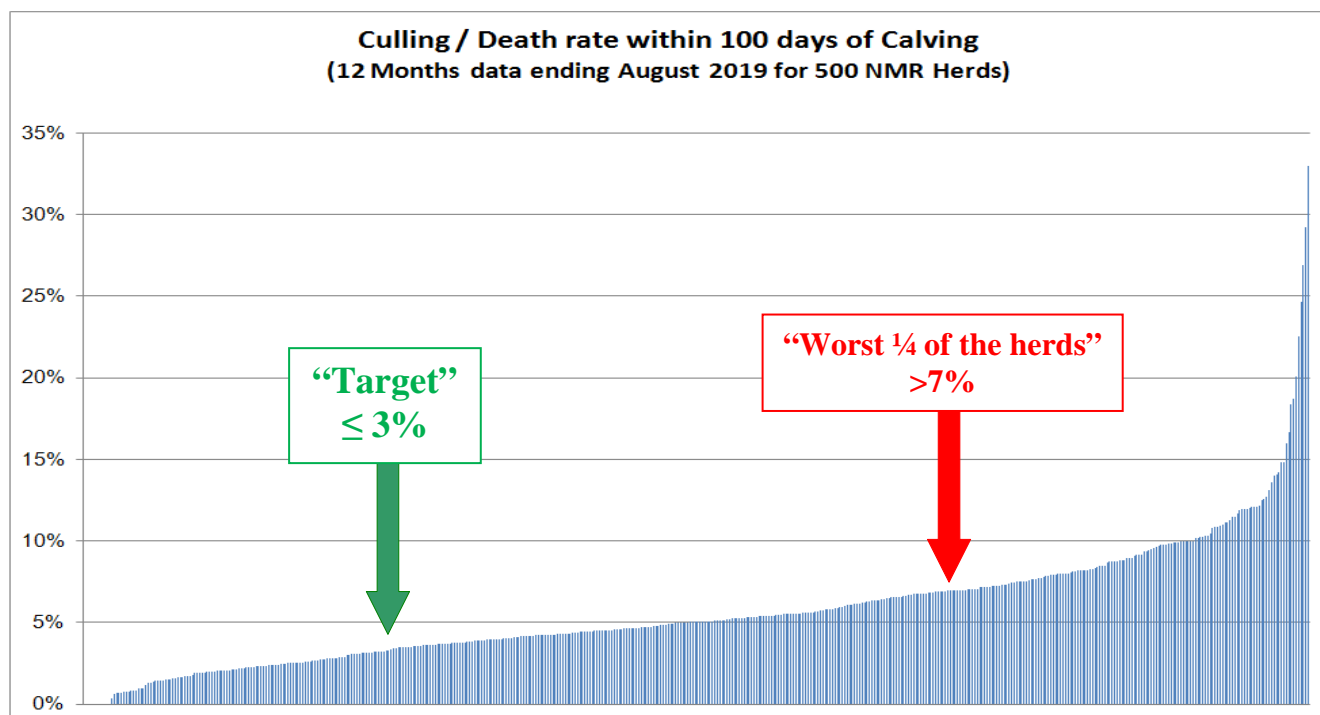
"Worst ¼ of the herds" >33%

B. Percentage of cows/heifers calving during the last 12 months that were culled (off take) / died during the first 100 days after calving. A possible indicator of "involuntary culling".

<div align="center">

Target (top ¼ of herds' level):   **3%**

Median: 5%

75% level: **7%**

Inter-quartile range: 4%

</div>

Culling / Death rate within 100 days of Calving
(12 Months data ending August 2019 for 500 NMR Herds)

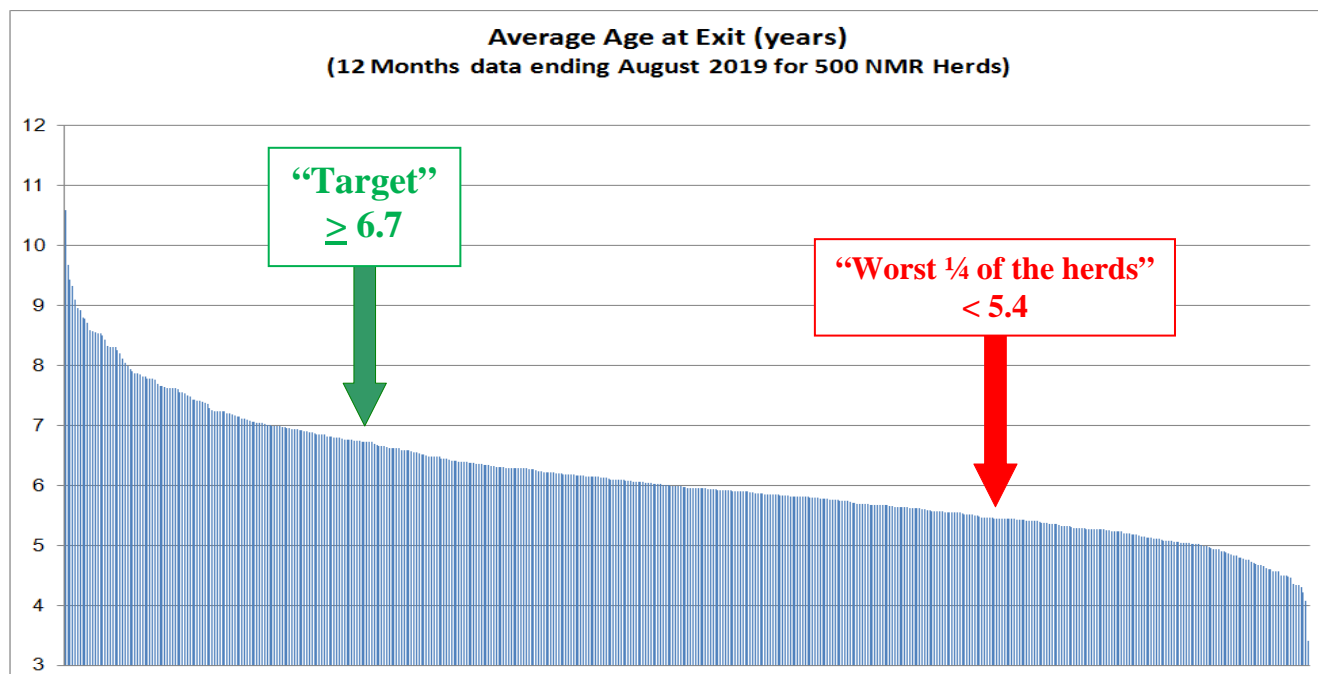"Target" ≤ 3%

"Worst ¼ of the herds" >7%

C. Average Age (in years) at exit: The average age of cows leaving the herd in the last 12 months at the time of exit. A potential measure of longevity.

<div align="center">

Target (top ¼ of herds' level): **6.7**

Median: 6.0

75% level: 5.4

Inter-quartile range: 1.3

</div>

Average Age at Exit (years)
(12 Months data ending August 2019 for 500 NMR Herds)

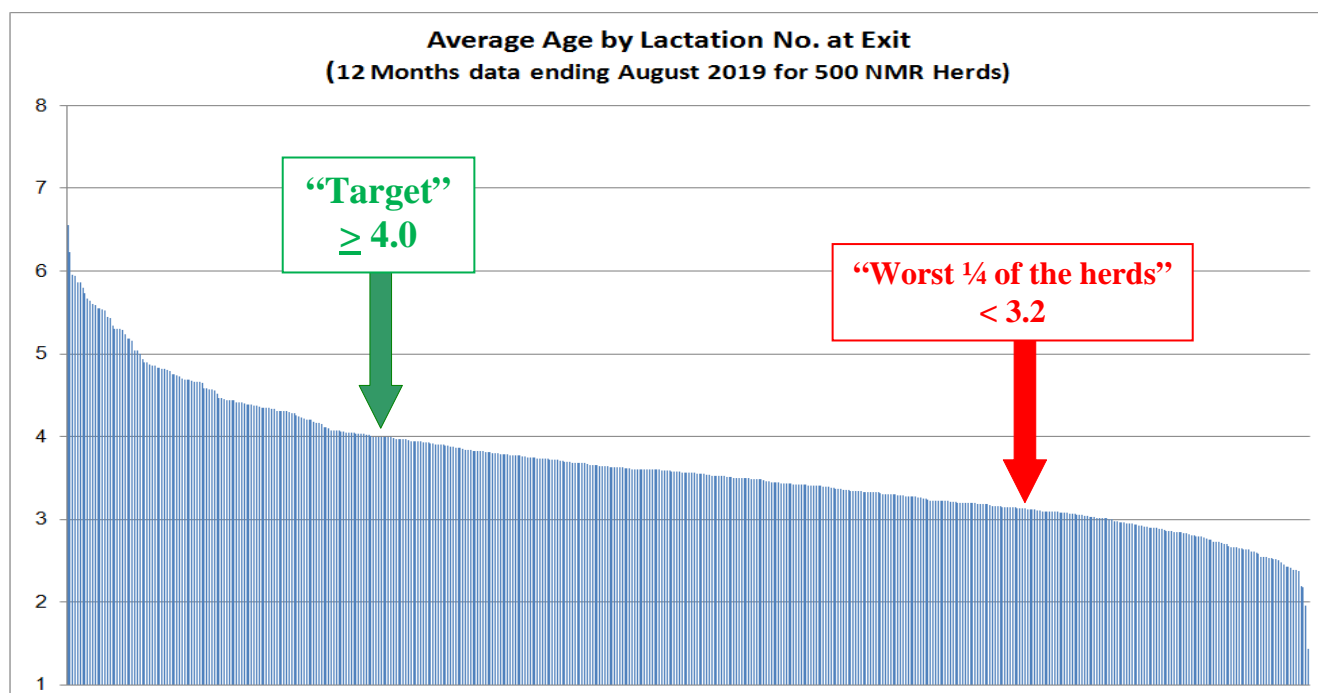"Target" ≥ 6.7

"Worst ¼ of the herds" < 5.4

D. Average Age at exit by lactations: The average lactation number of cows leaving the herd in the last 12 months. A potential measure of longevity.

<div align="center">

Target (top ¼ of herds' level): **4.0**

Median: 3.6

75% level: 3.2

Inter-quartile range: 0.8

</div>

Average Age by Lactation No. at Exit
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" ≥ 4.0

"Worst ¼ of the herds" < 3.2
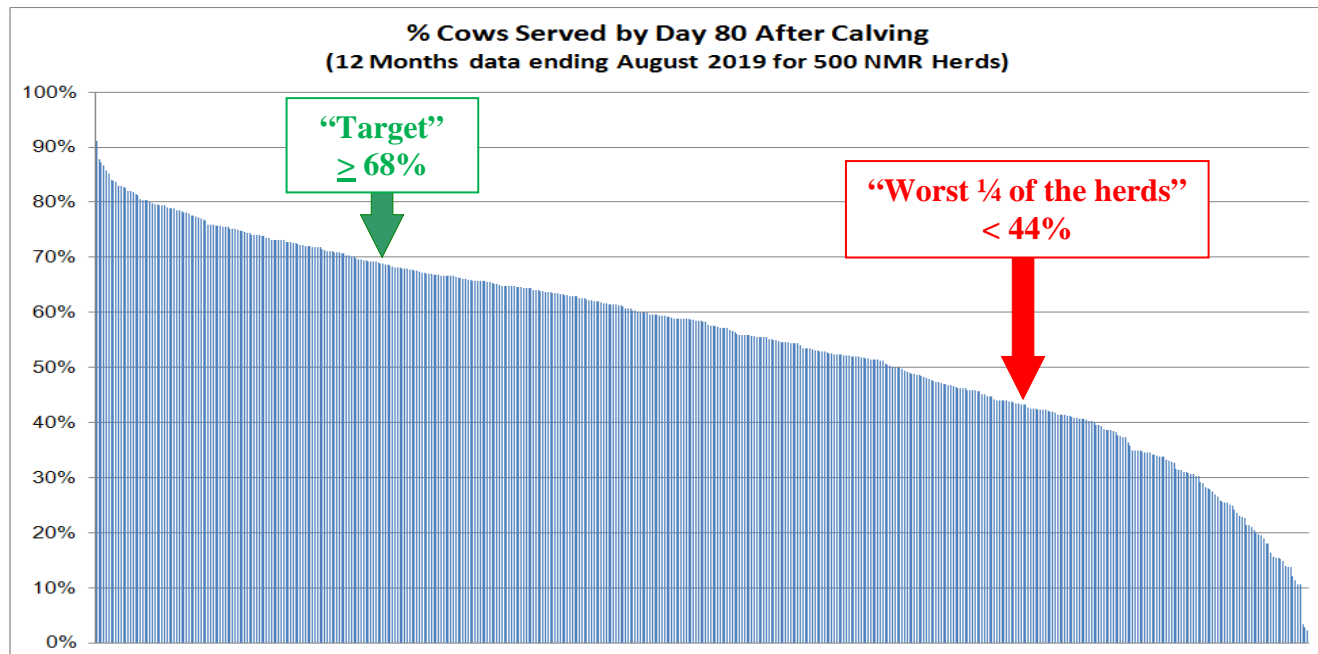
E. % Served by day 80: The percentage of calving cows served at least once within 80 days of calving.

<div align="center">

Target (top ¼ of herds' level):   **68%**

Median: 58%

75% level: 44%

Inter-quartile range: 24%

</div>

% Cows Served by Day 80 After Calving
(12 Months data ending August 2019 for 500 NMR Herds)
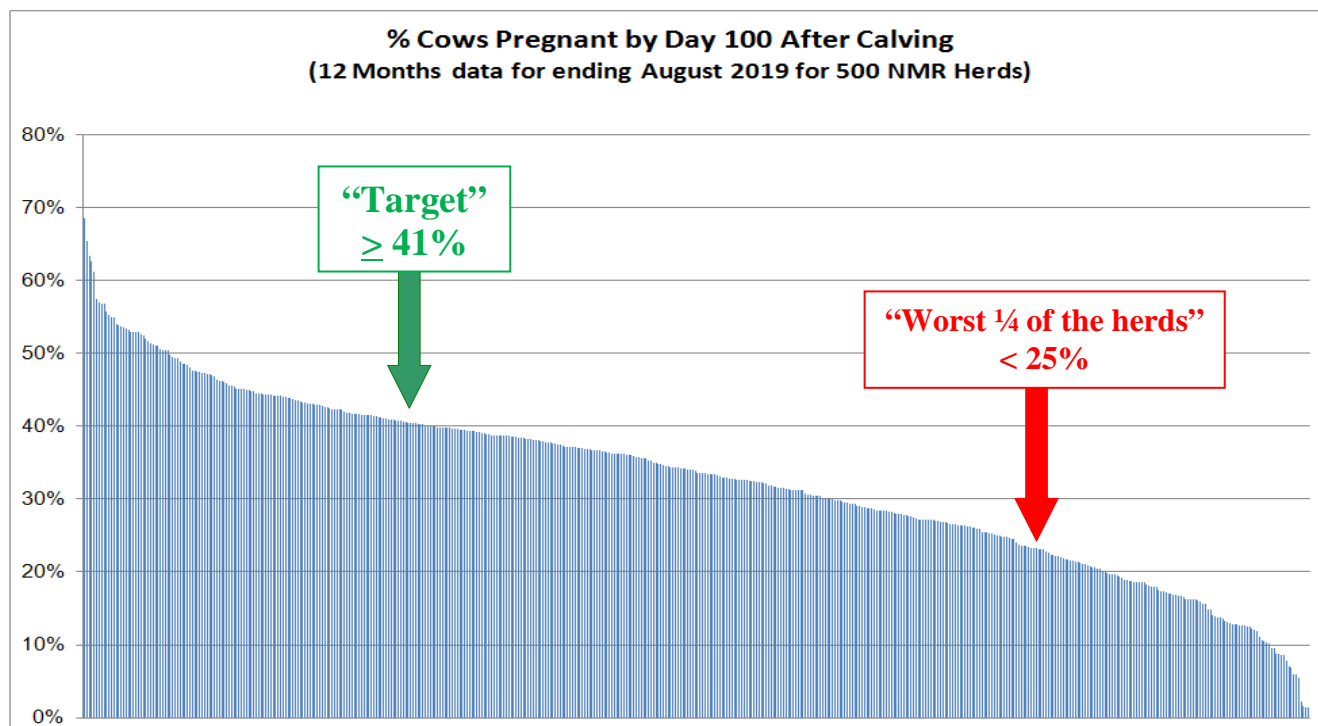
F. % conceived 100 days after calving: The percentage of calving cows that had conceived within 100 days of calving.

<div align="center">

Target (top ¼ of herds' level):   **41%**

Median: 34%
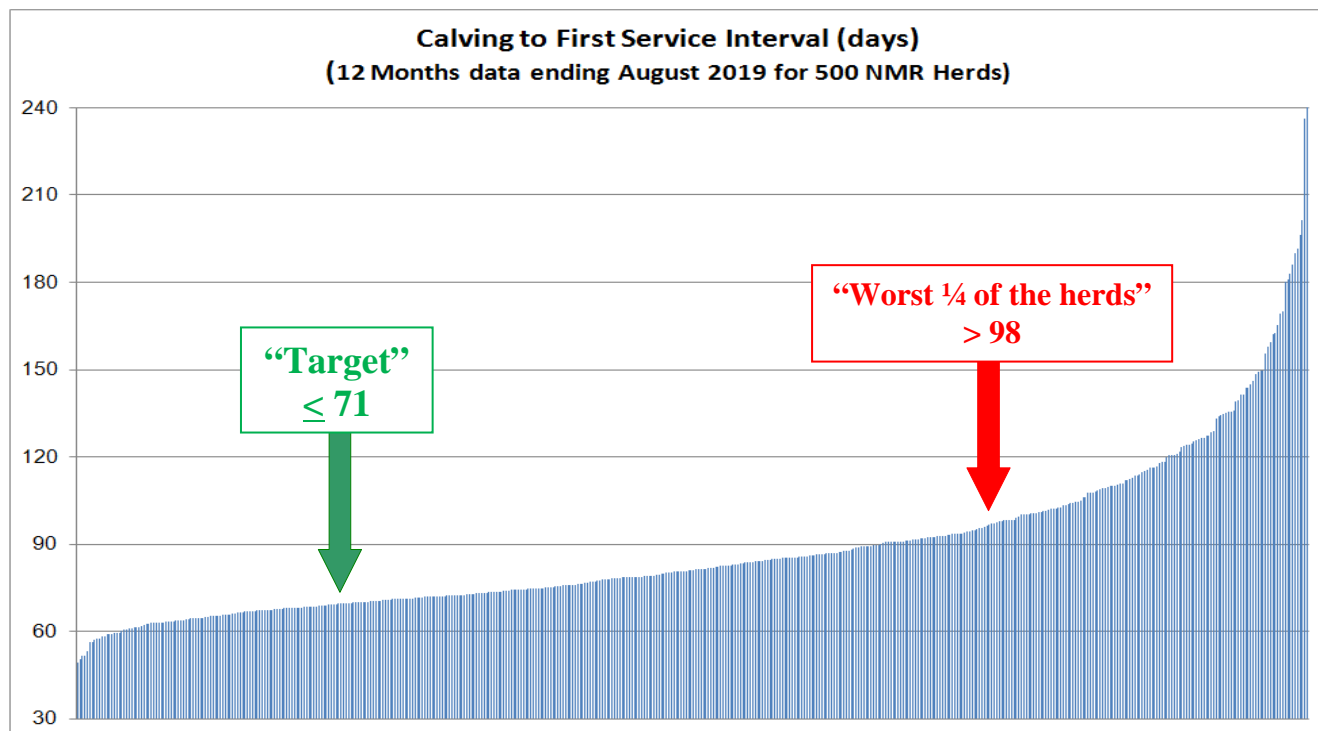
75% level: 25%

Inter-quartile range: 16%

</div>

% Cows Pregnant by Day 100 After Calving
(12 Months data for ending August 2019 for 500 NMR Herds)

G. Calving to 1st service interval: The average number of days between calving and 1st service.

<div align="center">

Target (top ¼ of herds' level): 71

Median: 81

75% level: 98

Inter-quartile range: 27

</div>

Calving to First Service Interval (days)
(12 Months data ending August 2019 for 500 NMR Herds)

"Target"
≤ 71

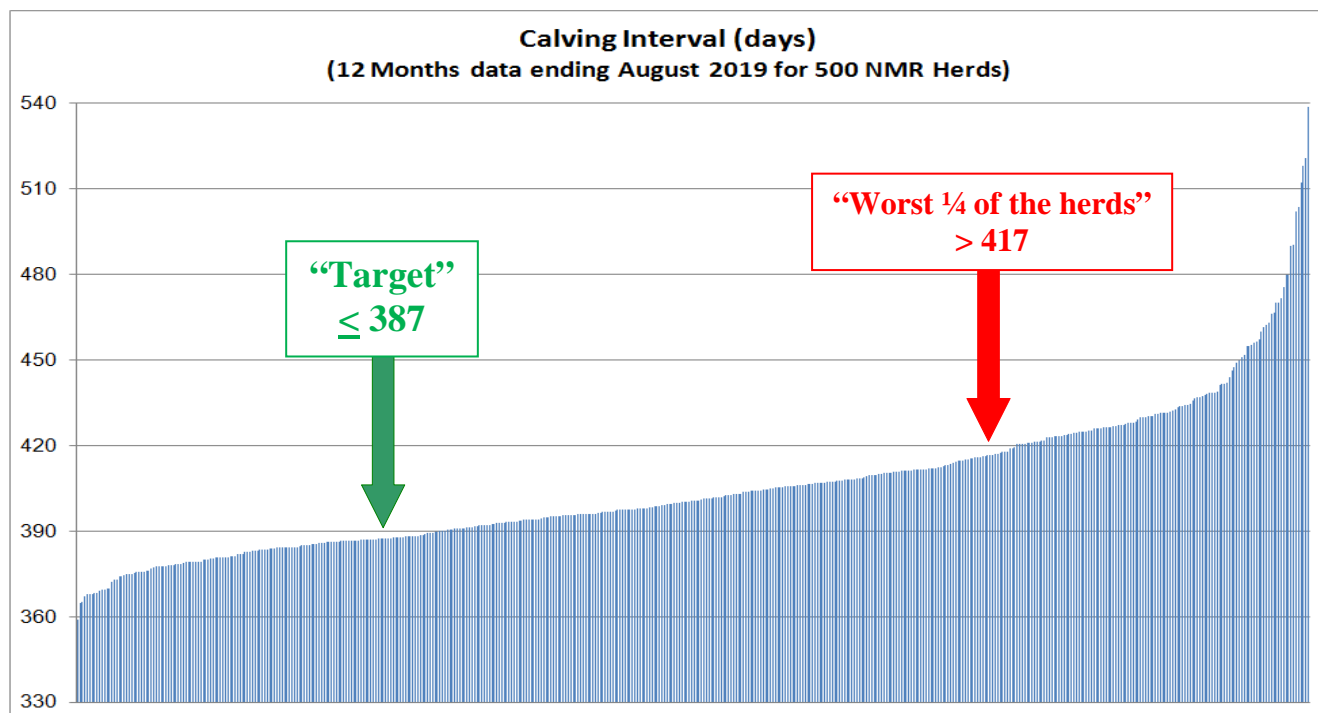"Worst ¼ of the herds"
> 98

H. Calving interval: The average interval between consecutive calvings (in days).

<div align="center">

Target (top ¼ of herds' level): 387

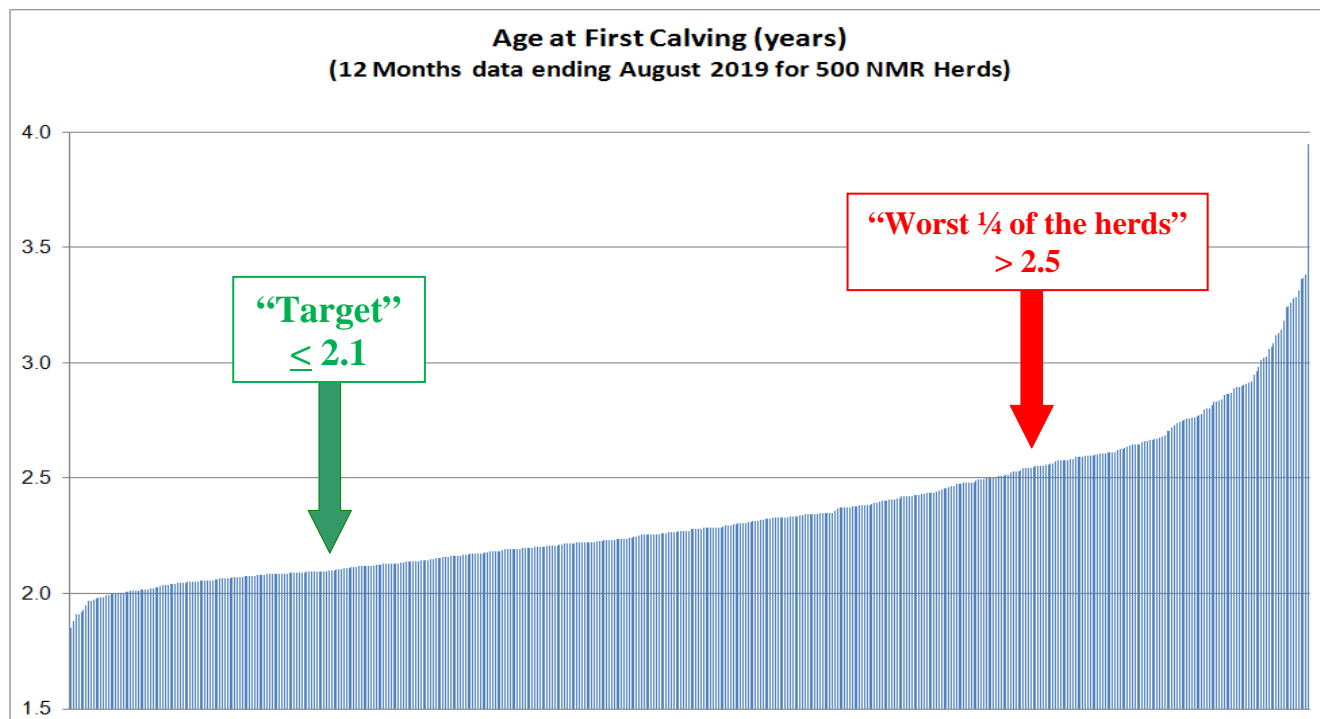Median: 401

75% level: 417

Inter-quartile range: 30

</div>

Calving Interval (days)
(12 Months data ending August 2019 for 500 NMR Herds)

"Target"
≤ 387

"Worst ¼ of the herds"
> 417

I. Age at 1st calving: The average age (in years) of heifers calving down over the last year.

<div align="right">

Target (top ¼ of herds' level): **2.1**

Median: 2.3

75% level: 2.5

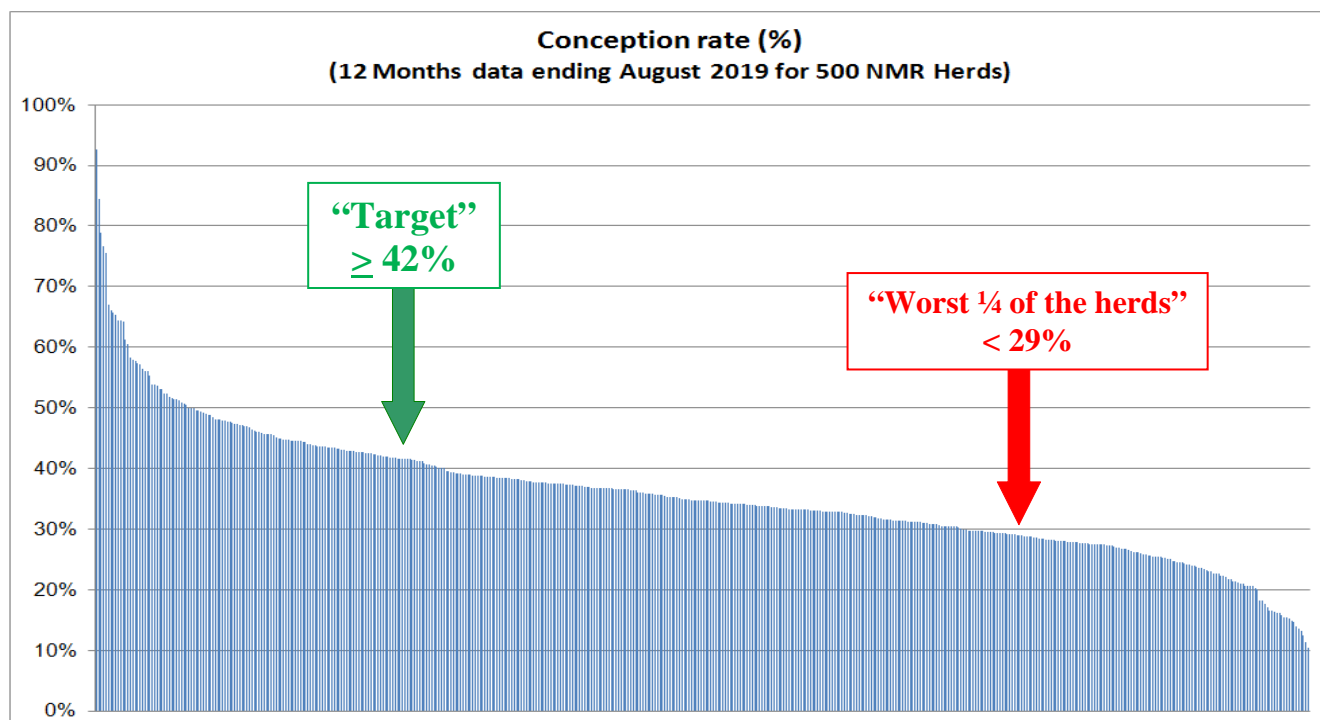Inter-quartile range: 0.4

</div>

J. Conception rate: The average conception rate for all services in the last 12 months.

<div align="right">

Target (top ¼ of herds' level): **42%**

Median: 35%

75% level: 29%
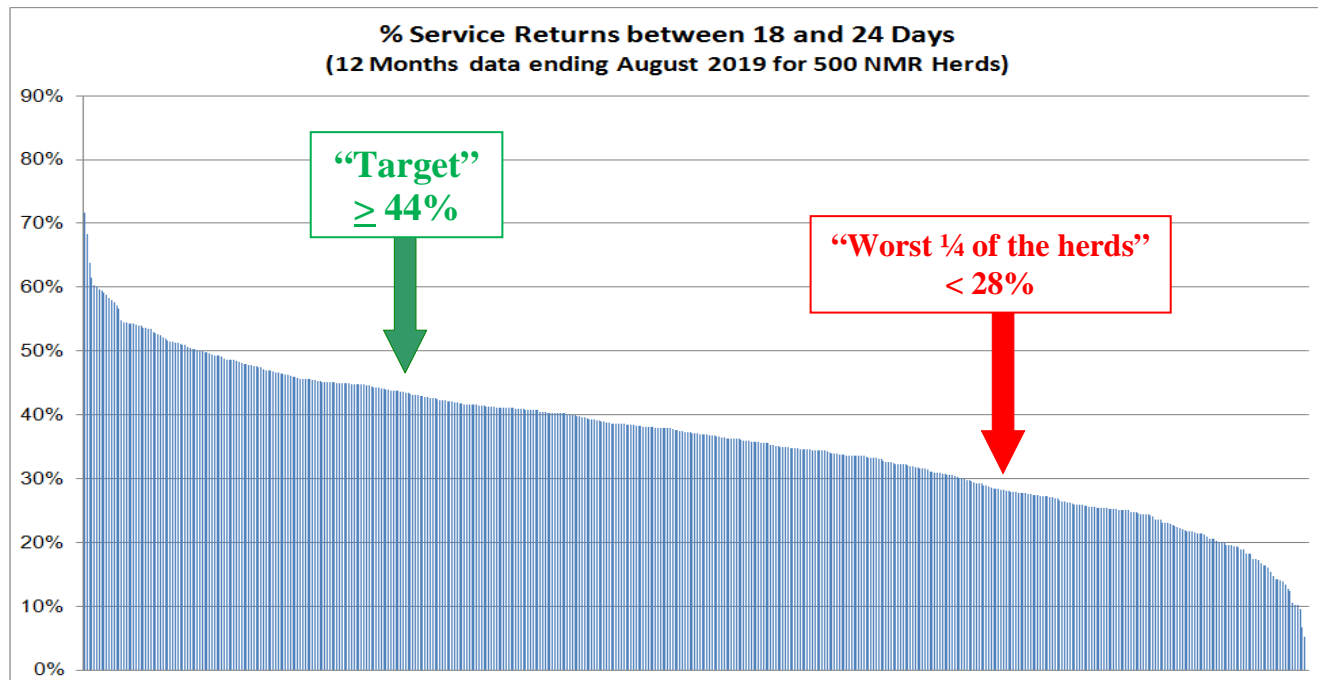
Inter-quartile range: 13%

</div>

K. % service intervals at 18-24 days (Heat detection): The percentage of all repeat services occurring 18-24 days (one oestrous cycle) after the previous service.

<div align="center">

Target (top ¼ of herds' level): 44%

Median: 37%

75% level: 28%

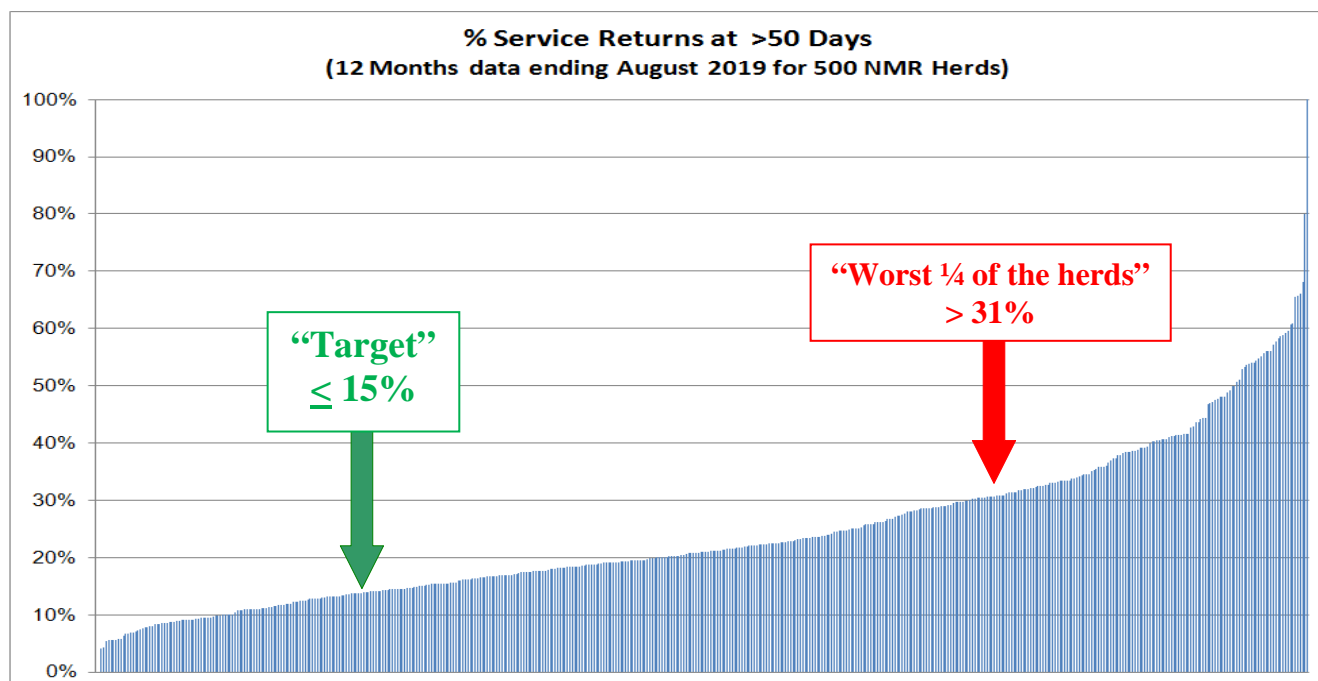Inter-quartile range: 16%

</div>

L. % service intervals >50 days: The percentage of all repeat services with an interval of over 50 days since the previous service. A potential indicator of poor heat detection.

<div align="center">

Target (top ¼ of herds' level): 15%

Median: 21%

75% level: 31%
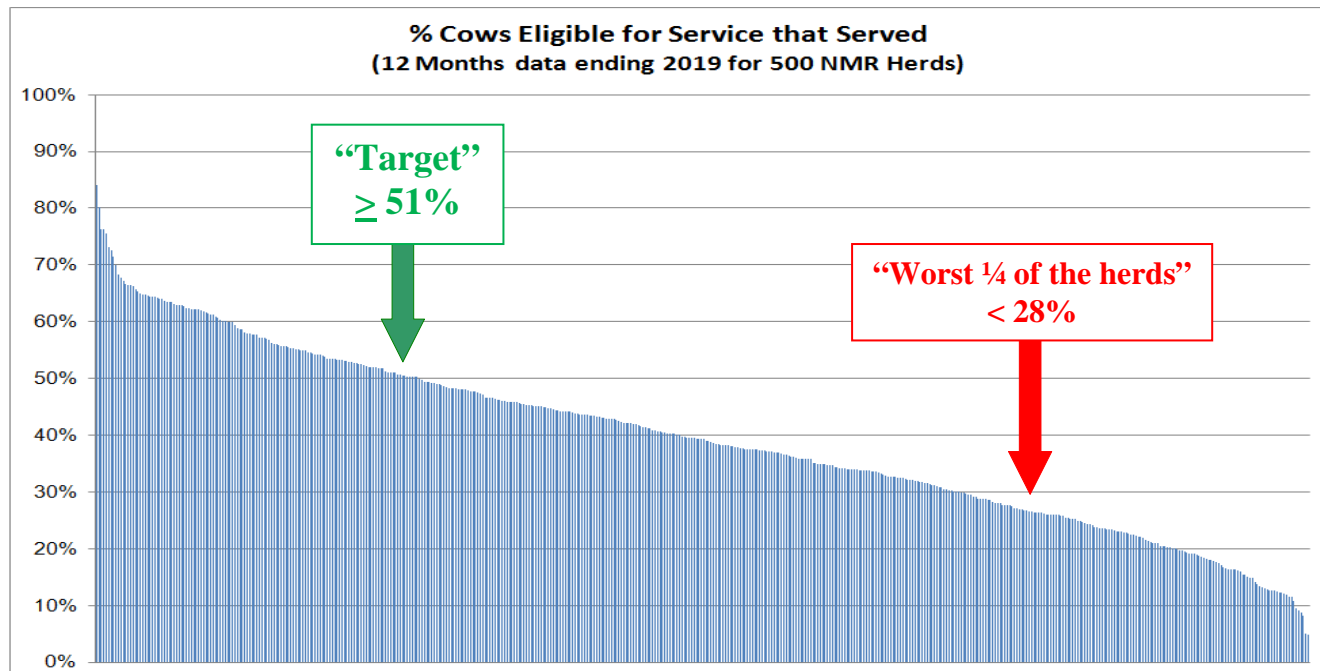
Inter-quartile range: 16%

</div>

M. Percentage of cows eligible for service (>42 days calved, not barren, not pregnant) that were served per 21 day oestrous period (Submission rate).

<div align="center">

Target (top ¼ of herds' level): 51%
Median: 39%
75% level: 28%
Inter-quartile range: 23%

</div>

% Cows Eligible for Service that Served
(12 Months data ending 2019 for 500 NMR Herds)

"Target" ≥ 51%

"Worst ¼ of the herds" < 28%

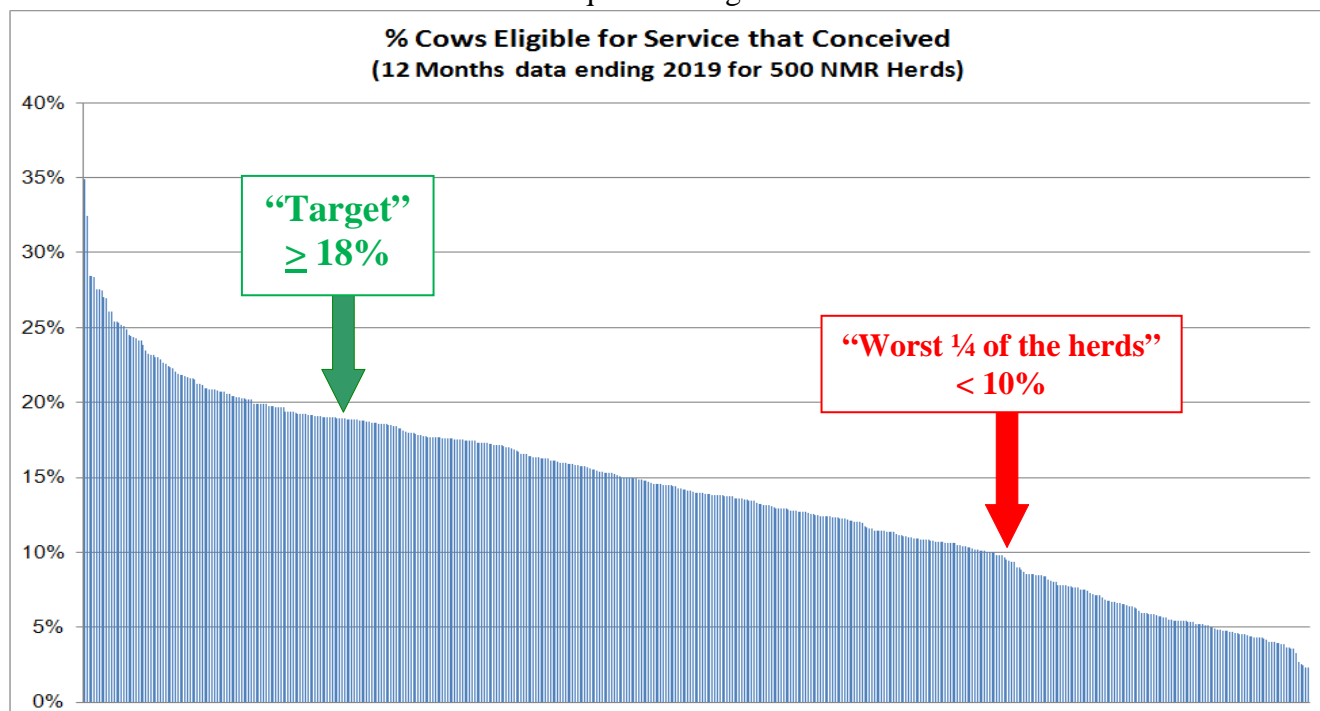**N. Percentage eligible for service (>42 days calved, not barren, not pregnant) that conceived per 21 day oestrus period (Pregnancy rate).**

<div align="center">

Target (top ¼ of herds' level): 18%
Median: 14%
75% level: 10%
Inter-quartile range: 8%

</div>

% Cows Eligible for Service that Conceived
(12 Months data ending 2019 for 500 NMR Herds)

"Target" ≥ 18%
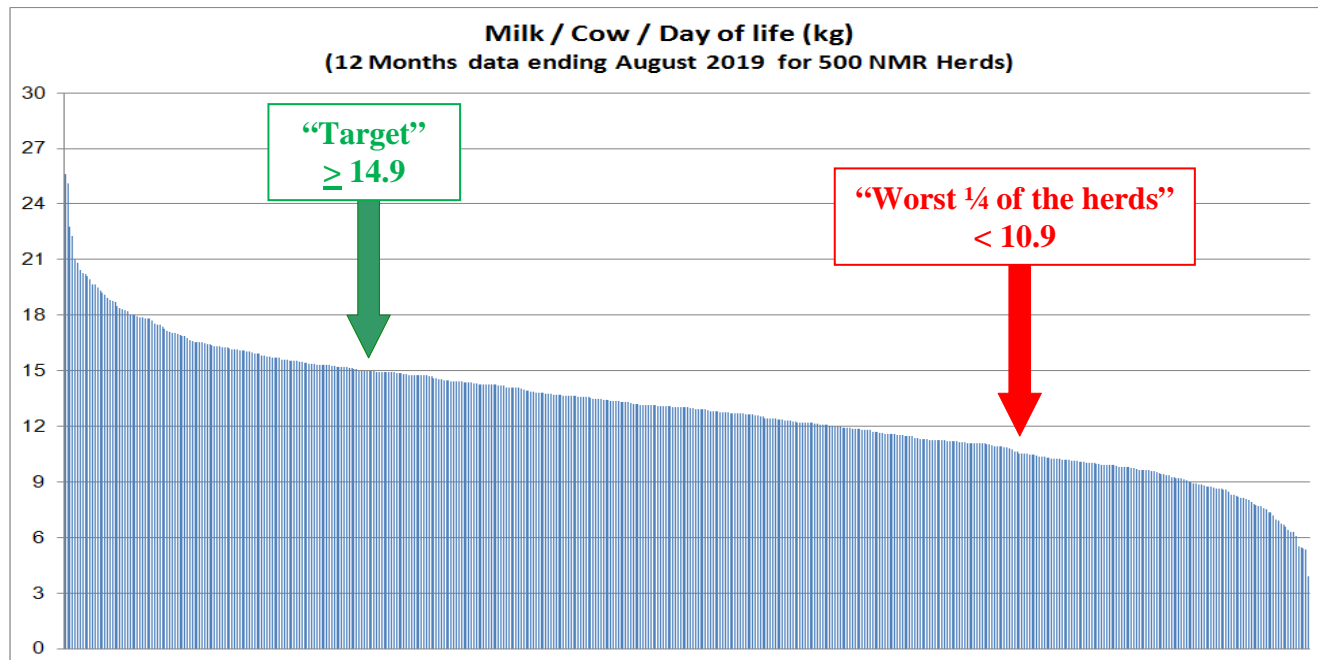
"Worst ¼ of the herds" < 10%

O. Lifetime milk / cow / day (kg): Equates to the average daily milk yield of cows across their whole lifetime (including unproductive periods: time as a heifer, dry periods).

<div align="center">

Target (top ¼ of herds' level):   **14.9**

Median: 13.0

75% level: 10.9

Inter-quartile range: 4.0

</div>

Milk / Cow / Day of life (kg)
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" ≥ 14.9

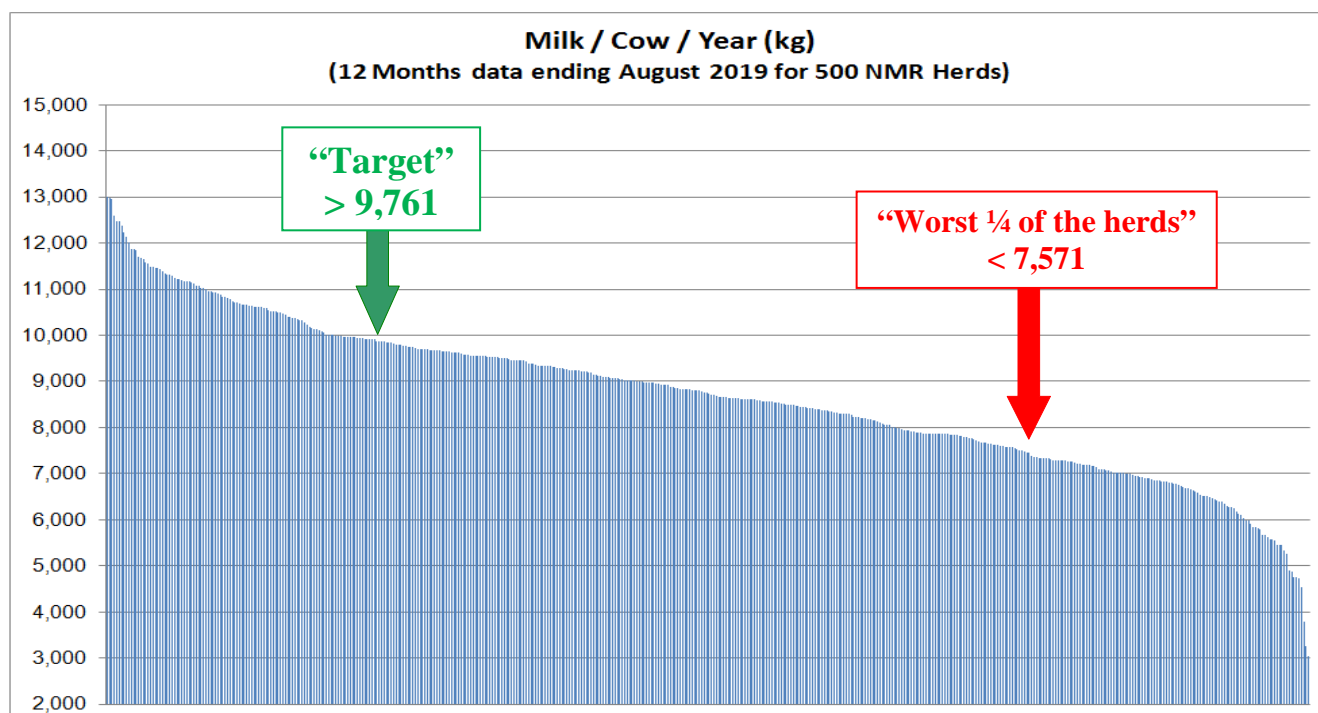"Worst ¼ of the herds" < 10.9

P. Milk / cow / year (kg): The average annual milk yield of all cows in the year. Total milk divided by the average cow population. A measure of milk yield per cow place in the herd.

<div align="center">

Target (top ¼ of herds' level):   **9,761**

Median: 8,737

75% level: 7,571

Inter-quartile range: 2,190

</div>

Milk / Cow / Year (kg)
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" > 9,761
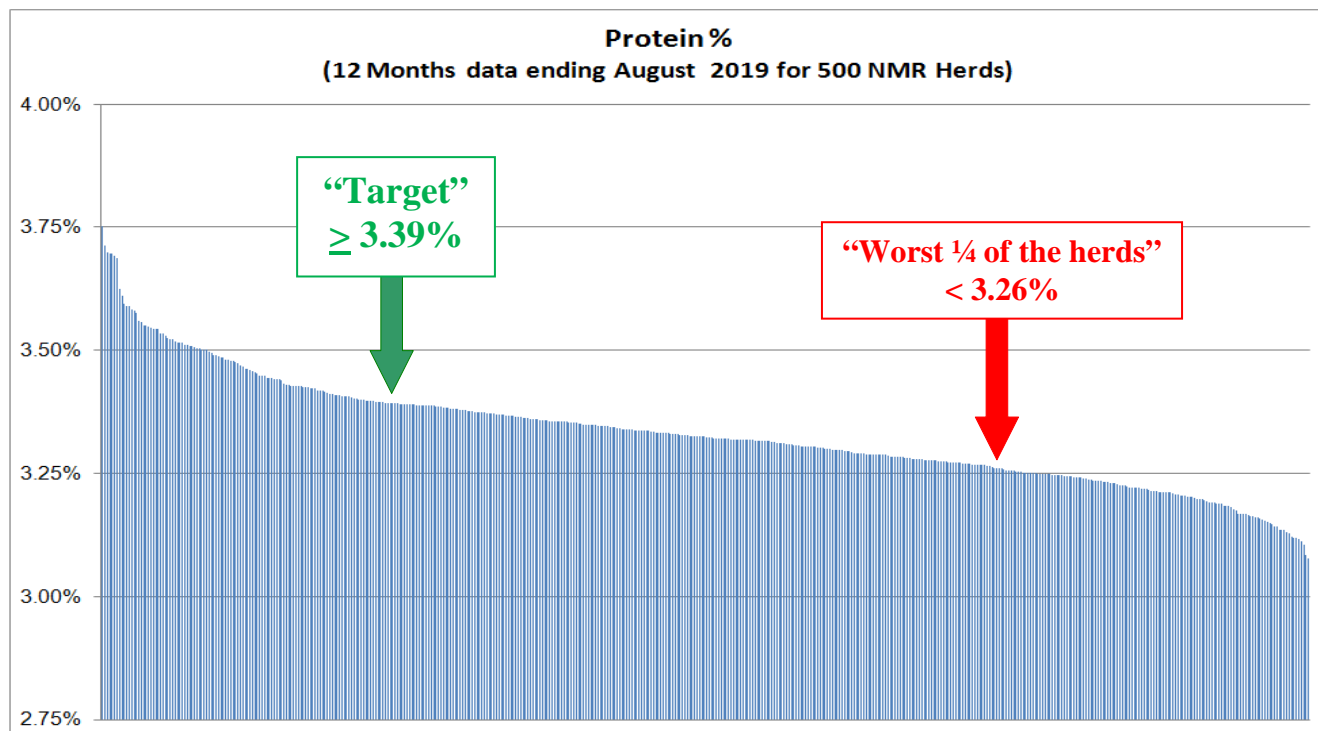
"Worst ¼ of the herds" < 7,571

Q. Average protein (%): The average % protein of all milk samples taken over the year.

Target (top ¼ of herds' level): **3.39%**

Median: 3.32%

75% level: 3.26%

Inter-quartile range: 0.13%

Protein %
(12 Months data ending August 2019 for 500 NMR Herds)

"Target"
≥ 3.39%

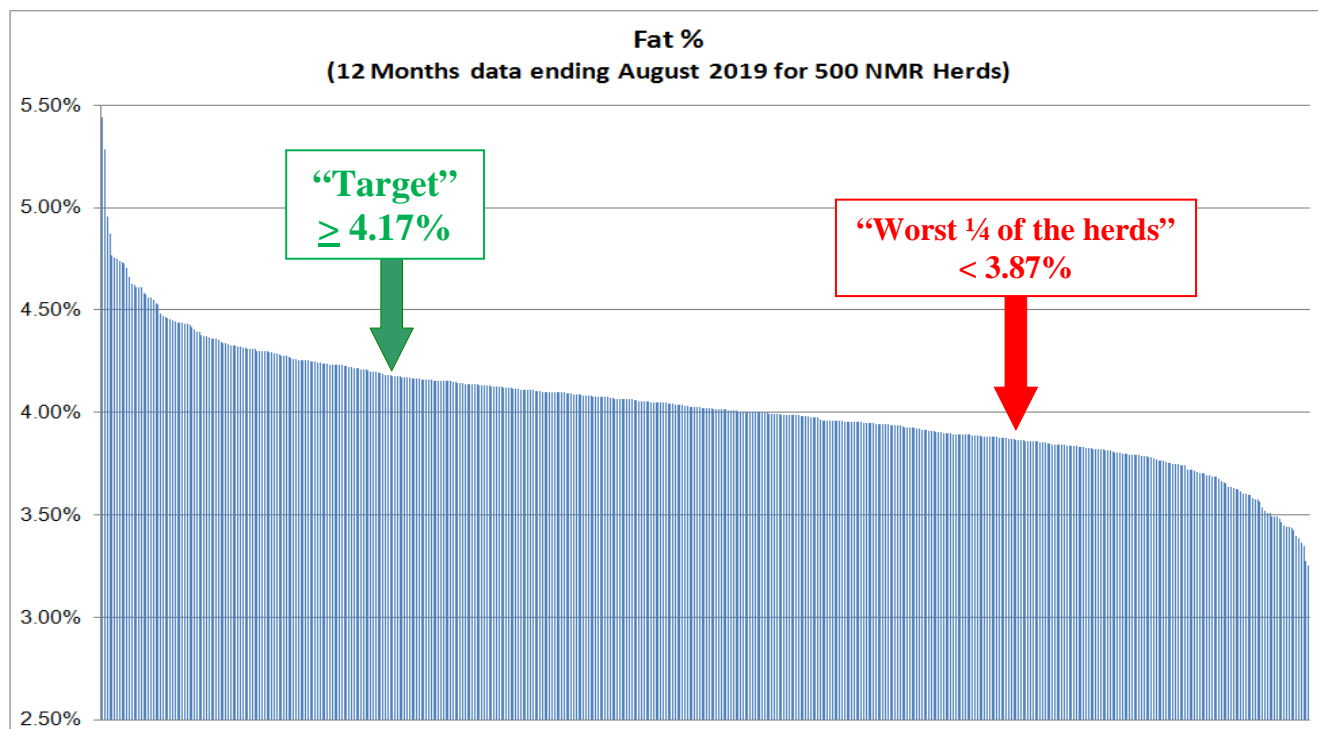"Worst ¼ of the herds"
< 3.26%

R. Average fat (%): The average % fat of all milk samples taken over the year.

Target (top ¼ of herds' level): **4.17%**
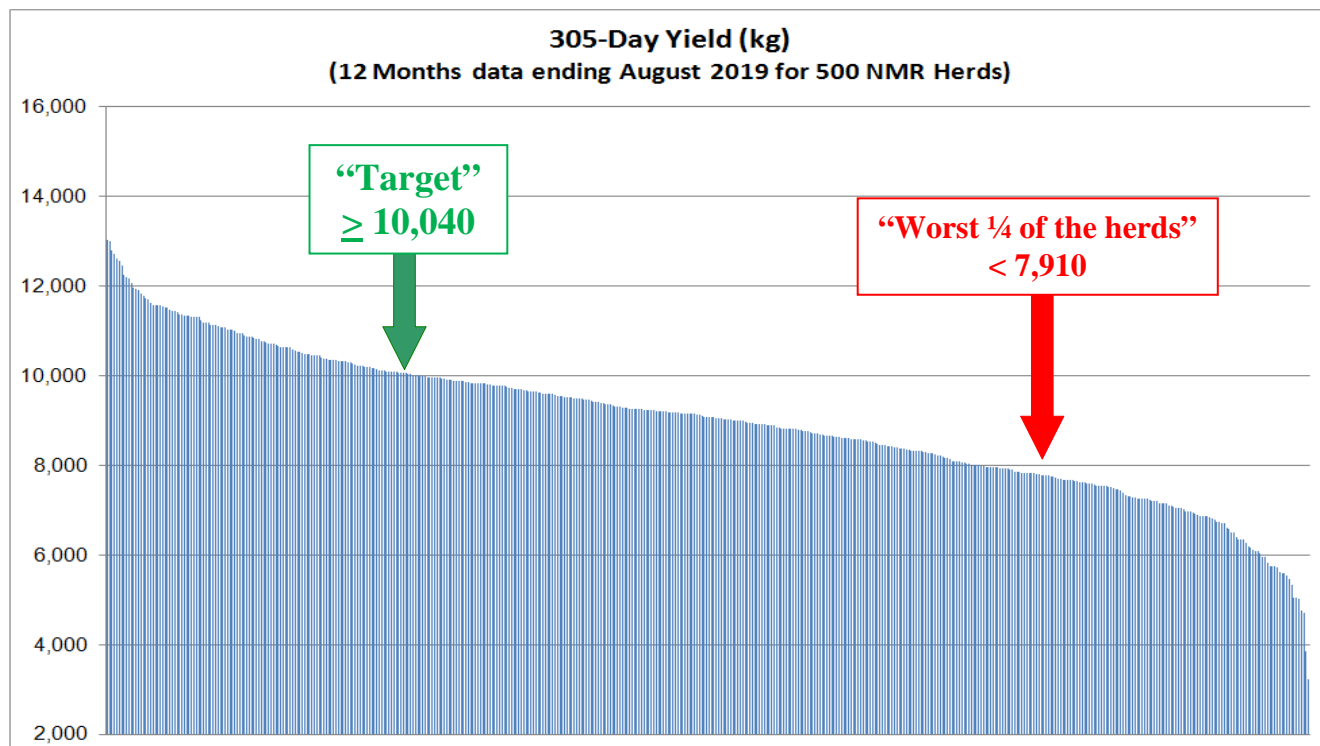
Median: 4.02%

75% level: 3.87%

Inter-quartile range: 0.30%

Fat %
(12 Months data ending August 2019 for 500 NMR Herds)

"Target"
≥ 4.17%

"Worst ¼ of the herds"
< 3.87%

17

S. 305 day yield (kg): The average yield of cows by day 305 of the lactation.

Target (top ¼ of herds' level):	**10,040**
Median:	9,078
75% level:	7,910
Inter-quartile range:	2,130

T. 305 day protein (kg): The average milk protein yield of cows by day 305 of the lactation.

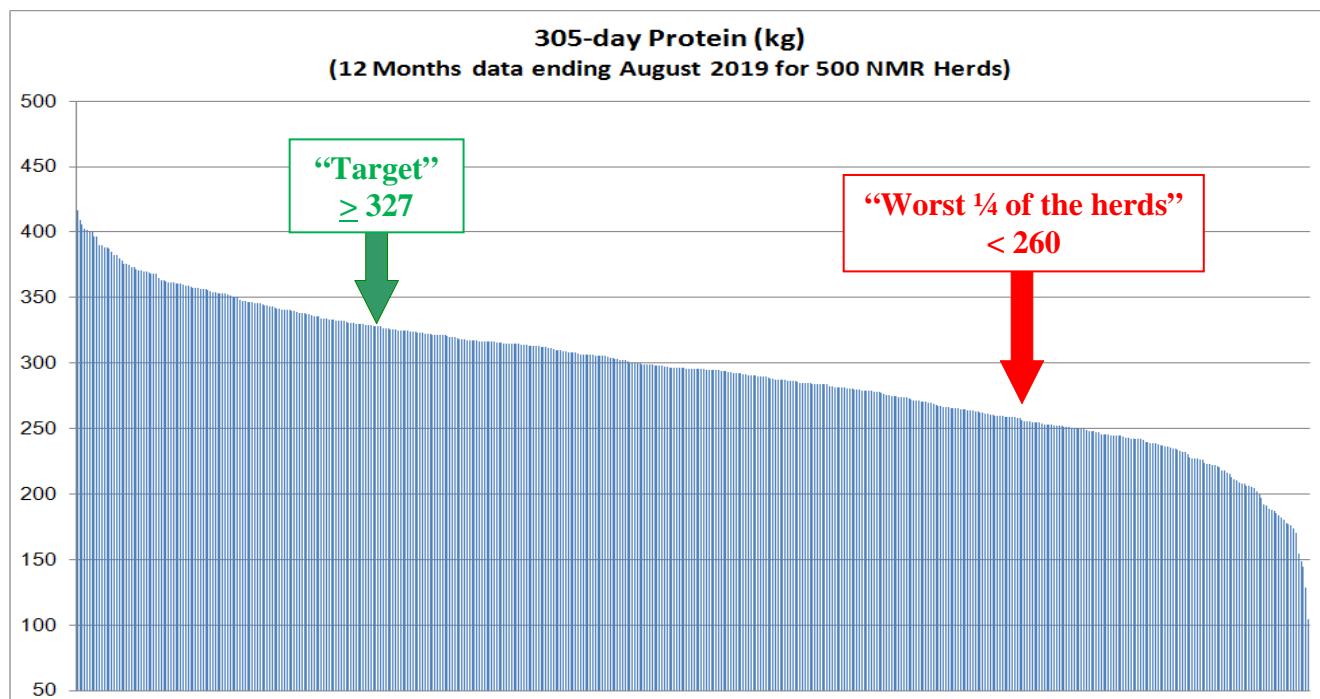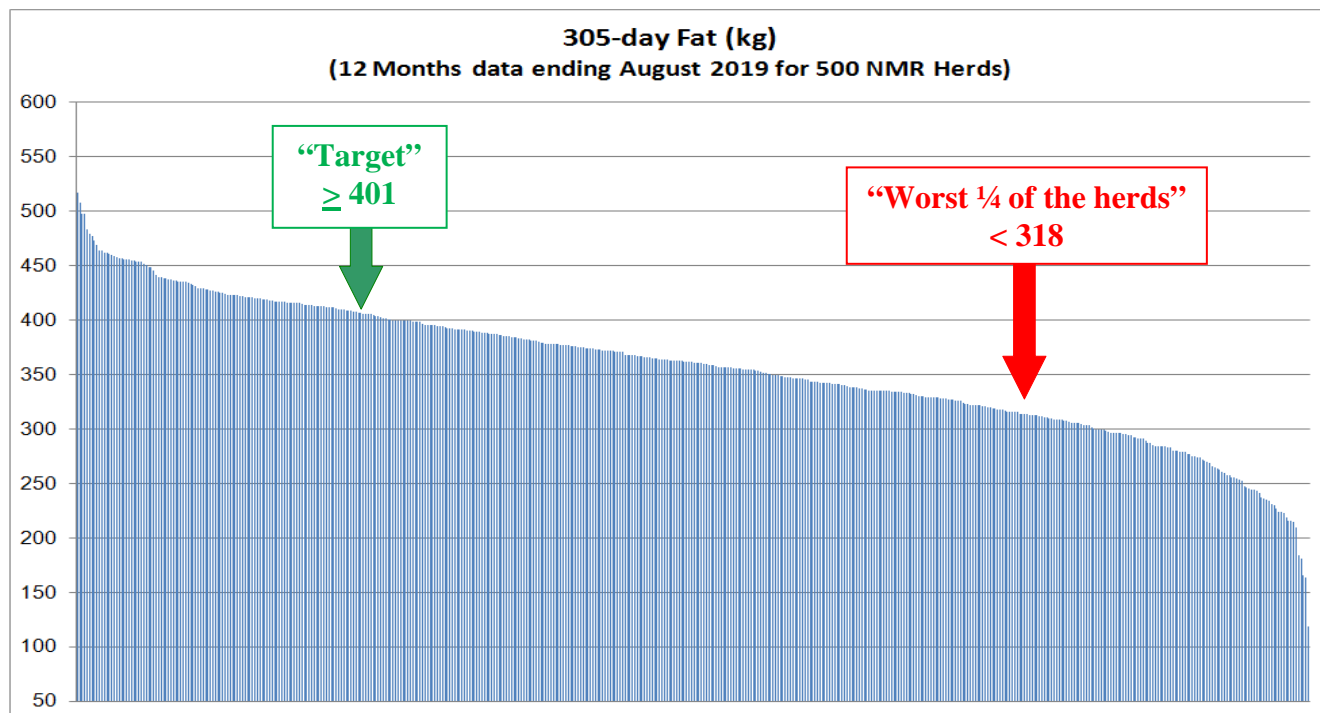|	
Target (top ¼ of herds' level):	**327**
Median:	296
75% level:	260
Inter-quartile range:	67

U. 305 day fat (kg): The average milk fat yield of cows by day 305 of the lactation.

<div align="center">

Target (top ¼ of herds' level): **401**

Median: 361
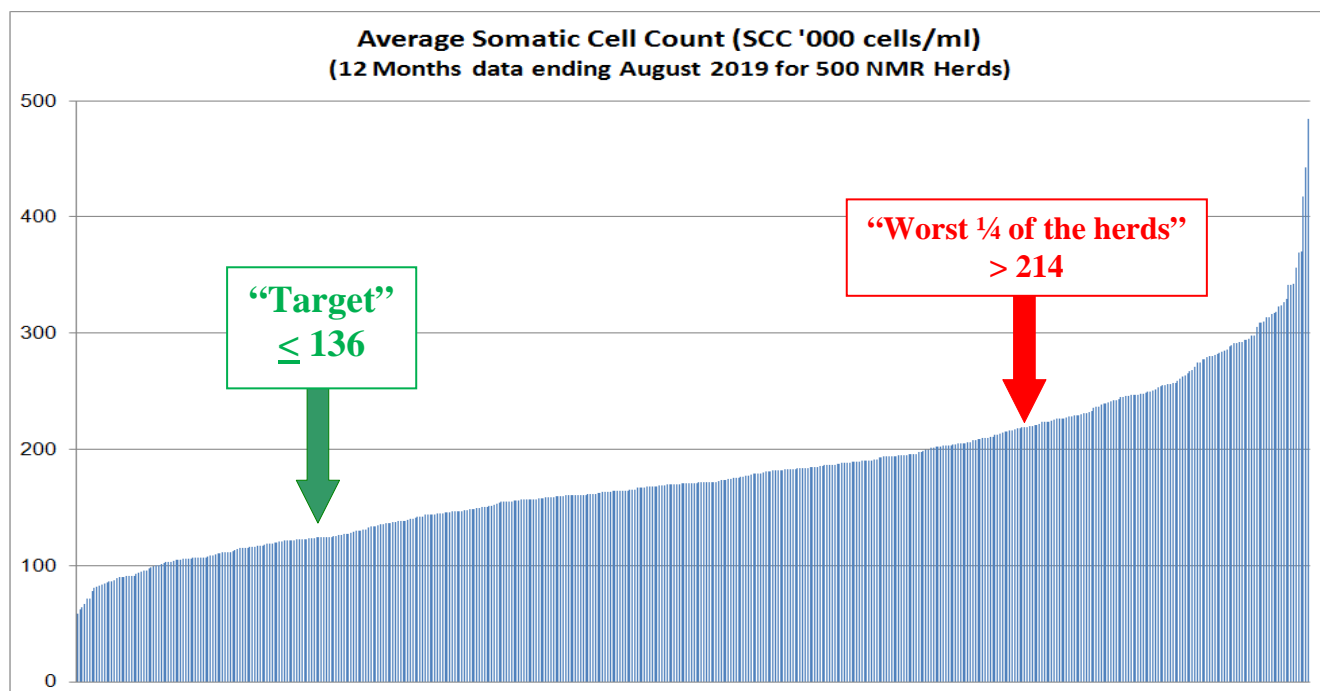
75% level: 318

Inter-quartile range: 83

</div>

V. Herd SCC ('000 cells/ml): The weighted average SCC of all milk samples taken in the last 12 months (*weighted for volume of production of each cow producing the sample*)**.**

<div align="center">

Target (top ¼ of herds' level): **136**

Median: 171

75% level: 214

Inter-quartile range: 78

</div>

W. % of milk samples with high SCC: The percentage of milk samples in the last 12 months with a SCC ≥ 200,000 cells/ml of milk. Indicates the size of any reservoir of infection.

Target (top ¼ of herds' level):	13%
Median:	17%
75% level:	22%
Inter-quartile range:	9%
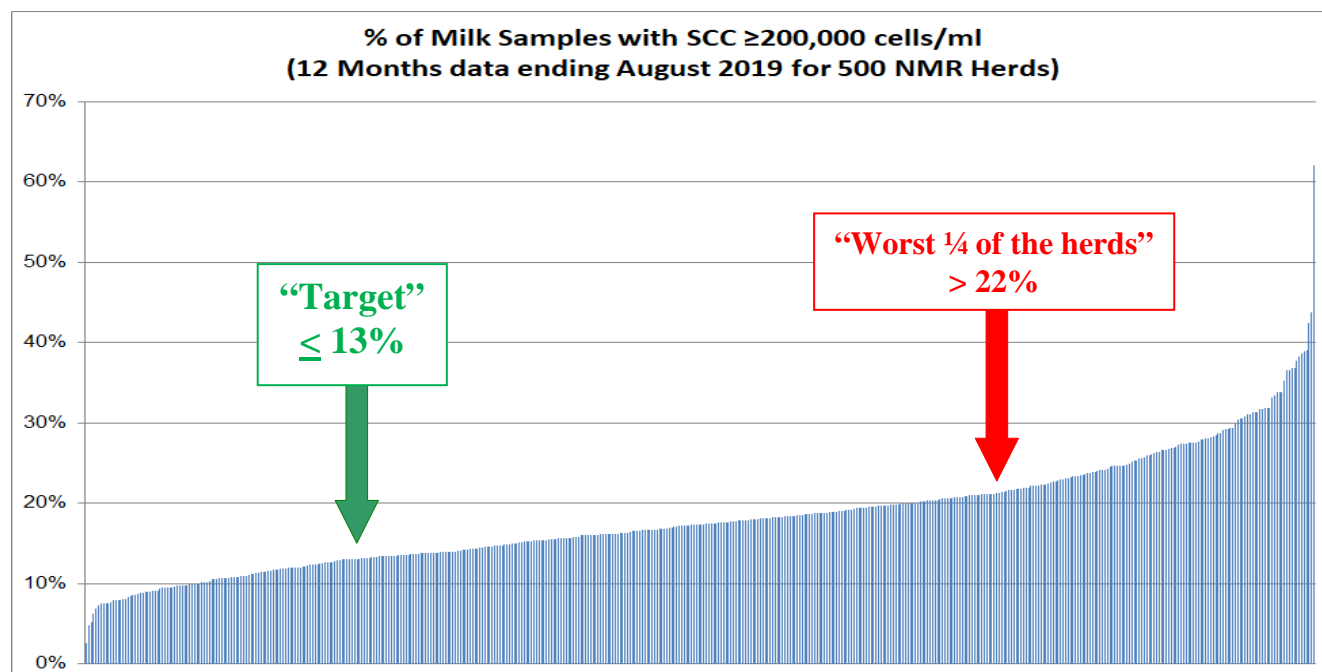
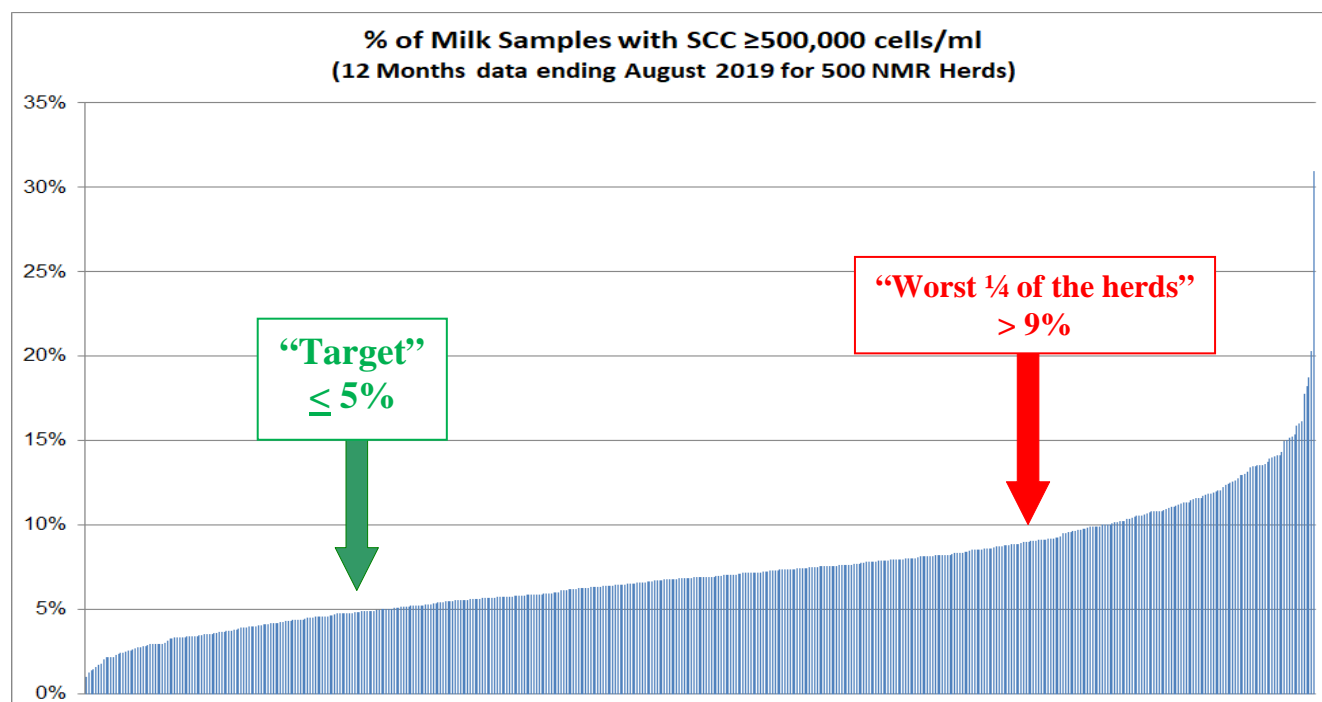**X. % of milk samples with SCC ≥ 500,000 cells/ml: The percentage of milk samples taken in the last 12 months with a SCC ≥ 500,000 cells/ml of milk.**

Target (top ¼ of herds' level):	5%
Median:	7%
75% level:	9%
Inter-quartile range:	4%

Y. % 1st recording SCC ≥ 200,000 cells/ml: The percentage of new lactations in the last year starting with a high SCC (≥ 200,000 cells) at the first milk recording.

Target (top ¼ of herds' level): 12%
Median: 16%
75% level: 21%
Inter-quartile range: 9%

% of Cows with high SCC (≥200,000/ml) at First Recording in Lactation
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" ≤ 12%

"Worst ¼ of the herds" > 21%
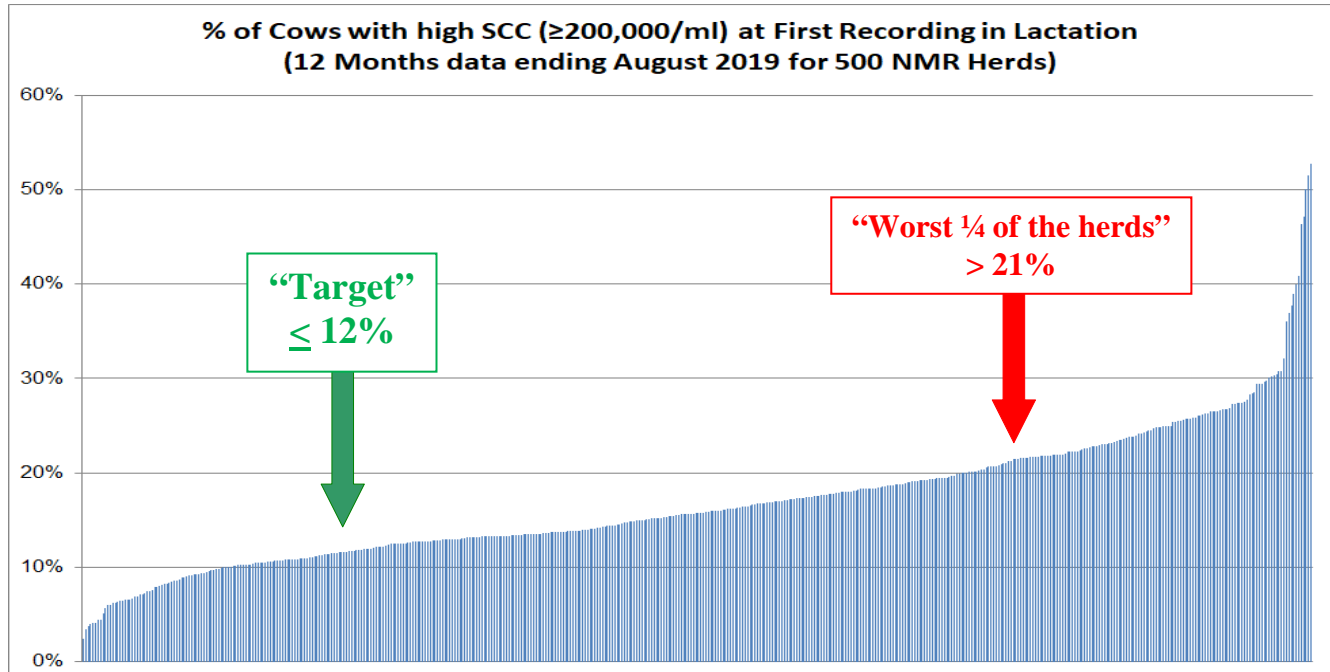
Z. Percentage chronic SCC ≥ 200,000 cells/ml: The % of all milk samples taken over the last 12 months that were from CHRONIC cows (cows whose milk was ≥ 200,000 cells at both the CURRENT AND PREVIOUS milk recordings).

Target (top ¼ of herds' level): 6%
Median: 9%
75% level: 12%
Inter-quartile range: 6%

% of Cows with Chronic Infections
(12 Months data ending August 2019 for 500 NMR Herds)
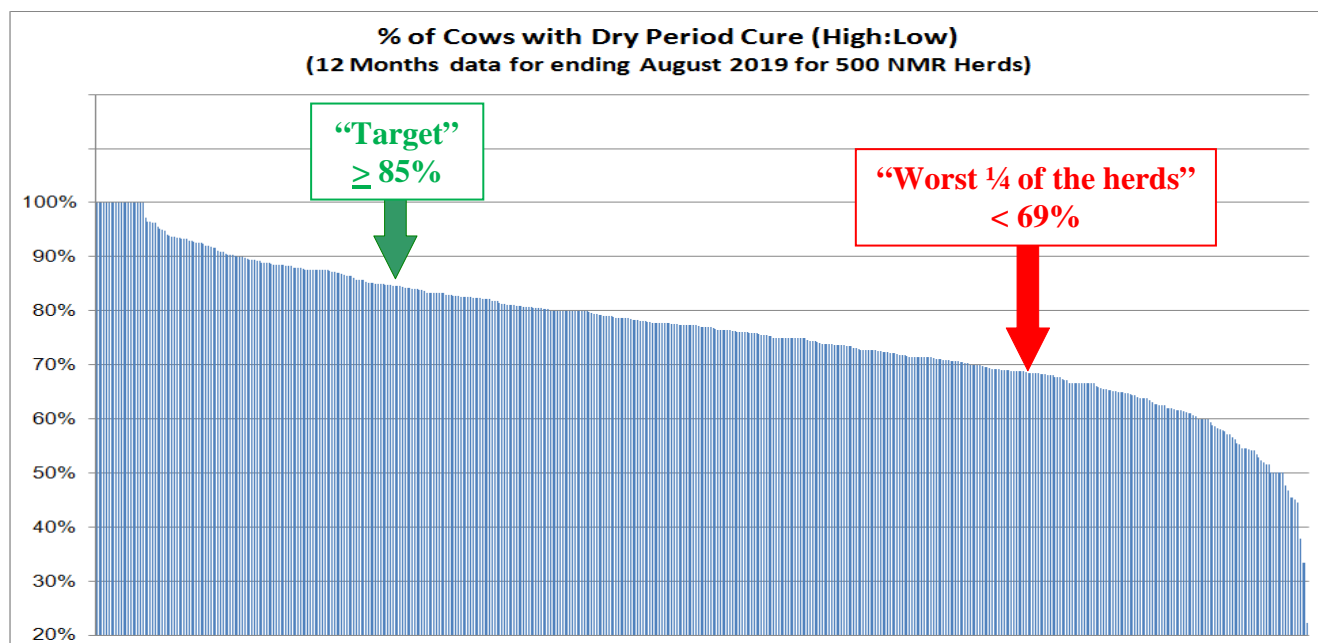
"Target" ≤ 6%

"Worst ¼ of the herds" > 12%
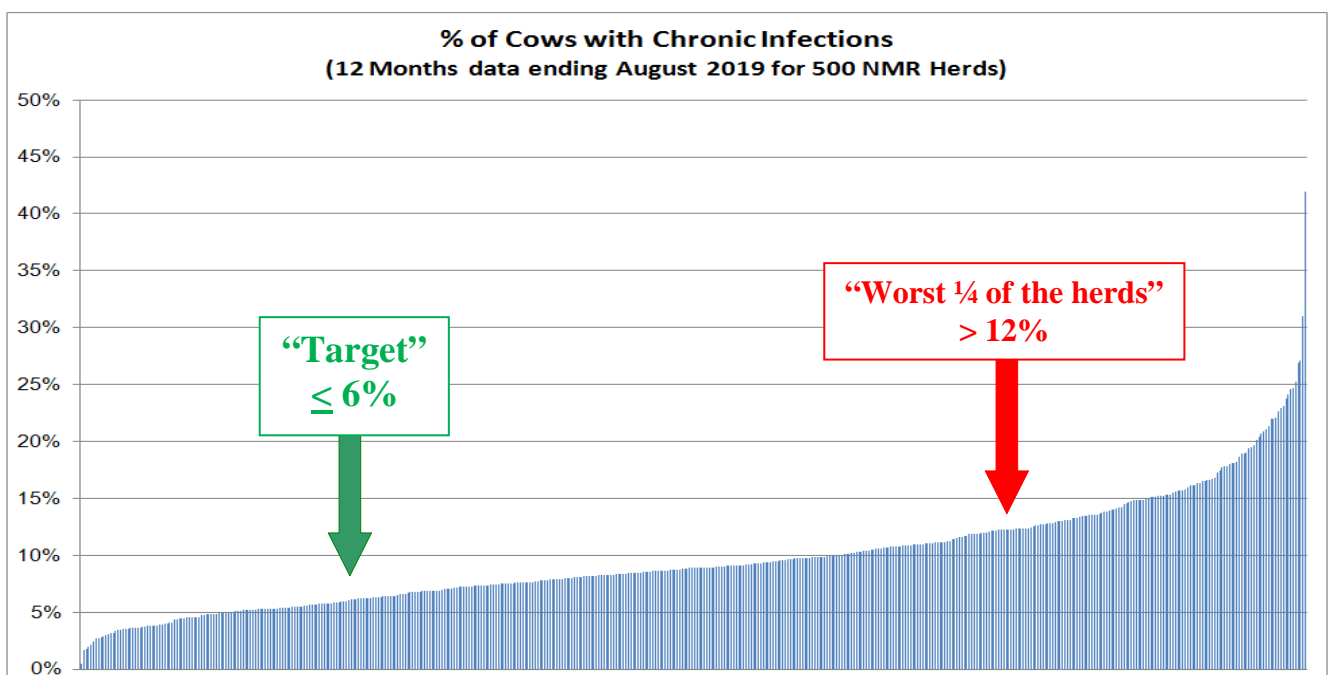
ZA. Dry period cure (High:Low): The % of cows calving in the last year that ended their previous lactation with a high SCC (≥ 200,000 cells), started the new lactation with a LOW cell count (< 200,000 cells). The % of high SCC cows "cured" in the dry period.

Target (top ¼ of herds' level):	85%
Median:	77%
75% level:	69%
Inter-quartile range:	16%

% of Cows with Dry Period Cure (High:Low)
(12 Months data for ending August 2019 for 500 NMR Herds)

"Target" ≥ 85%

"Worst ¼ of the herds" < 69%

ZB. Dry period protection (Low:Low): The % of cows calving in the last year that ended the previous lactation with a LOW SCC (< 200,000 cells) then started the new lactation with a LOW cell count (< 200,000 cells). The % of low SCC cows "protected" in the dry period.

Target (top ¼ of herds' level):	90%
Median:	85%
75% level:	80%
Inter-quartile range:	10%

% of Cows with Dry Period Protection (Low:Low)
(12 Months data ending August 2019 for 500 NMR Herds)

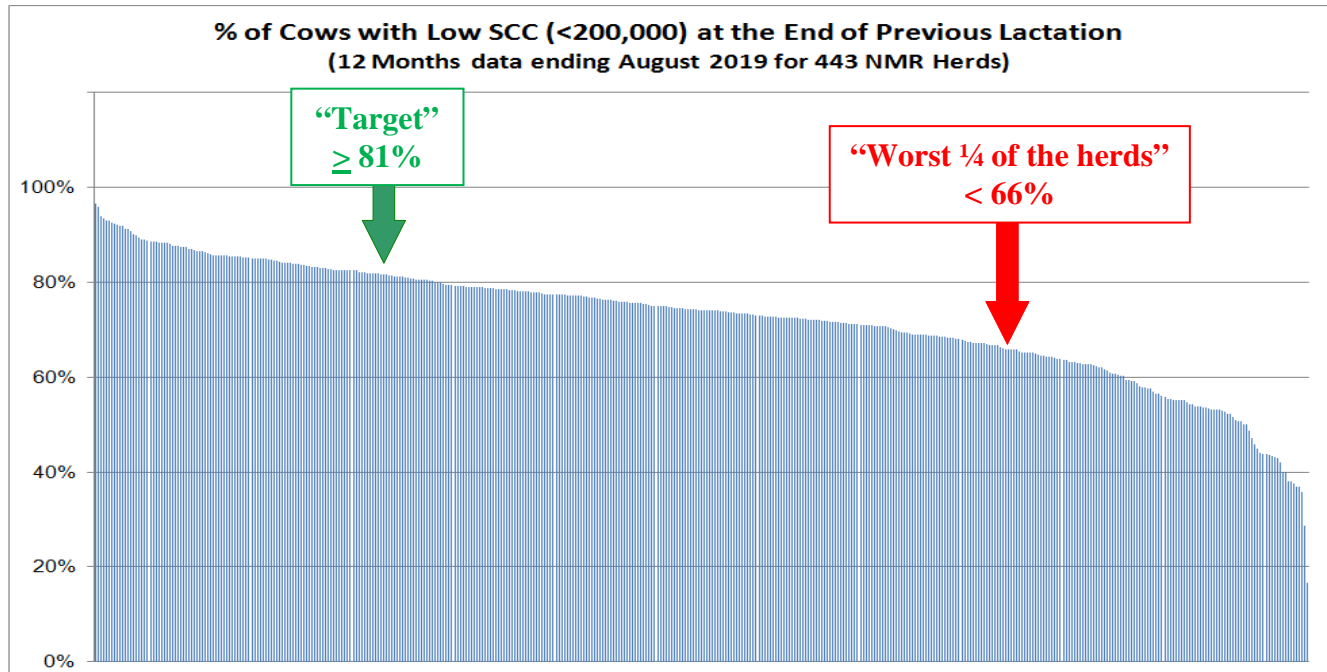"Target" ≥ 90%

"Worst ¼ of the herds" < 80%
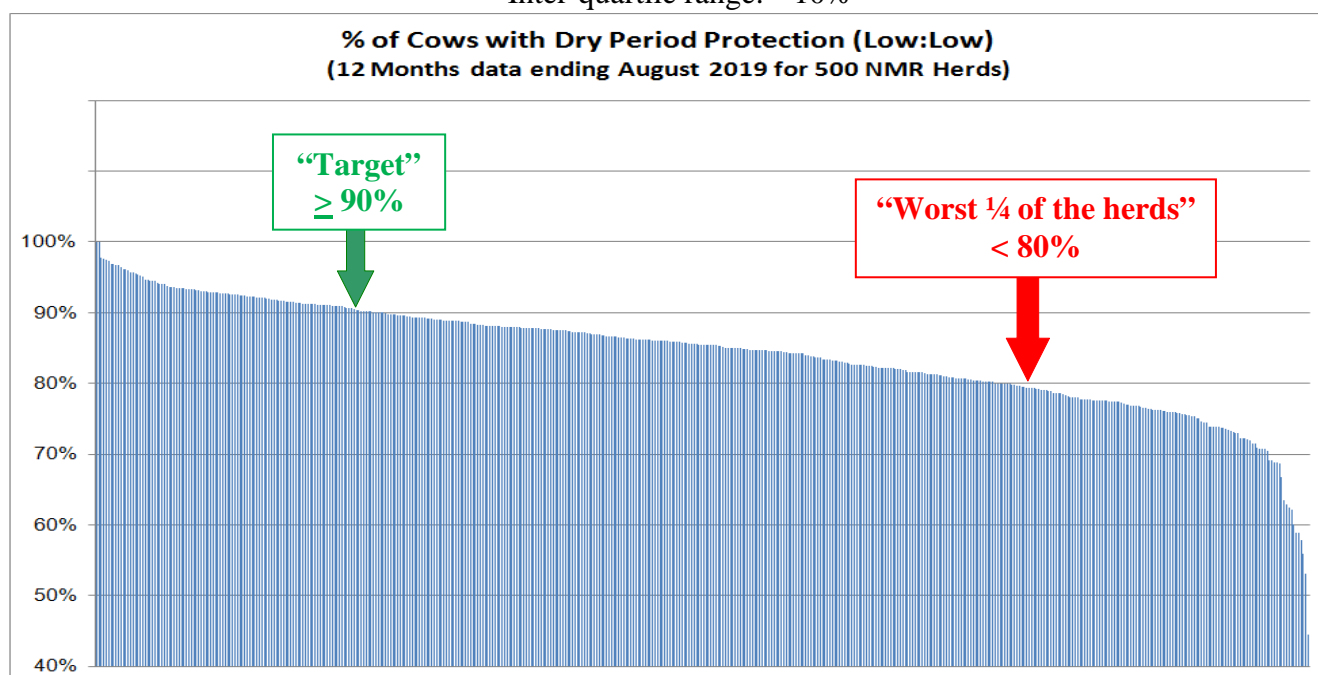
ZC. % Low at the end of previous lactation: The percentage of cows calving in the last year that ended their previous lactation with a LOW SCC (< 200,000 cells).

<div align="center">

Target (top ¼ of herds' level): **81%**

Median: 74%

75% level: 66%

Inter-quartile range: 15%

</div>

% of Cows with Low SCC (<200,000) at the End of Previous Lactation
(12 Months data ending August 2019 for 443 NMR Herds)

"Target" ≥ 81%

"Worst ¼ of the herds" < 66%

ZD. % NEW SCC milk samples: Of all milk samples, the percentage that were of the NEW Herd Companion SCC Category (the first HIGH SCC (≥ 200,000cells/ml) in a lactation following one or more low SCC samples).

<div align="center">

Target (top ¼ of herds' level): **5%**

Median: 6%

75% level: 8%

Inter-quartile range: 3%

</div>

% of New SCC ≥ 200,000 cells/ml
(12 Months data ending August 2019 for 500 NMR Herds)

"Worst ¼ of the herds" > 8%
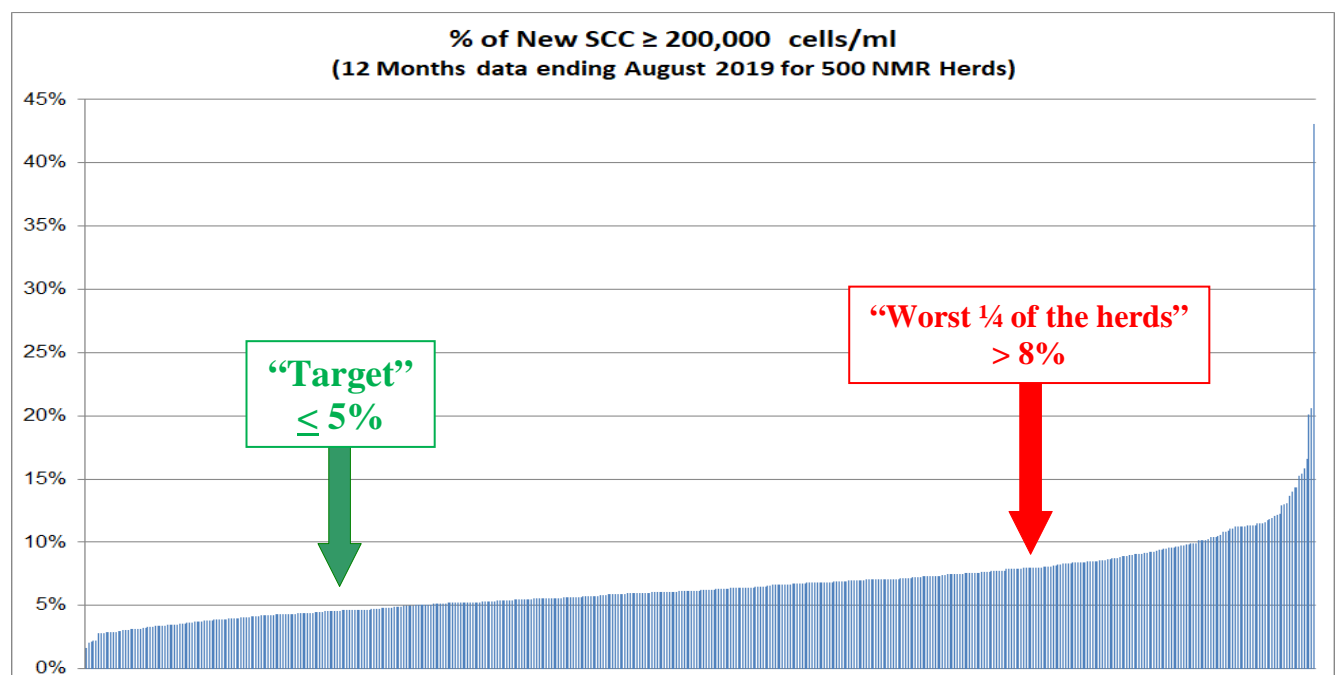
"Target" ≤ 5%

ZE. % dried-off with no SCC ≥ 200,000 cells/ml: The percentage of cows recording only LOW SCC samples (< 200,000 cells/ml) in completed lactations.

Target (top ¼ of herds' level):   **54%**
Median: 46%
75% level: 37%
Inter-quartile range: 17%
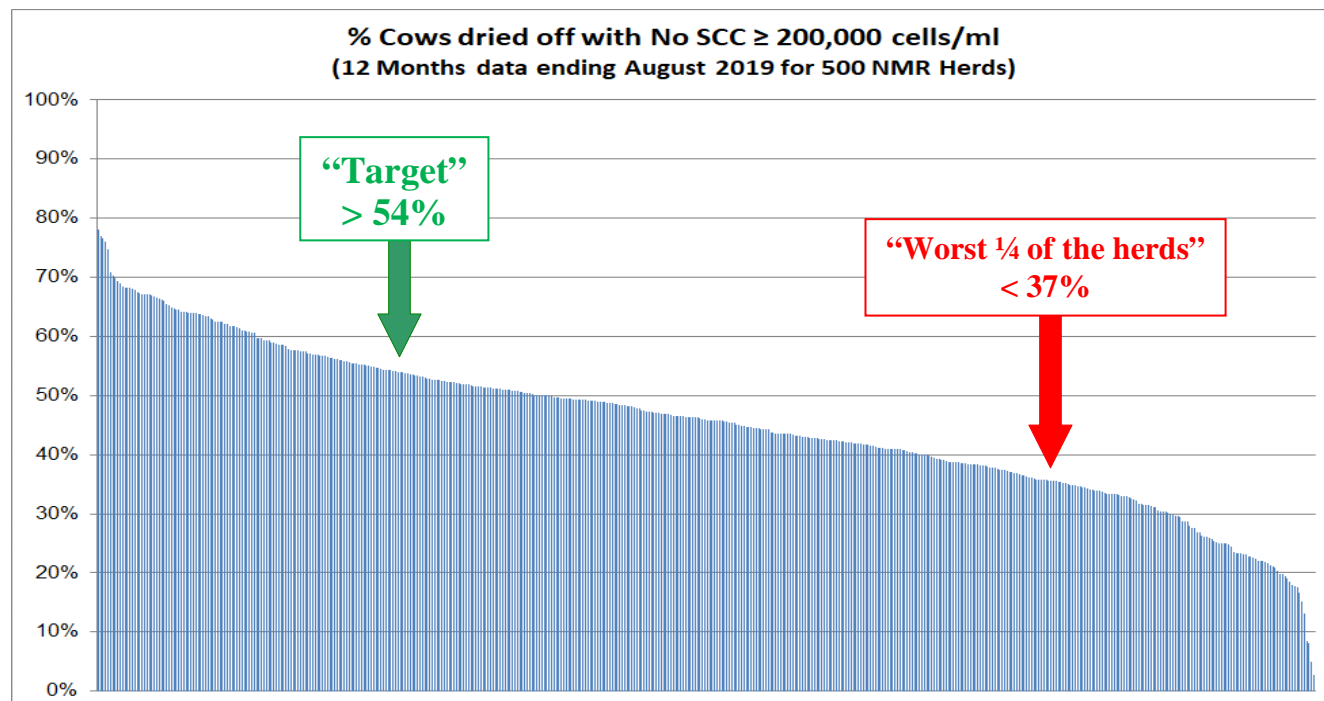
ZF. Threshold Index new high / new low: The total cows changing from Low to High SCC divided by the total cows changing from High to Low SCC at consecutive recordings.

Target (top ¼ of herds' level):   **1.12**
Median: 1.25
75% level: 1.40
Inter-quartile range: 0.28

24

ZG. Recovery % of New/First/Repeat infections: Of HIGH SCC cows (≥ 200,000cells/ml) that at the previous recording were either low SCC or not yet in milk, the percentage that were LOW SCC (< 200,000 cells/ml) at the following recording.

<div align="center">

Target (top ¼ of herds' level): **60%**

Median: 55%
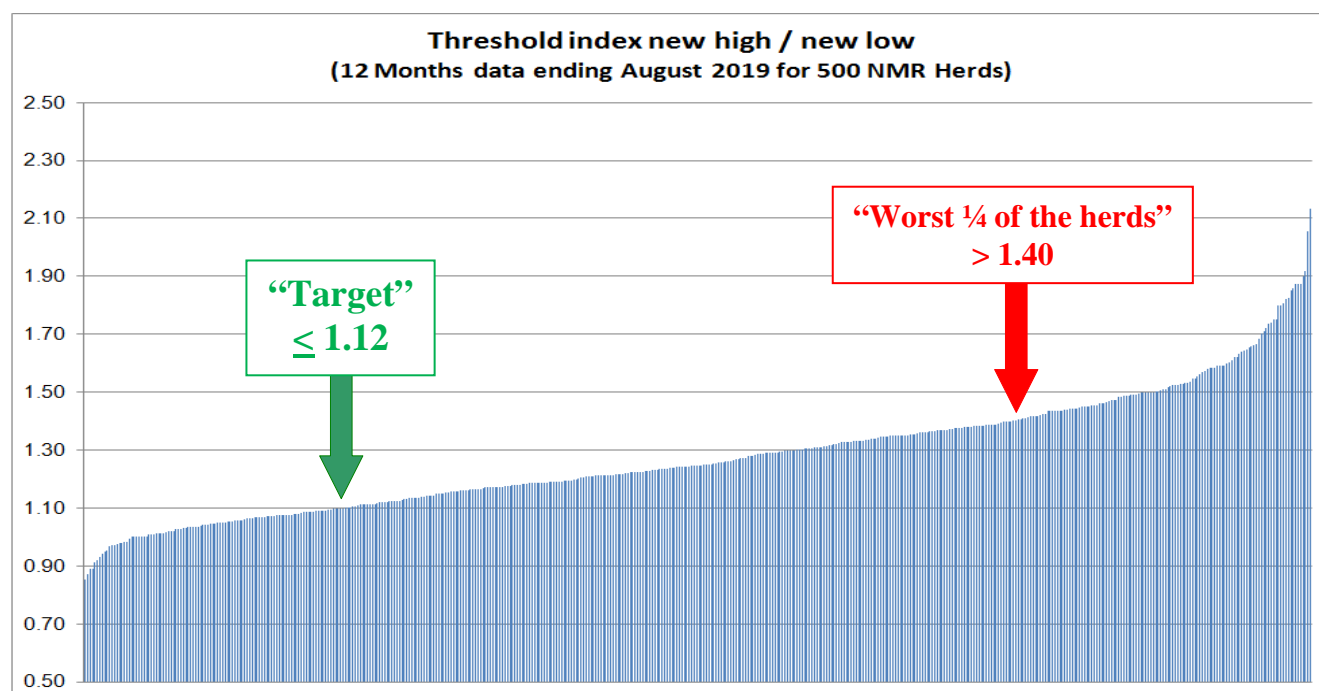
75% level: 50%

Inter-quartile range: 10%

</div>

%New/first/repeat Recovery
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" ≥ 60%

"Worst ¼ of the herds" < 50%
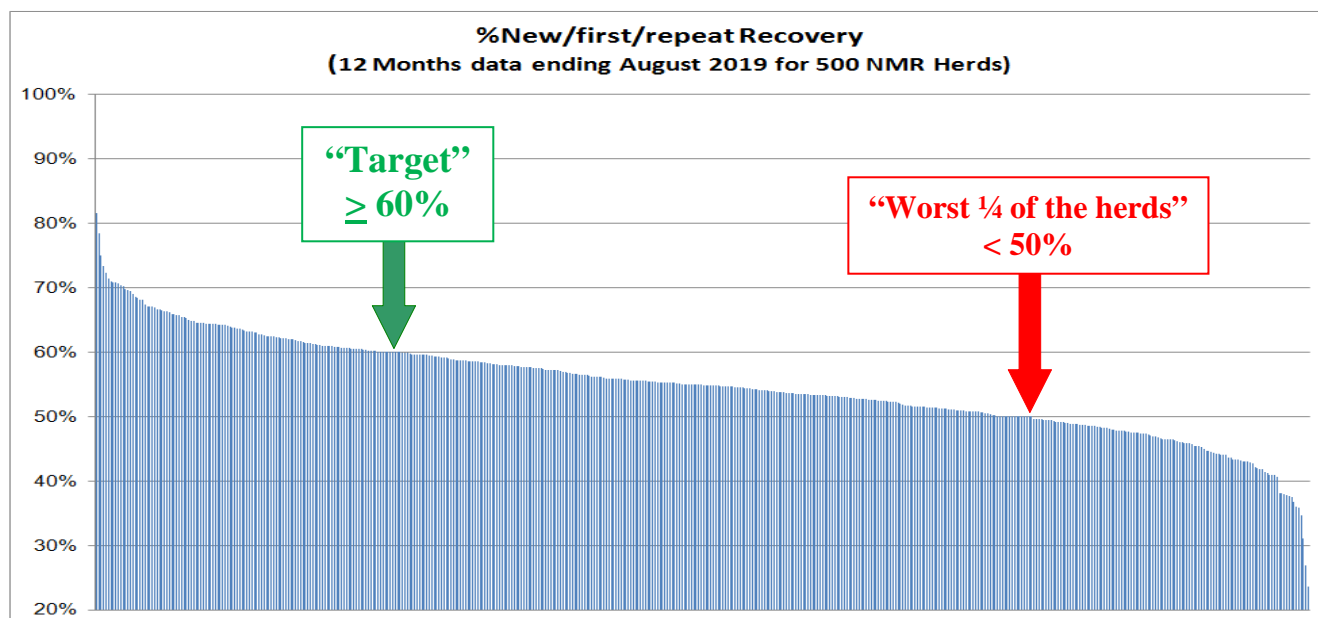
ZH. Recovery % of chronic infections: Of cows with two or more consecutive HIGH SCC recordings (≥ 200,000 cells/ml), the percentage that recorded a LOW SCC (< 200,000 cells/ml) at the following recording.

<div align="center">

Target (top ¼ of herds' level): **25%**

Median: 21%

75% level: 17%

Inter-quartile range: 8%

</div>

% Recovery from Chronic infections
(12 Months data ending August 2019 for 500 NMR Herds)

"Target" ≥ 25%

"Worst ¼ of the herds" < 17%
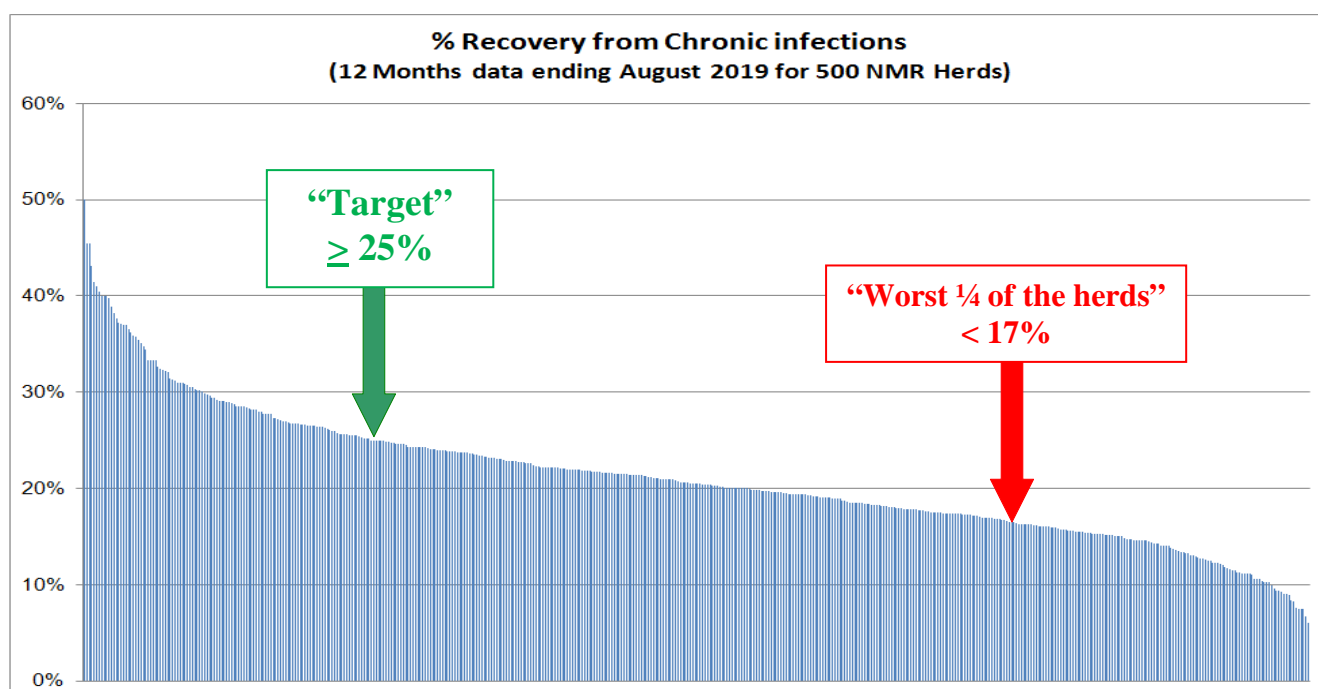
ZJ. Mastitis rate: Number of clinical mastitis cases per 100 cows in milk in the herd over a year.

<div align="center">

Target (top ¼ of herds' level):   **18**

Median: 30

75% level: 48

Inter-quartile range: 30

</div>

Section 3: Trends in Key Performance Indicators 2010 to 2019

The target and median figures from the current study are compared with the results from the first study for the year ending 30 September 2010 and from last year's study. Table 2 below shows changes in the media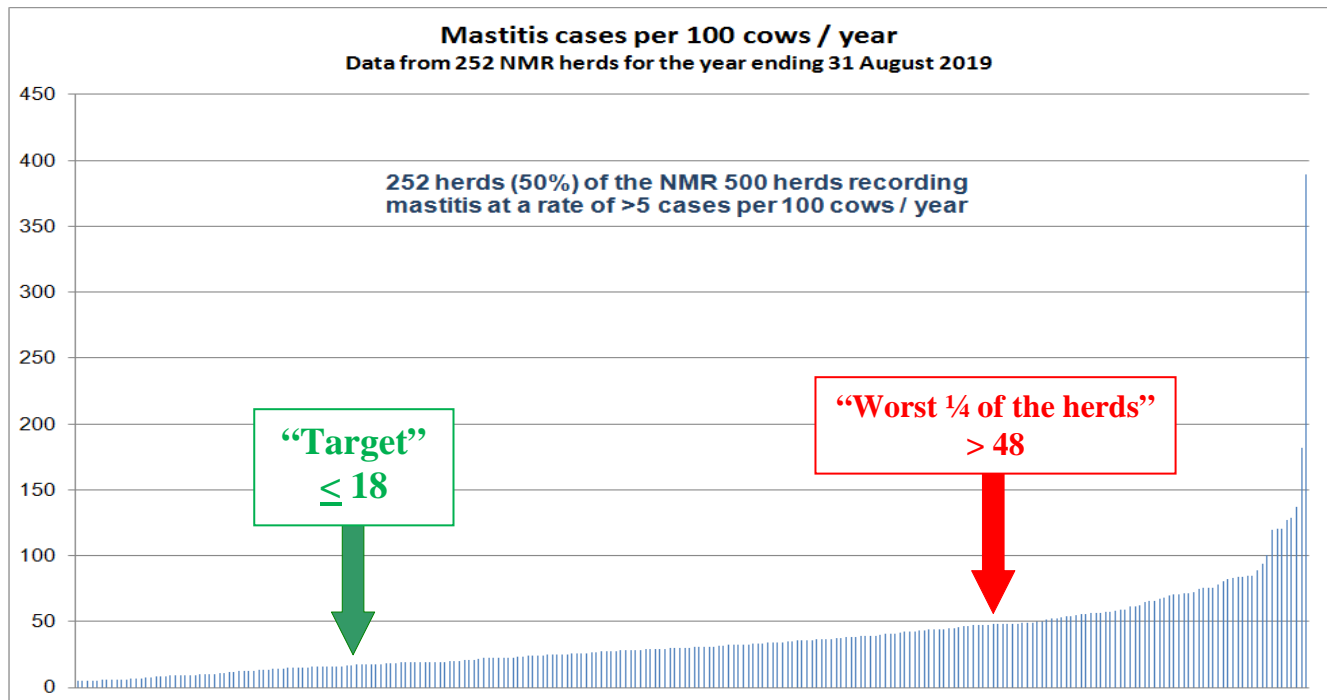n and target (top 25% performance) values for each parameter over the period. The majority of parameters have improved (**green**) over the period with the exception of overall culling, age & number of lactations at exit which show some deterioration (**red**). Many of the parameters have continued to improve since last year, although some have remained the same (**black**, in the 2019 columns). There is no attempt at identifying any statistical significance in these changes.

Table 2. Comparison of median and target values derived from the study of 500 NMR recording herds in 2018 with the original study in 2010, and with the current results as well.

Parameter	Median			Target "Best 25%"		
Year of the Study	*2010*	*2018*	*2019*	*2010*	*2018*	*2019*
A. Culling rate	24%	27%	27%	18%	22%	22%
B. Percentage culled (off take) / died 100 days after calving	7%	6%	5%	4%	4%	3%
C. Age at exit (years)	6.6	6.0	6.0	7.4	6.7	6.7
D. Age at exit by lactations	3.9	3.6	3.6	4.5	4.1	4.0
E. Percentage Served by day 80	46%	57%	58%	59%	68%	68%
F. Percentage conceived 100 days after calving	26%	34%	34%	33%	41%	41%
G. Calving to 1st service interval (days)	105	81	81	87	71	71
H. Calving interval (days)	424	400	401	409	388	387
I. Age at 1st calving (years)	2.4	2.3	2.3	2.3	2.1	2.1
J. Conception rate	32%	35%	35%	40%	42%	42%
K. %Service intervals at 18-24 days (Heat detection)	30%	35%	37%	38%	42%	44%
L. %Service intervals >50 days	32%	23%	21%	22%	16%	15%
M. %Cows eligible for service served (Submission rate)	27%	37%	39%	37%	49%	51%
N. %Cows eligible for service conceived (Pregnancy rate)	9%	13%	14%	13%	17%	18%
O. Lifetime milk / cow / day (kg)	10.5	12.5	13.0	12.6	14.7	14.9
P. Milk / cow / year (kg)	7,665	8,446	8,737	8,760	9,487	9,761
Q. Average protein%	3.27%	3.28%	3.32%	3.33%	3.35%	3.39%
R. Average fat%	3.96%	4.02%	4.02%	4.12%	4.17%	4.17%
V. Average SCC ('000 cells/ml)	210	178	171	169	142	136
W. % SCC ≥200,000 cells/ml	24%	18%	17%	19%	14%	13%
X. % SCC ≥500,000 cells/ml	9%	7%	7%	7%	5%	5%
Y. % 1st recording SCC ≥200,000 cells/ml	20%	17%	16%	15%	13%	12%
Z. % chronic SCC ≥200,000 cells/ml	14%	10%	9%	10%	7%	6%
ZA. % Dry period cure (High:Low)	74%	76%	77%	80%	83%	85%
ZB. % Dry period protection (Low:Low)	84%	85%	85%	89%	89%	90%
ZC. % Low at end of previous lactation (SCC<200,000 cells/ml)	60%	72%	74%	70%	81%	81%

Changes in Herd size over the 10 annual KPI studies

Figure 3 below shows changes in herd size (number of cows) since 2010, indicating dairy herds in UK tended to increase in size over the last 10 years with a large range between the larger and the smaller 25% of the herds.

Figure 3. Herd size
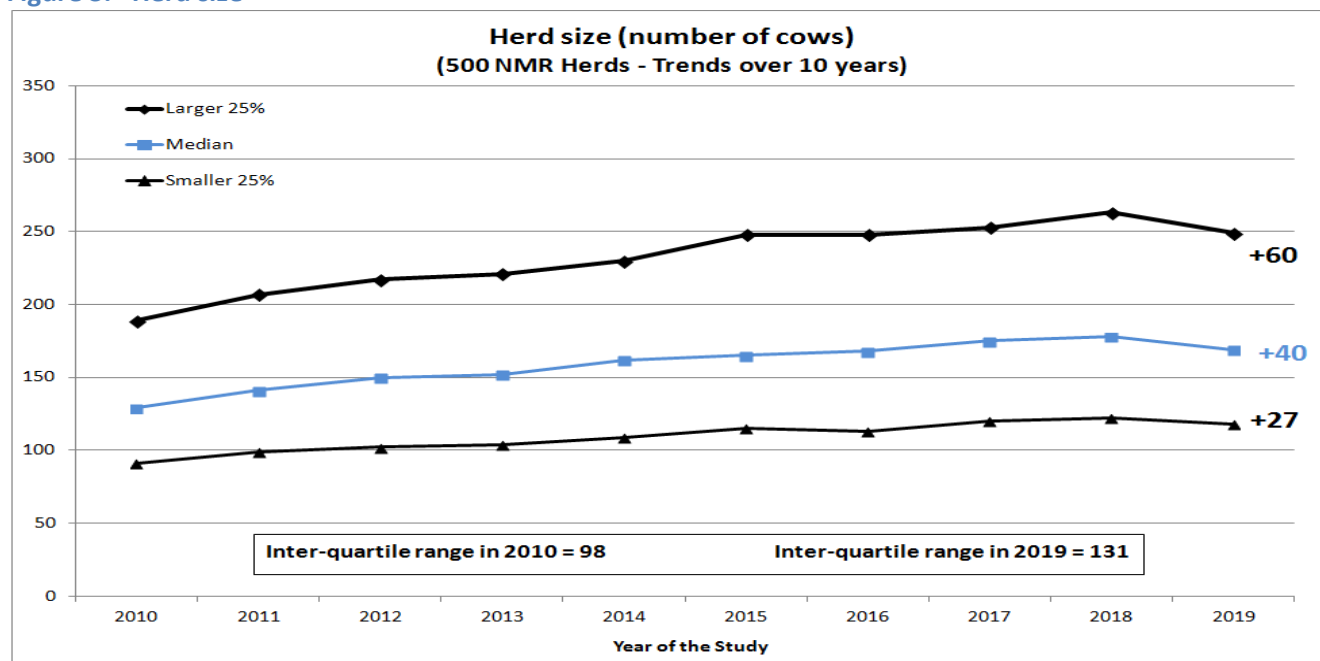
Changes in Key Parameters over the 10 annual KPI studies

The figures below show the changes over the ten annual KPI studies (2010 to 2019) for a number of important parameters. The three lines represent the "better" quartile, median and "poorer" quartile values each year for each parameter.

3.1 Trends in Culling & Longevity Parameters over the last 10 years

Figure 4. Culling rate
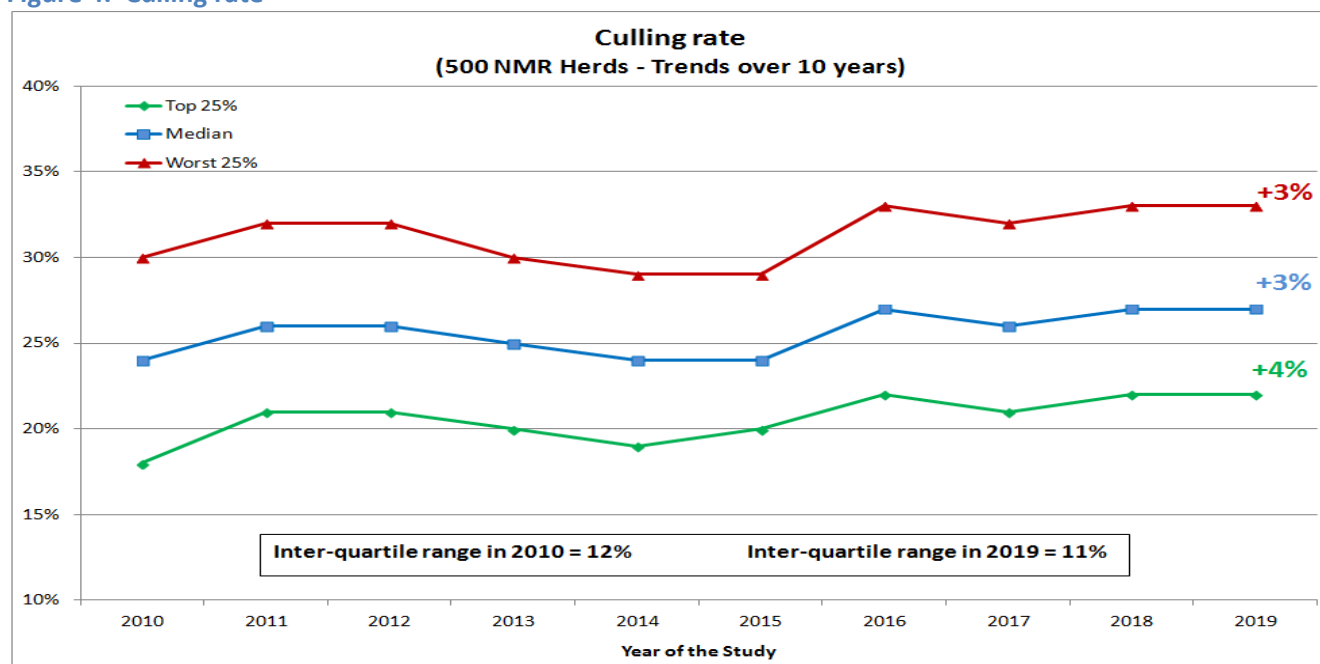
Figure 5. Culling (off take) / died in the first 100 days of lactation

Culling rate in First 100 days After Calving
(500 NMR Herds - Trends over 10 years)

Legend: Top 25%, Median, Worst 25%

Inter-quartile range in 2010 = 6%   Inter-quartile range in 2019 = 4%

-3%
-2%
-1%

Year of the Study

Figure 6. Age at exit (by number of Years)

Age at Exit (years)
(500 NMR Herds - Trends over 10 years)

Legend: Top 25%, Median, Worst 25%

Inter-quartile range in 2010 = 1.4   Inter-quartile range in 2019 = 1.3

-0.7
-0.6
-0.6

Year of the Study

29

Figure 7. Age at exit (by number of Lactations)
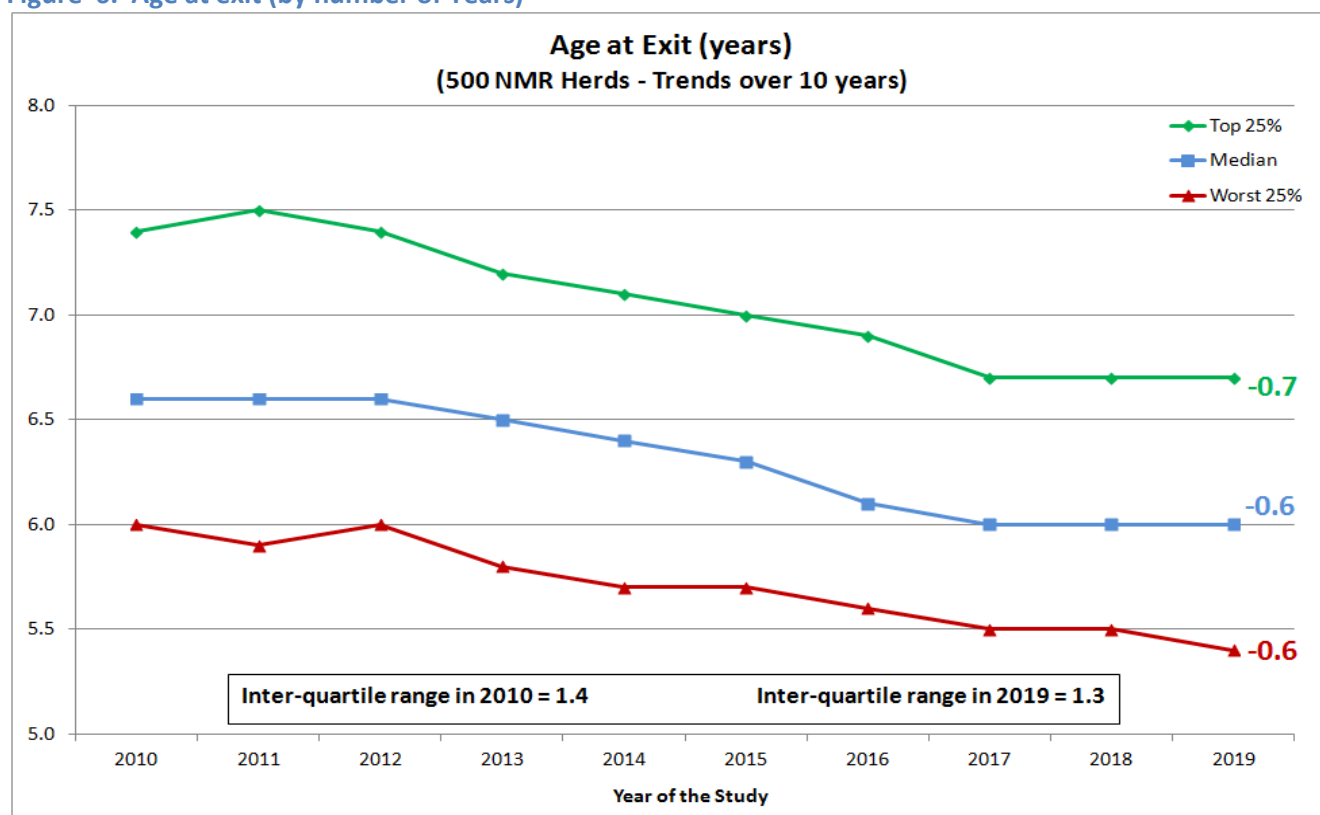
Figure 7. Age at exit (by number of Lactations)
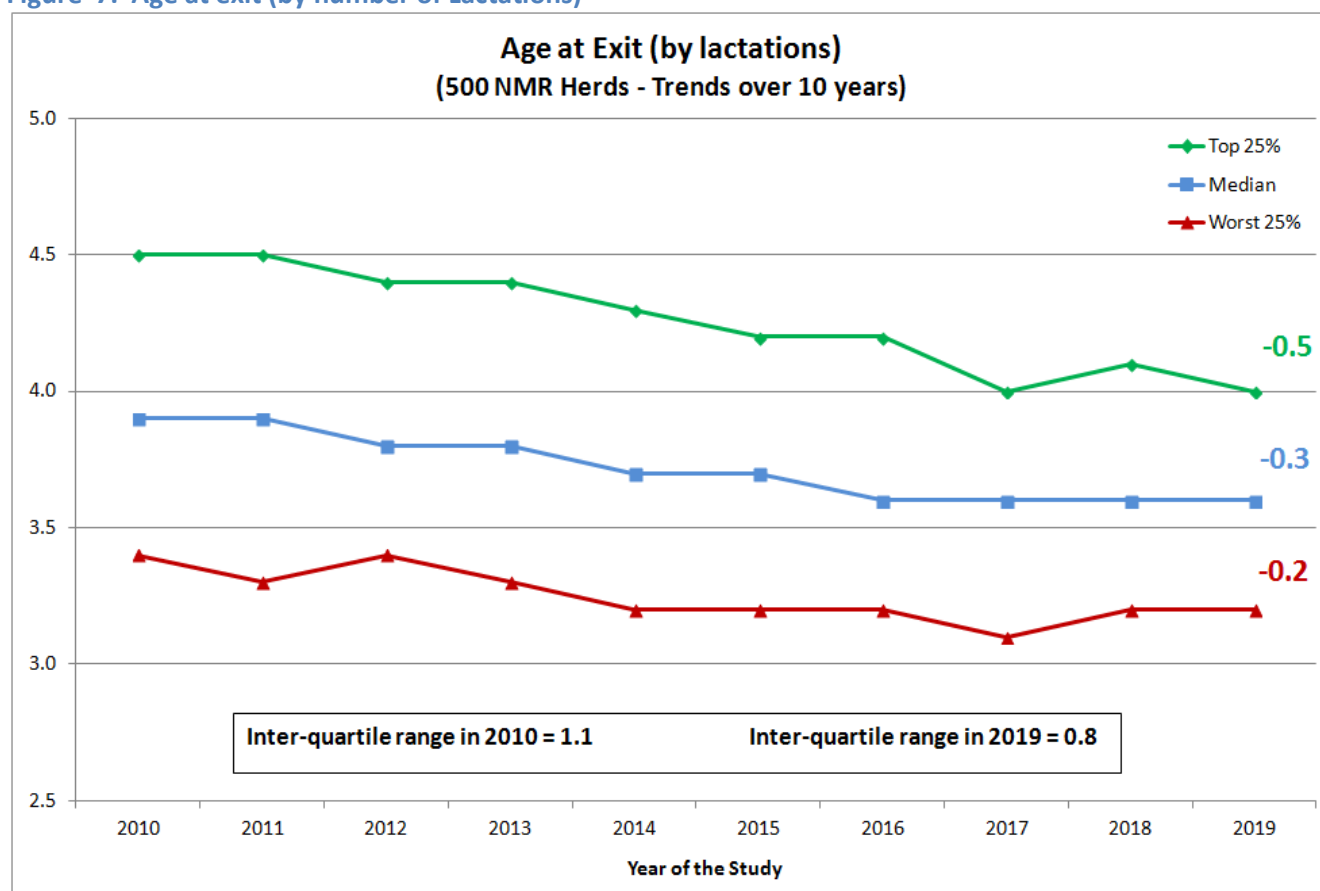
3.2 Trends in Key Fertility Parameters over the last 10 years

Figure 8. Age at first calving

Figure 8. Age at first calving
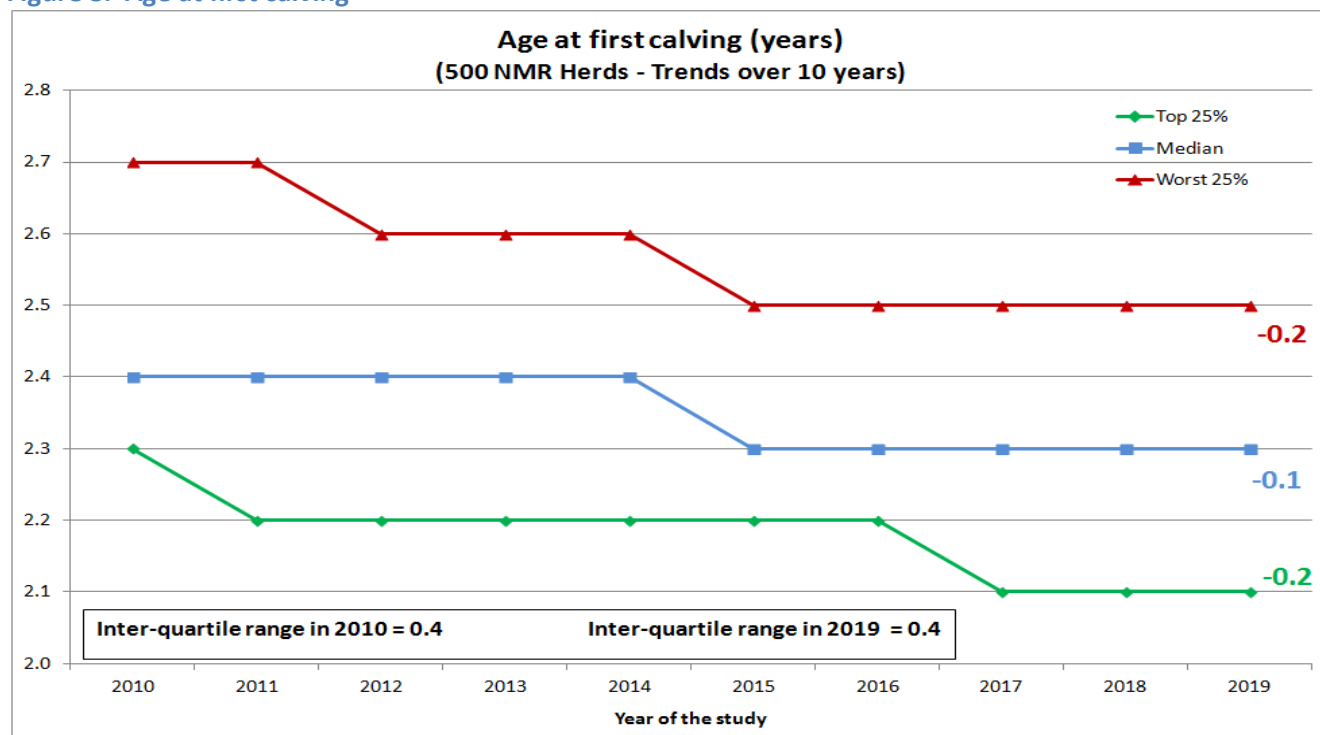
Figure 9. Percentage of cows served by Day 80 after calving

%Served by day 80 after calving
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+9%
+12%
+12%

Inter-quartile range in 2010 = 27%   Inter-quartile range in 2019 = 24%
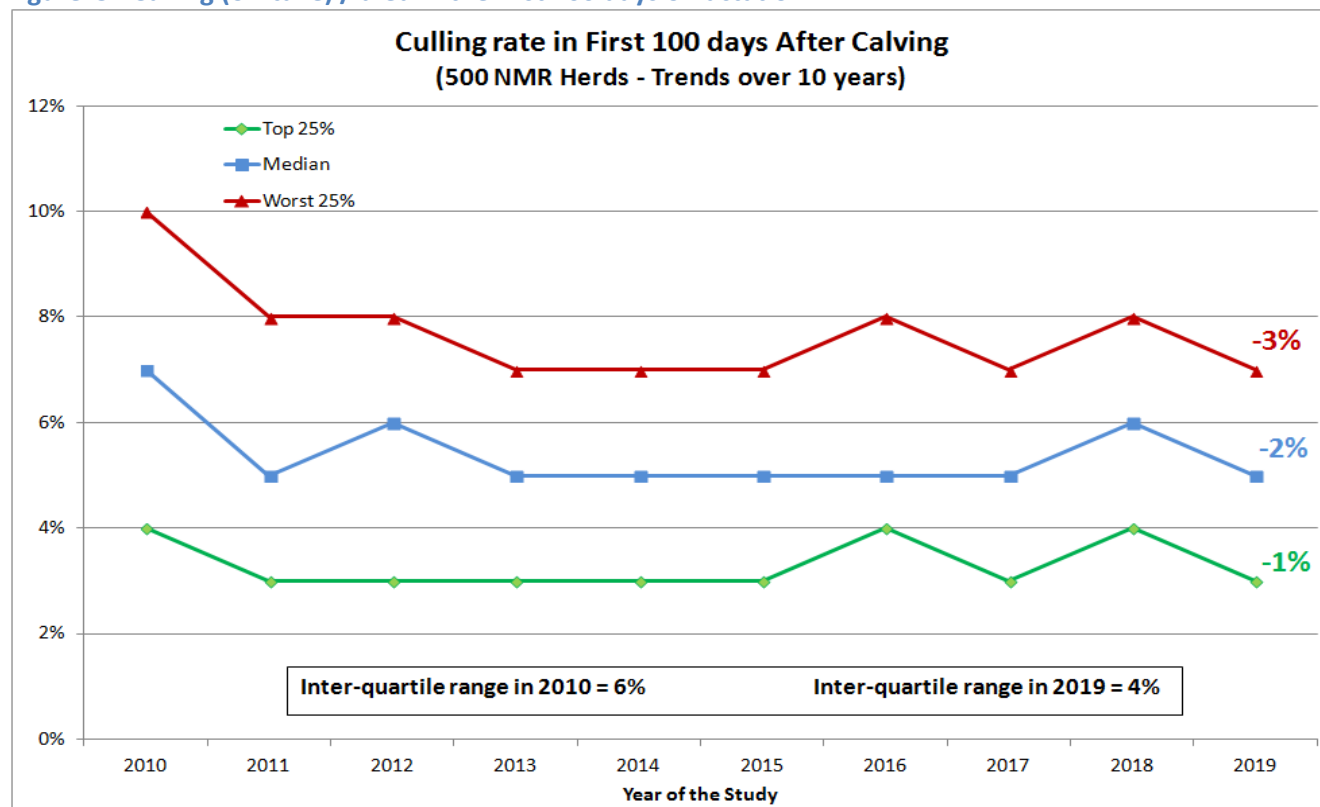
Year of the study
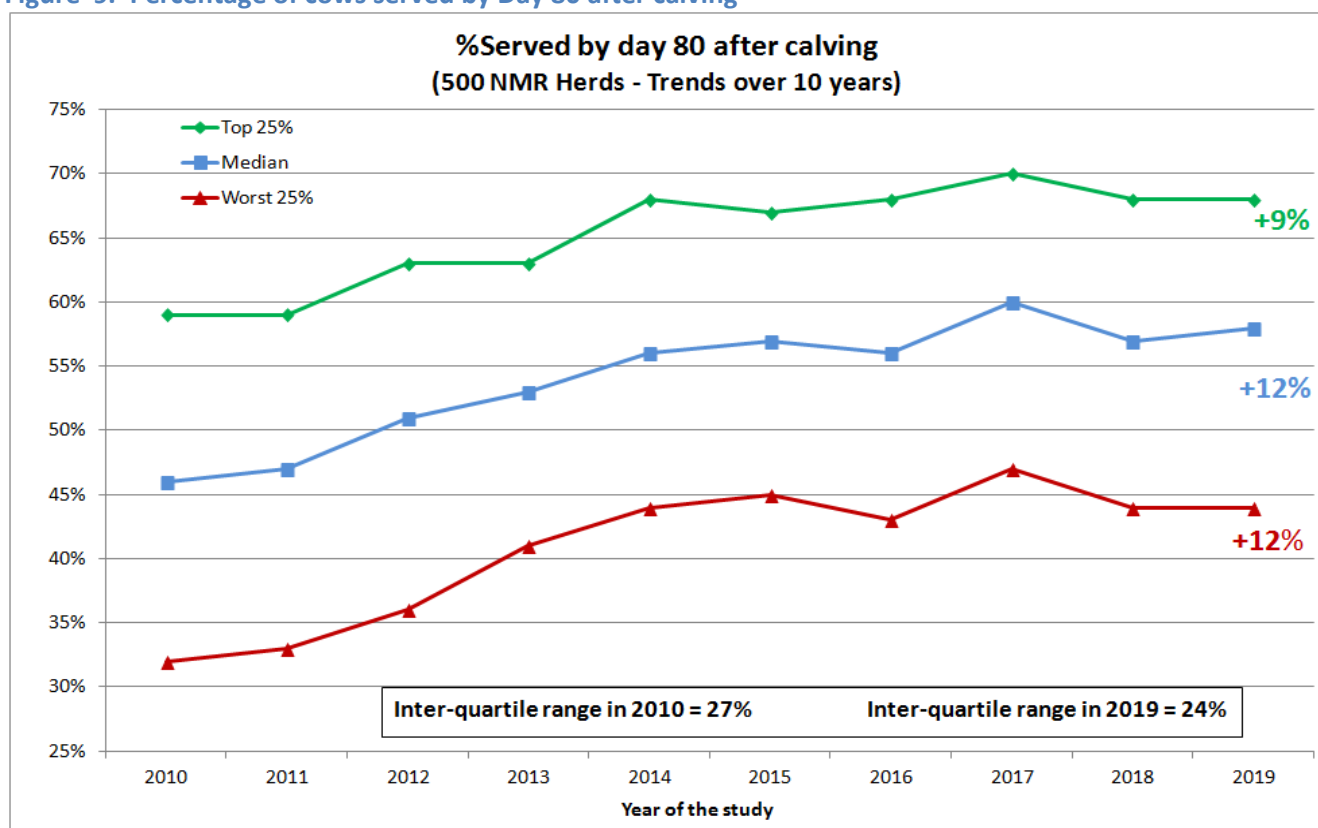
Figure 10. Percentage of cows pregnant (conceived) by Day 100 after calving

%Conceived by day 100 after calving
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+8%
+8%
+9%

Inter-quartile range in 2010 = 17%   Inter-quartile range in 2019 = 16%

Year of the Study

31
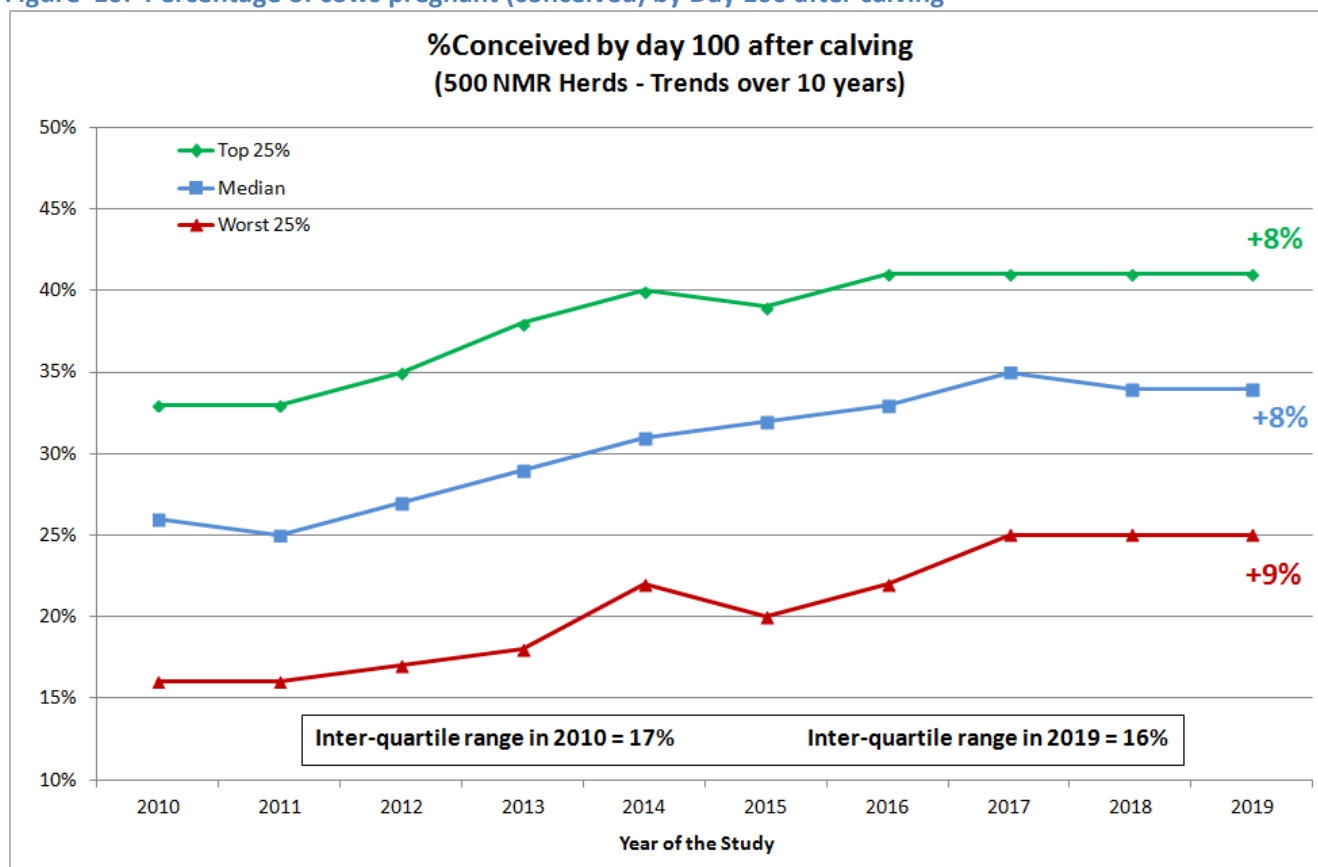
Figure 11. Percentage of all repeat services that are 18-24 days after the previous service (Heat detection)

%Service intervals 18 to 24 days
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+6%
+7%
+6%

Inter-quartile range in 2010 = 16%   Inter-quartile range in 2019 = 16%

Year of the Study
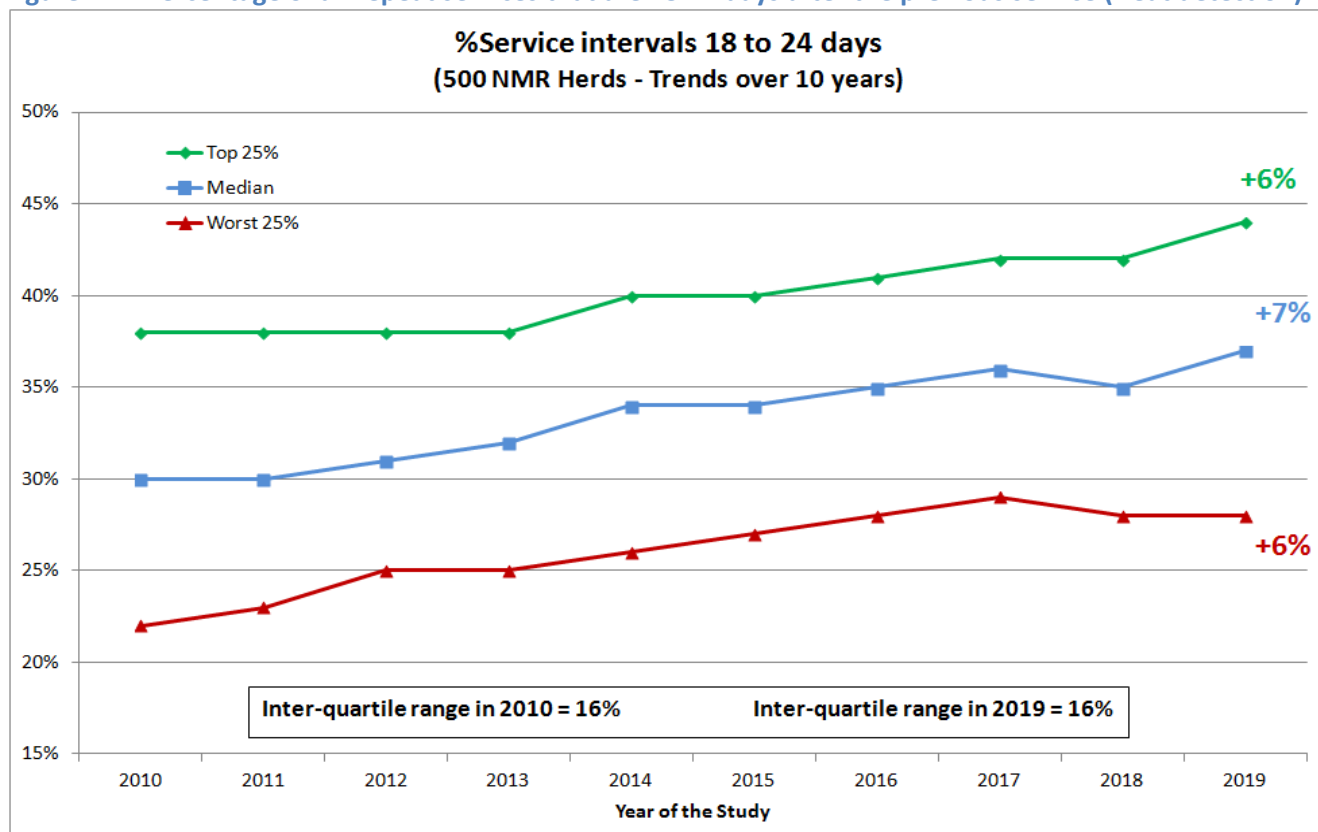
Figure 12. Percentage of all service resulting in a conception

Conception rate
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+2%
+3%
+3%

Inter-quartile range in 2010 = 14%   Inter-quartile range in 2019 = 13%

Year of the Study

32
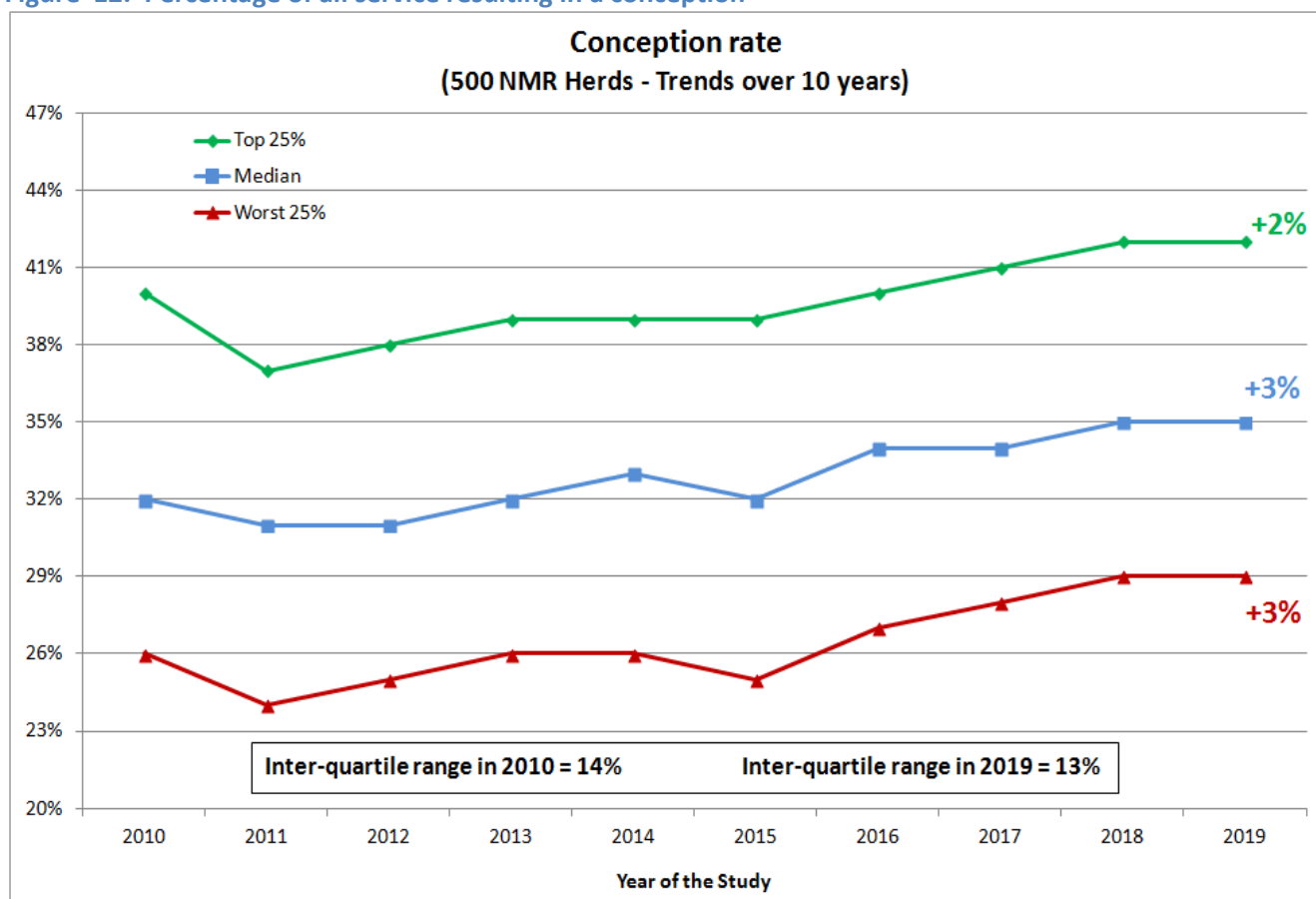
Figure 13. Submission rate

Submission rate (%Eligible for service served)
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+14%
+12%
+9%

Inter-quartile range in 2010 = 18%   Inter-quartile range in 2019 = 23%

Year of the Study
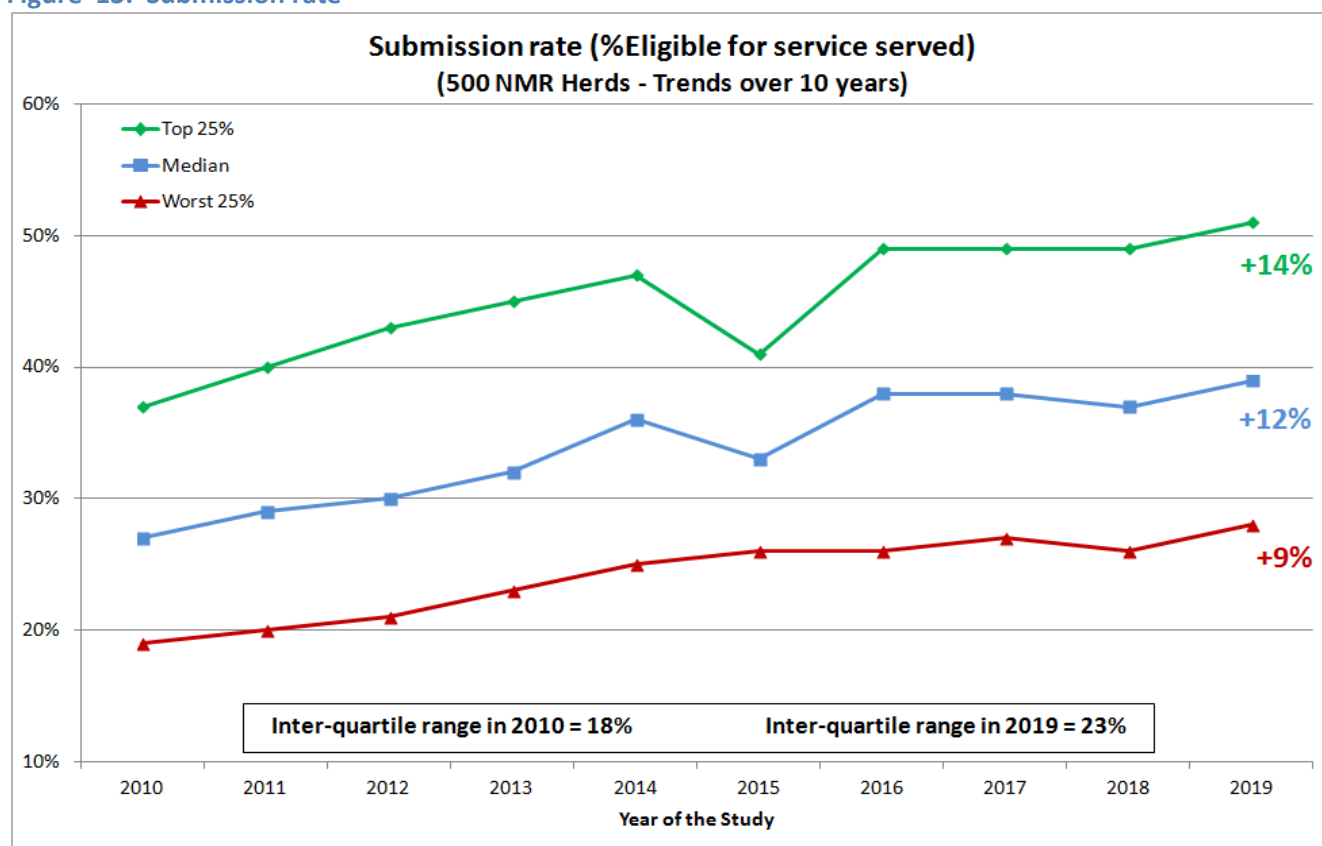
Figure 14. Pregnancy rate

Pregnancy rate (%Eligible for service that conceived)
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+5%
+5%
+5%

Inter-quartile range in 2010 = 8%   Inter-quartile range in 2019 = 8%

Year of the Study

Figure 15. Calving interval

Calving interval (days)
(500 NMR Herds - Trends over 10 years)

Legend: Top 25% (green diamond), Median (blue square), Worst 25% (red triangle)

-24 (Worst 25%)
-23 (Median)
-22 (Top 25%)

Inter-quartile range in 2010 = 32   Inter-quartile range in 2019 = 30

Year of the Study

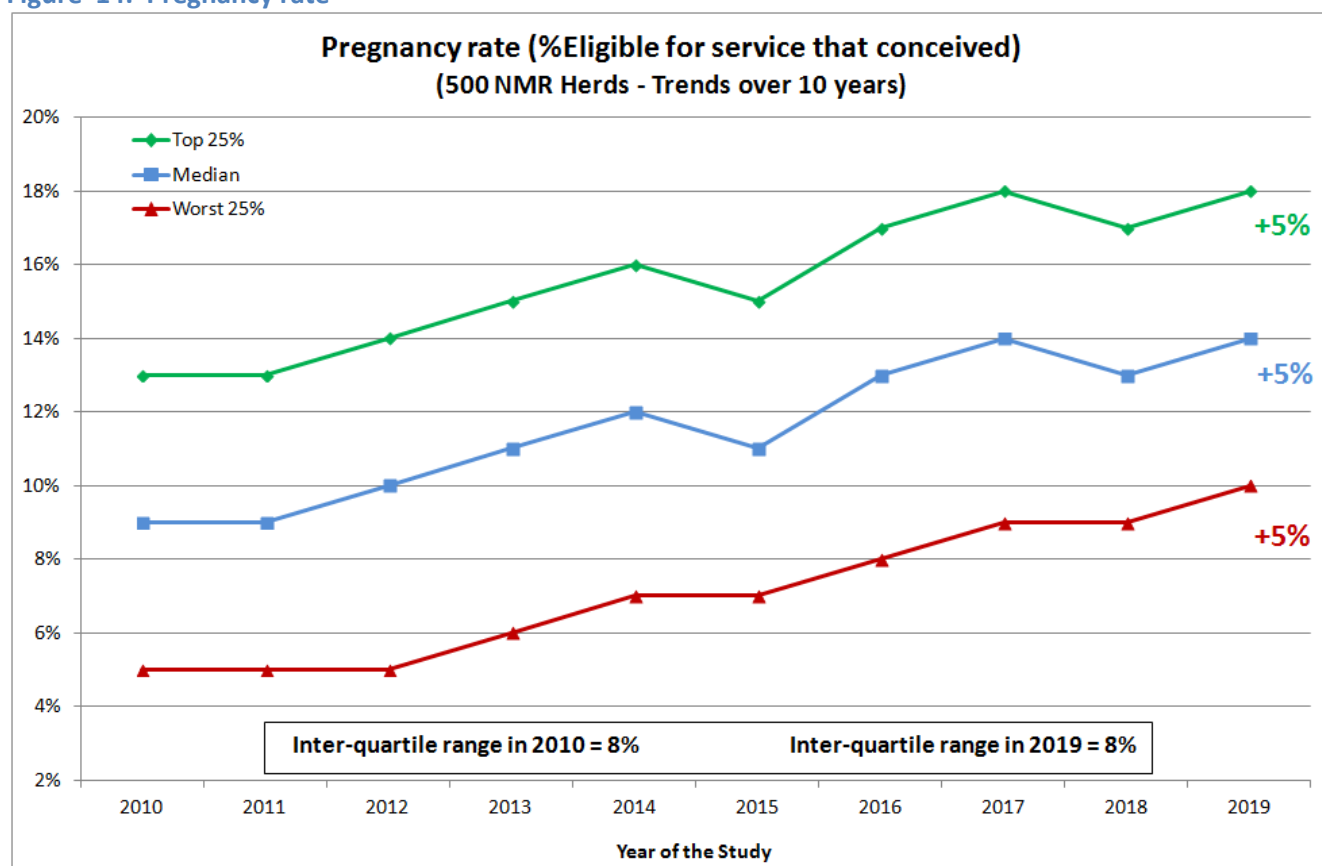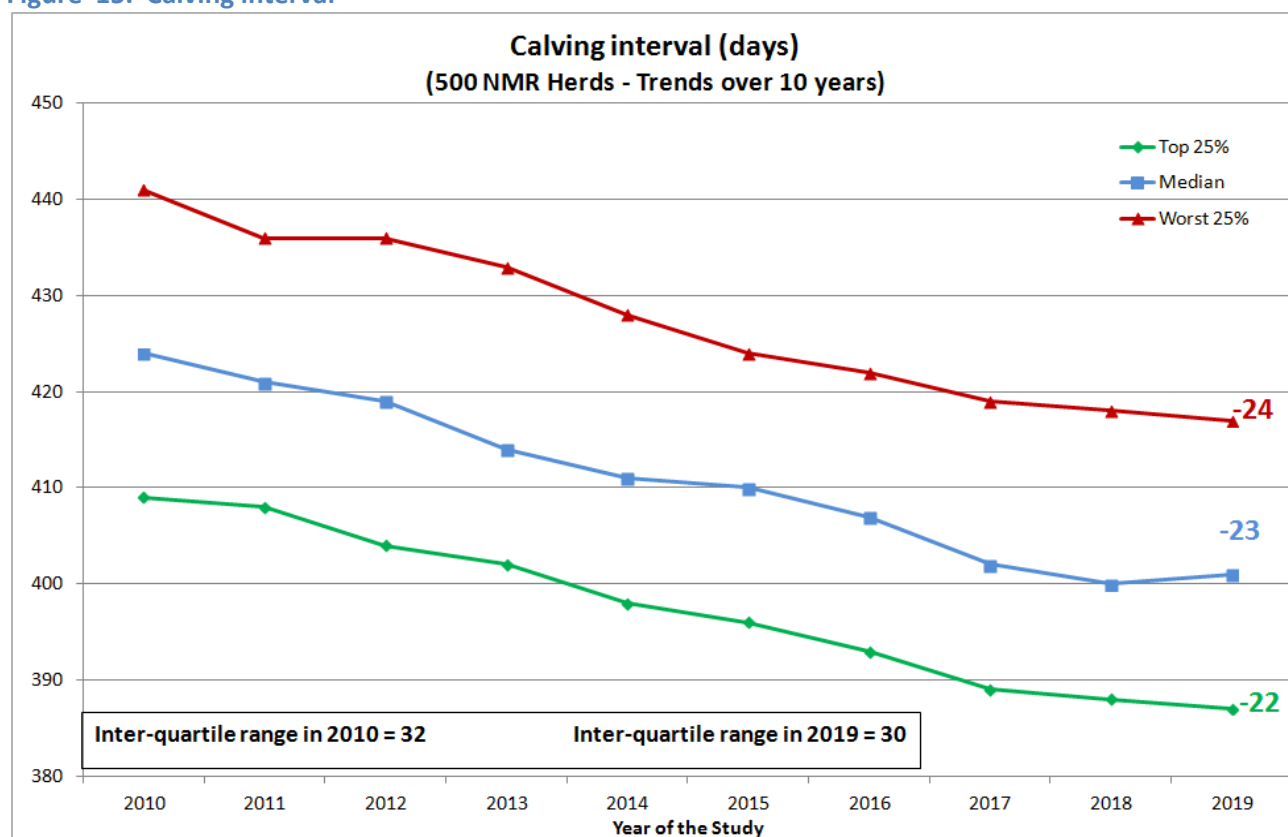## 3.3 Trends in Milk Production Parameters over the last 10 years

Figure 16. Lifetime milk per cow / day (kg). This includes days between birth and first calving.

Lifetime milk per cow / day (kg)
(500 NMR Herds - Trends over 10 years)

Legend: Top 25% (green diamond), Median (blue square), Worst 25% (red triangle)

+2.3 (Top 25%)
+2.5 (Median)
+2.6 (Worst 25%)

Inter-quartile range in 2010 = 4.3   Inter-quartile range in 2019 = 4.0

Year of the Study
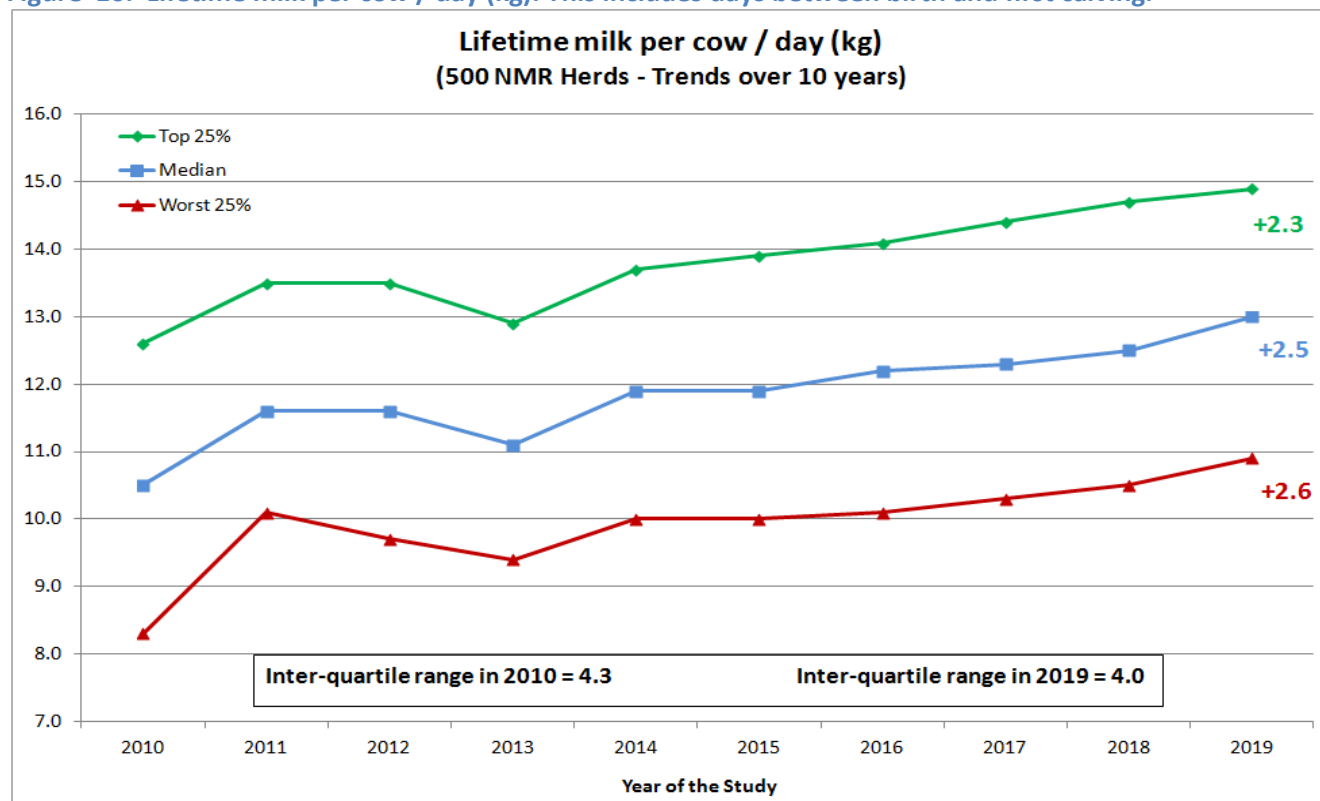
Figure 17. Milk per cow / year (kg)

Milk per cow / year (kg)
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+1,001
+1,072
+1,001

Inter-quartile range in 2010 = 2,190   Inter-quartile range in 2019 = 2,190

Year of the Study
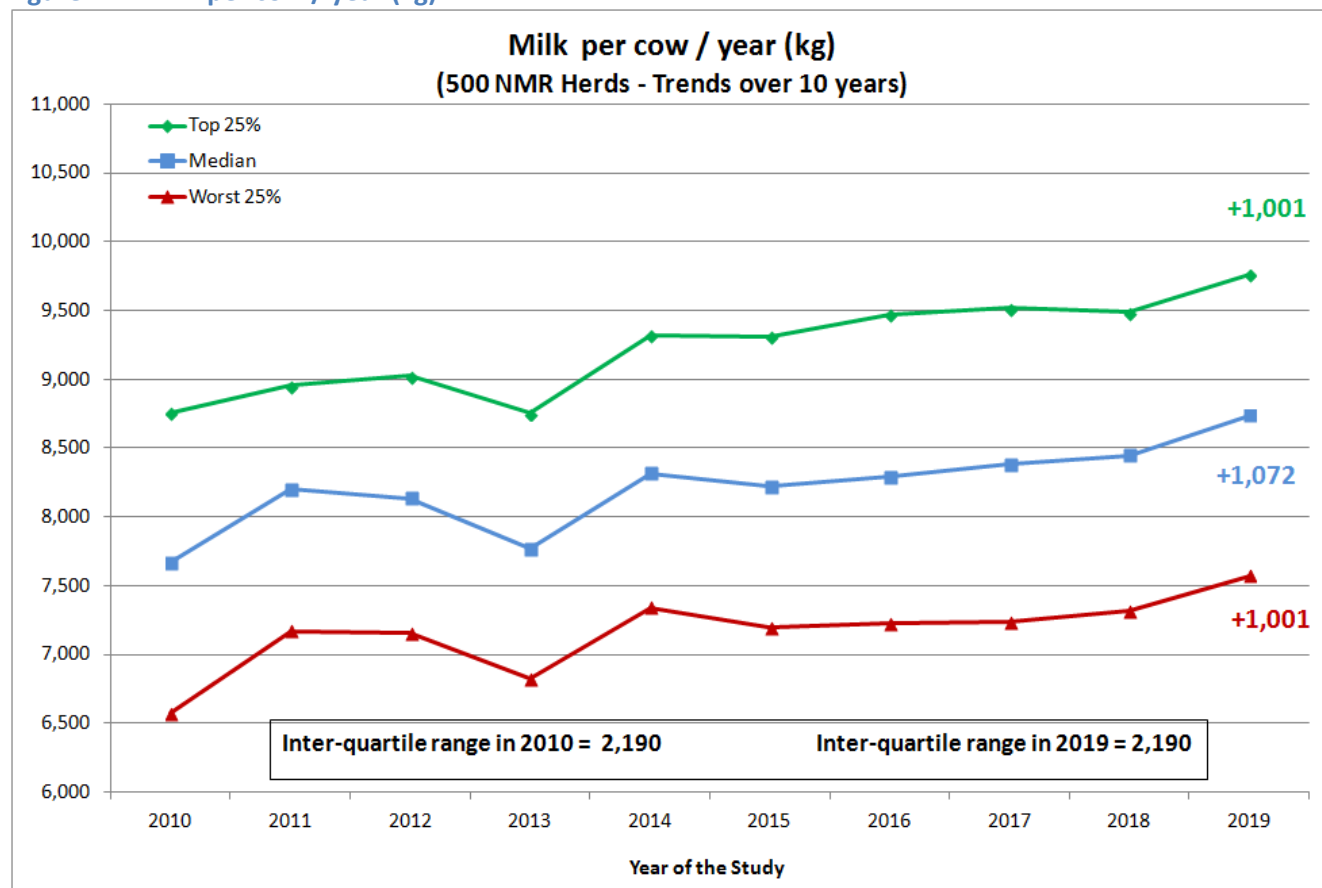
3.4 Trends in Key SCC & Mastitis Parameters over the last 10 years

Figure 18. Herd Somatic cell Count
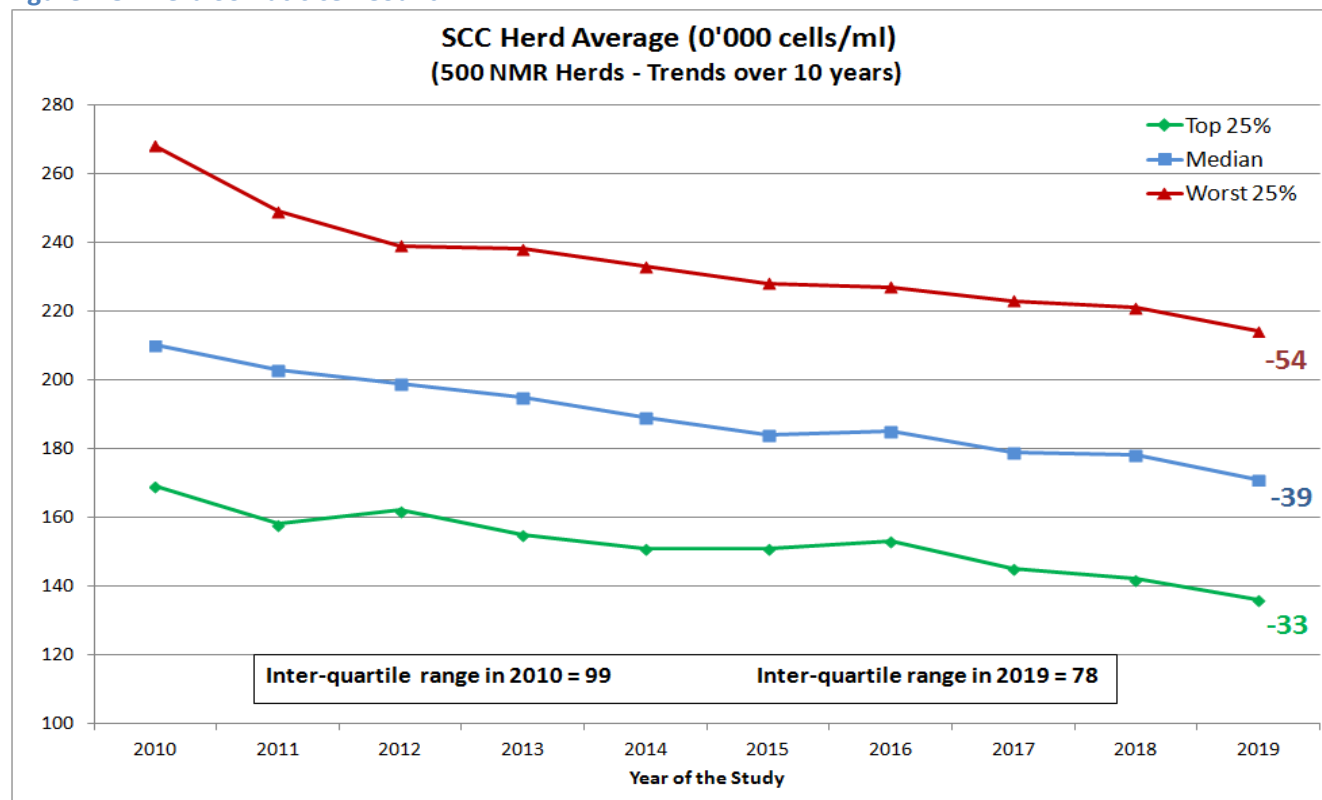
SCC Herd Average (0'000 cells/ml)
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

-54
-39
-33

Inter-quartile range in 2010 = 99   Inter-quartile range in 2019 = 78

Year of the Study

%Chronic SCC >=200,000 cells/ml
(500 NMR Herds - Trends over 10 years)

- Top 25%
- Median
- Worst 25%

-7%
-5%
-4%

Inter-quartile range in 2010 = 9%   Inter-quartile range in 2019 = 6%

Year of the Study
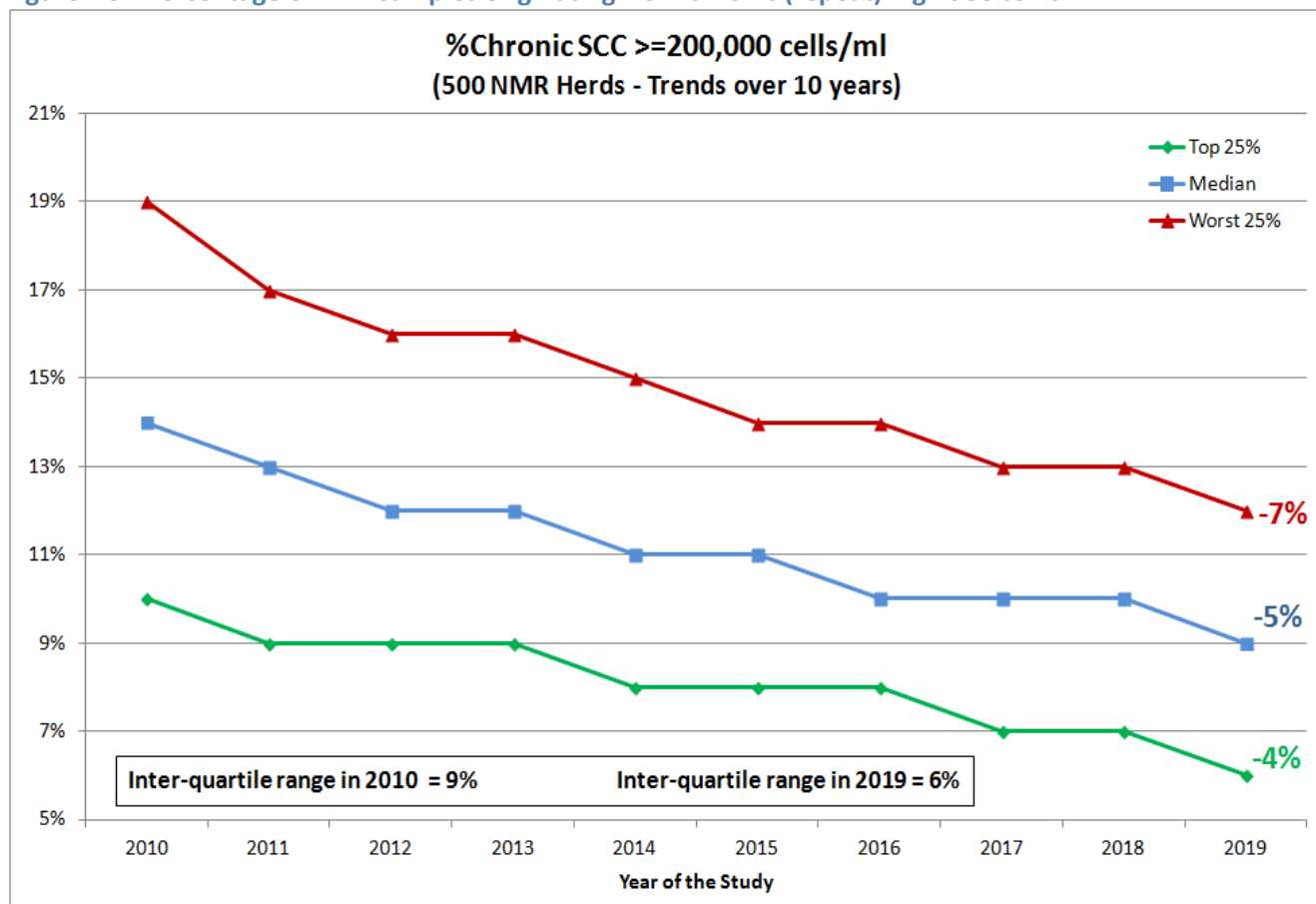
Figure 20. Percentage of cows dried-off with no high SCC in lactation

% Dried -off with no SCC ≥ 200,000 cells/ml
(500 NMR Herds – Trends over 10 years)

- Top 25%
- Median
- Worst 25%

+11%
+13%
+12%

Inter-quartile range in 2010 = 18%   Inter-quartile range in 2019 = 17%

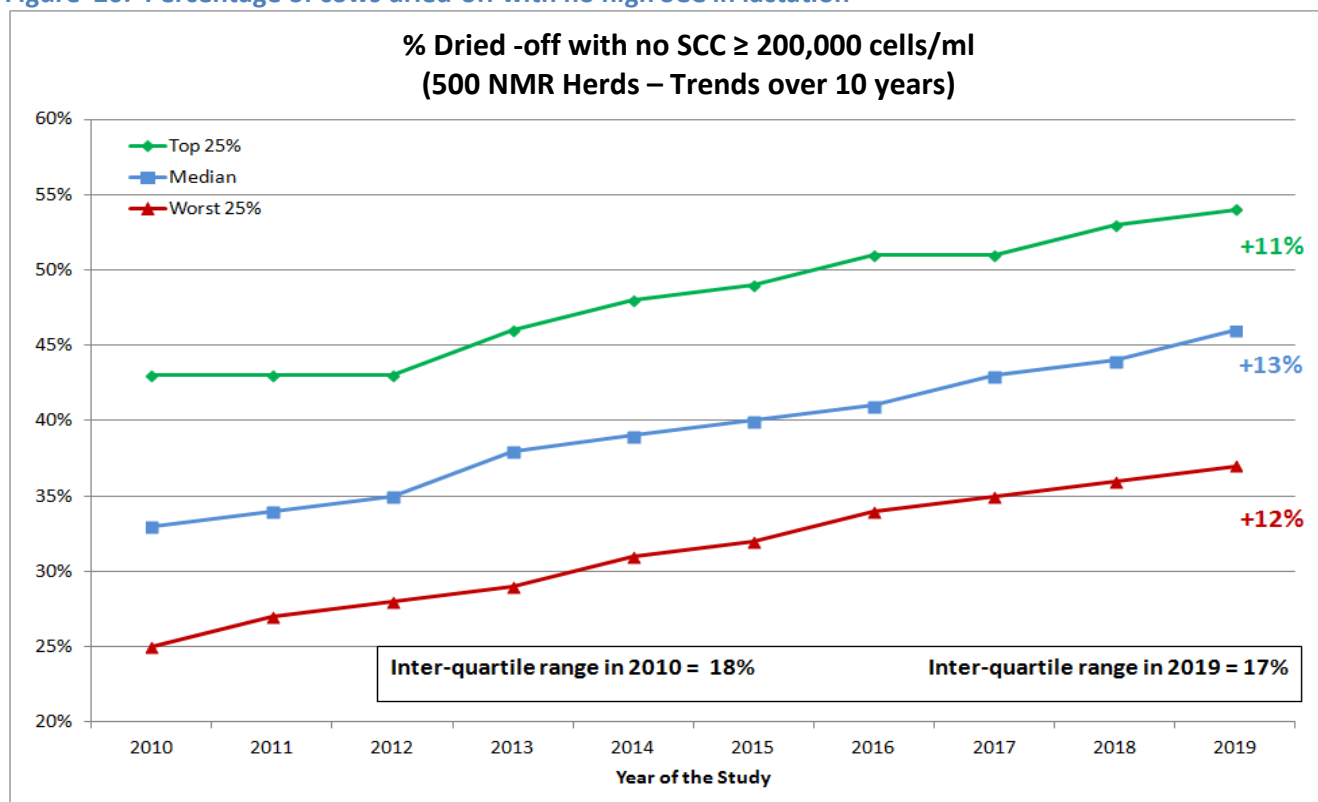Year of the Study

Figure 21(a). Mastitis rate (cases / 100 cows in milk / year) – mastitis groups of herds in last 4 years

Mastitis case per 100 cows / year
(between 252 & 262 NMR Mastitis Herds - Trends over 4 years)

Inter-quartile range in 2016 = 32   Inter-quartile range in 2019 = 30
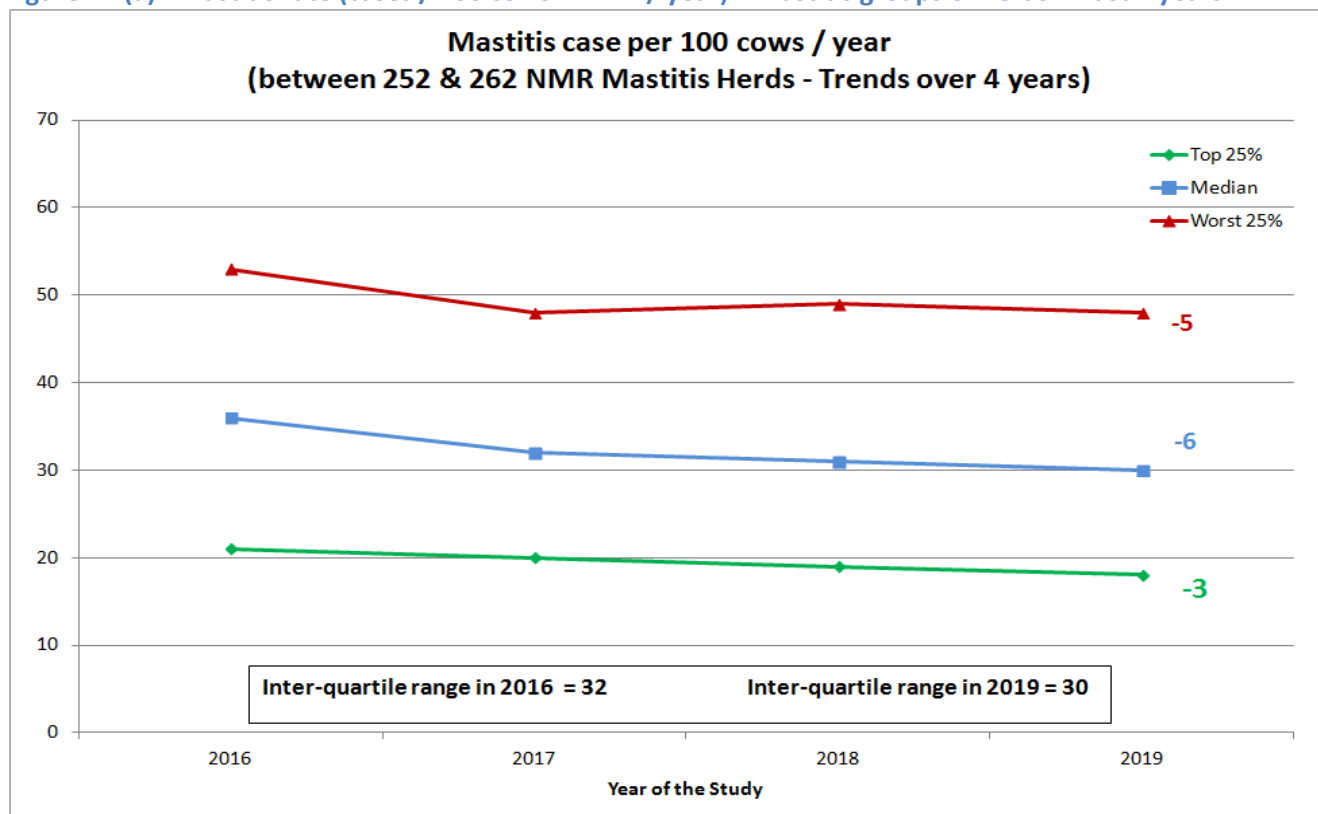
Figure 21(b). Mastitis rate (cases / 100 cows in milk / year) – the same herds over last 4 years

Mastitis case per 100 cows / year
(155 NMR Herds - The same herds over 4 years)

Inter-quartile range in 2016 = 35   Inter-quartile range in 2019 = 29
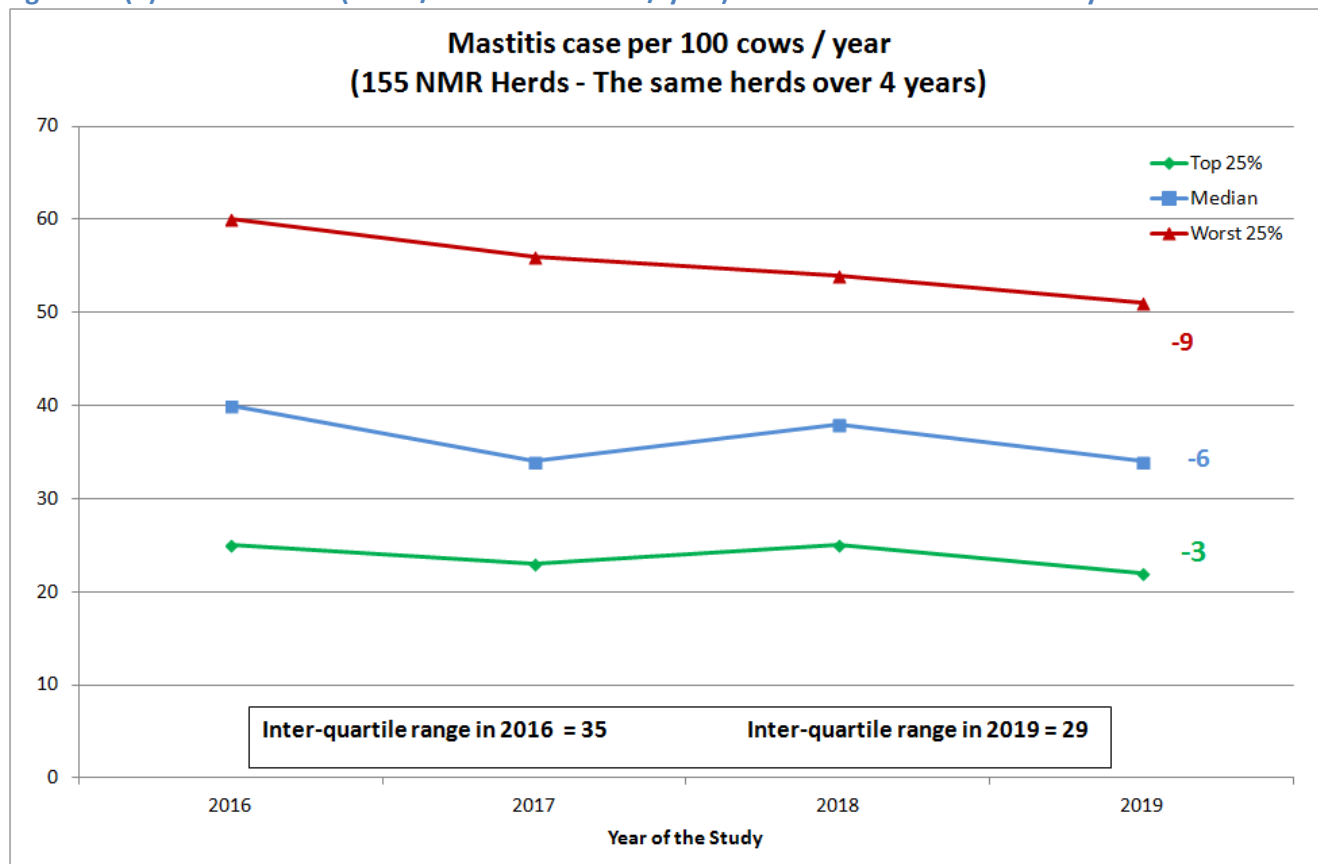
Section 4. The Practical Use of Key Performance Indicators By Farmers And Their Technical Advisers

The figures obtained from this study can be treated as "national standards" for UK 'black and white' dairy herds in 2019, with target values set at the level currently achieved or bettered on one in four of the 500 farms in the survey. A farmer can readily see where their herd would perform for each parameter relative to the 500 herds. This can be used to focus discussion on the causes and options/need for improvement.

The Key Performance Indicators Report in the InterHerd+ program provides an overview of performance for an individual herd. Parameters are calculated in an identical way so are directly comparable to the KPI values in the study. Comparing the performance of the herd with the results of the study highlights areas of strength and weakness in that herd's performance (Figure 22).

The combination of parameters relating to production, fertility and health, emphasizes the dynamic nature of dairy production and the need for high standards across all areas of herd management. Many herds are excellent in one area of production, fertility or health but seldom in all. There is always room for improvement in efficiency.

Figure 22. The Key Performance Indicator Report of InterHerd+

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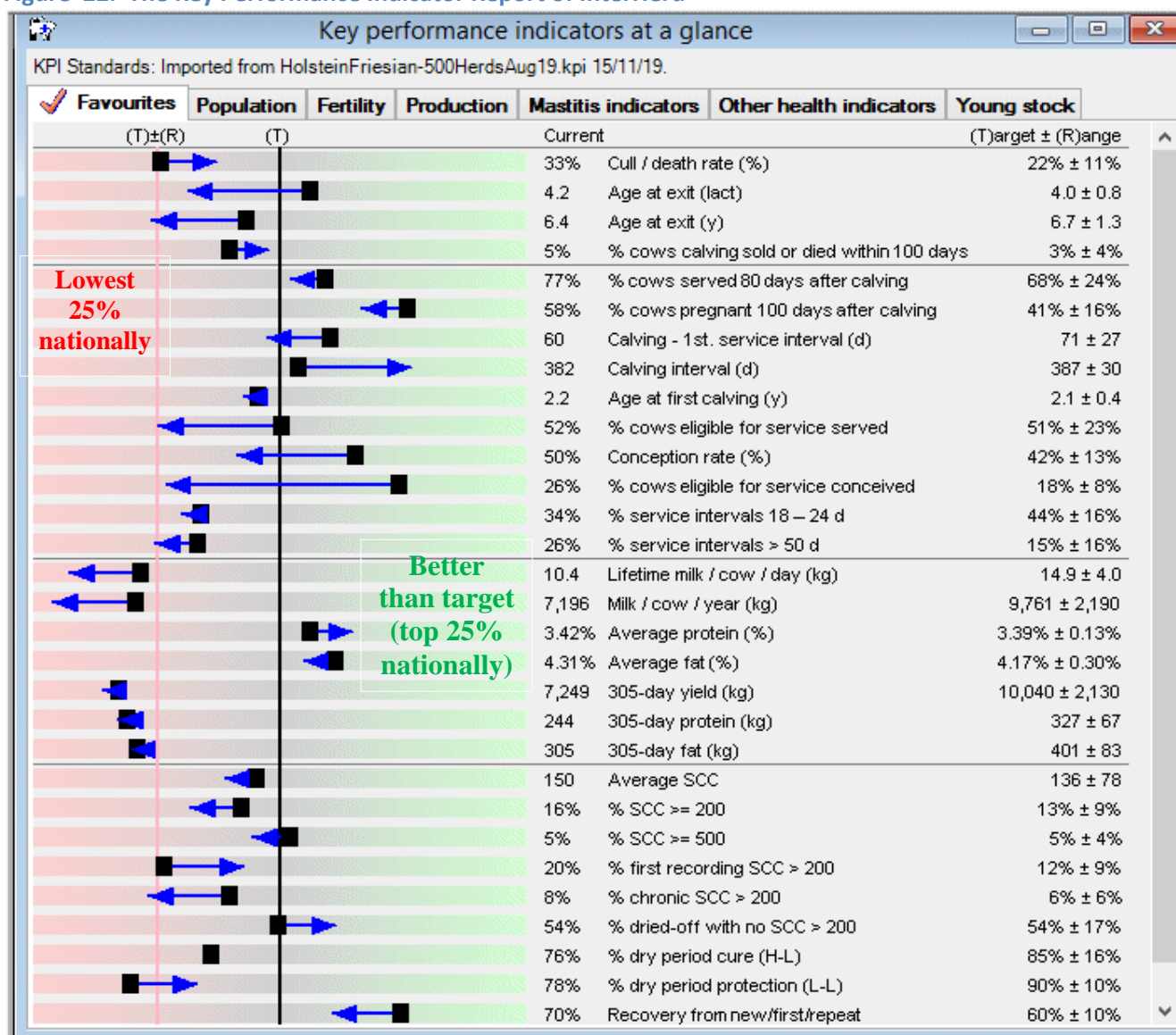
The meaning of the different lines and values against each key performance indicator are explained in Figure 23 below.

Figure 23. The KPI Report: The figures explained
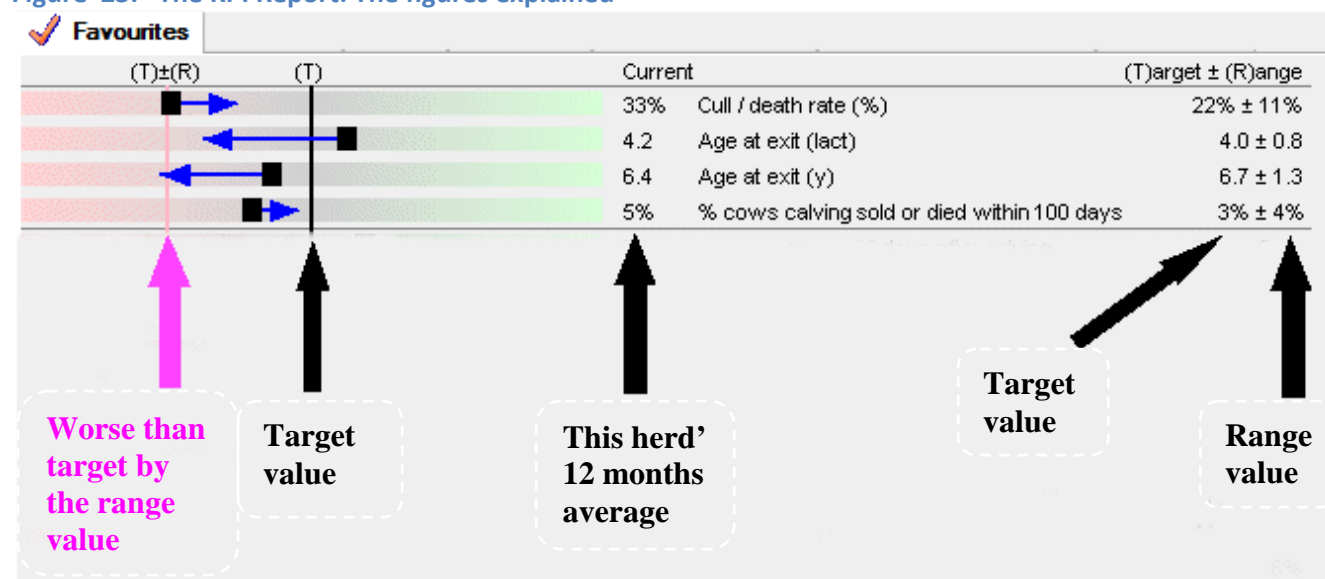
The value displayed to the left of each parameter title represents the herd's performance over the last year. It is the rolling 12 month average for that parameter. In Figure 23 the herd had a cull/death rate averaging 33% over the previous 12 months.

To the right of each listed parameter is a **target** value and a **range** (corresponding to the values given in Tables 1(a) & 1(b). In Figure 23 above the TARGET value for cull/death rate is 22% with a range of ±11%.

These values are also displayed graphically to the left of the parameter titles. The **target** value is represented by the **vertical black** line. The area to the right hand side is shaded green to denote a performance level that is **better** than the target value.

Left of the target line is shaded **red** denoting performance that is **worse** than the target value. The **vertical red** line represents the level that is "**worse than the target by the range value**" (so the performance of the poorer performing 25% of herds). In Figure 23 for culling rate, the red vertical line represents the target (22%) worse by the range (11%) so a culling rate of 33%.

The positions of the black square and blue arrow show how the current herd is performing for each parameter relative to the specified target and range values. The arrow indicates any direction of change.

- The **black square** is the **12 month rolling average** value for that parameter. So it is the longer-term performance based on the last 12 months of data (the value displayed to the left of the parameter title).
- The **blue** arrow head is the **3 months rolling average** value for that parameter. In other words it is the short-term performance based on the last 3 months only. The line and arrow show the difference and direction of change between the 3 and 12 month average values. Beware that while this may indicate a significant change in herd performance, the blue line may also be influenced by seasonal factors in that 3 month period.

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Using the target and range values to highlight a herd's strengths & weaknesses

Herd strengths: This study identifies the level achieved by the best 25% of the herds for each parameter. That value is then set as the "TARGET" for comparison with other herds. In Figure 18, any KPI with a black square to the **right (green side) of the vertical black target line** is "**in the best 25%**" when compared to the 500 study herds. In Figure 24 below, the herd displayed has 13 parameters that are "better than target" so this herd would currently be in the top 25% of herds nationally for those parameters. This mainly includes most fertility parameters, protein & fat%, in addition to few SCC parameters.

Herd weaknesses: The **vertical red line** represents the performance achieved or bettered by 75% of the 500 herds (the target, worse by the range). Any parameter with a black square to the **left of the vertical red line** would be "**in the bottom 25%**" for that parameter when compared to the 500 study herds. There are 7 parameters highlighted in Figure 24, including culling, milk yield and dry period protection rate, so this herd would currently appear in the bottom 25% of herds for those parameters.

Average performance levels: Parameters that fall between the vertical black and red lines are within the inter-quartile range (so the middle 50% of herds) when compared with the 500 study herds.

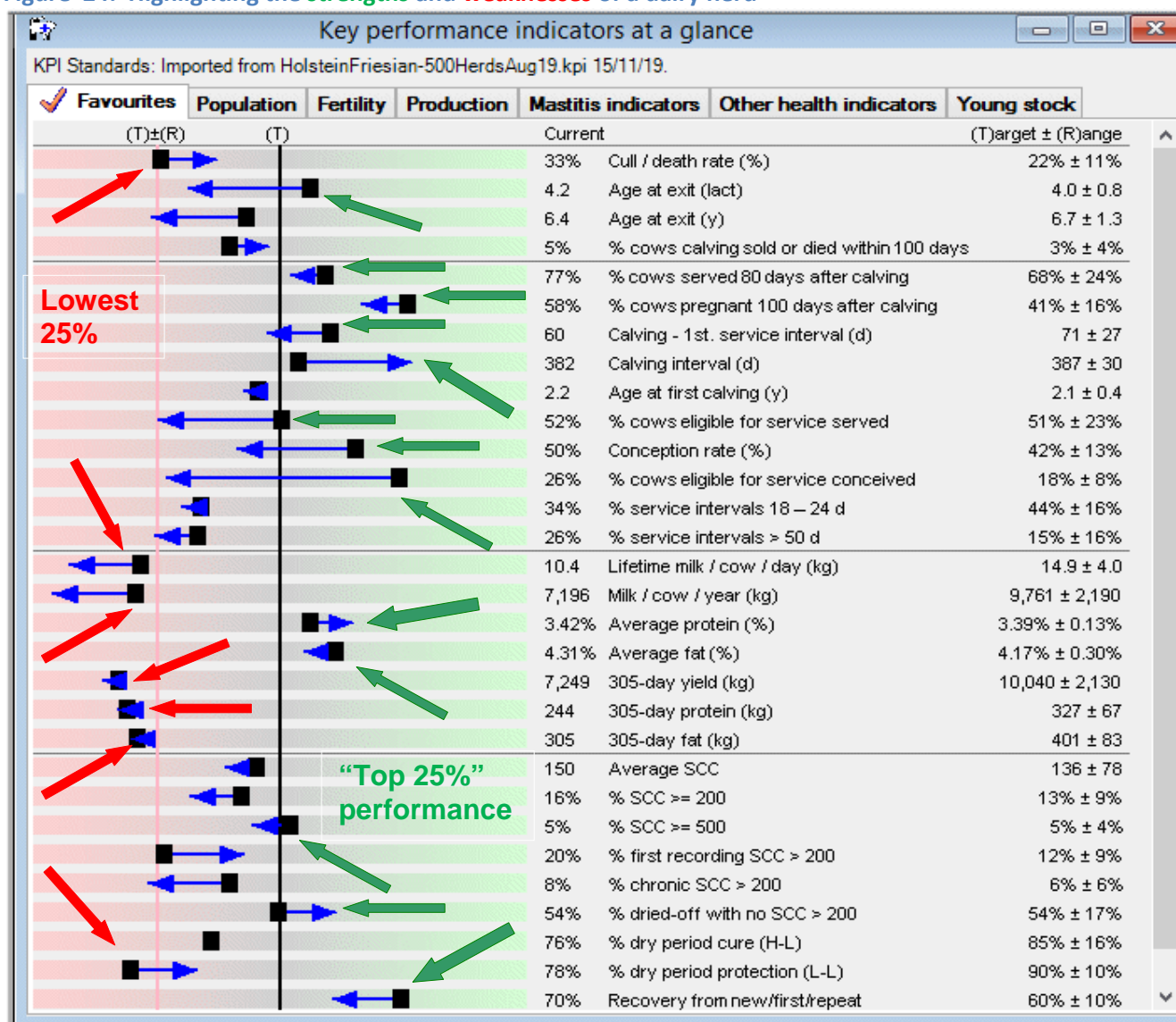**Figure 24. Highlighting the strengths and weaknesses of a dairy herd**

Figure 24 must be treated as a **DISCUSSION DOCUMENT**. The emphasis is on achieving an appropriate balance of performance in production, fertility and health. A parameter in the top 25% is

not necessarily a good thing. The herd in Figure 24, for example, has high protein% & fat% values for milk, but as it is a relatively low yielding herd the 305-day yield of protein & fat would put the herd in the lowest 25%.

The aim is to **stimulate informed discussion between farmers and their advisers** about **what** is happening **and WHY.**

Relationship between parameters: Herd SCC vs % chronic high SCC milk samples

The 500 herd studies also provide data to investigate correlations between different Key Performance Indicators which can provide simple messages for farmers and advisers. A good example of this is the strong correlation between the Herd SCC and the percentage of milk samples deriving from chronic high SCC cows (2nd/3rd/4th etc consecutive high SCC milk sample). Figure 25 shows the distribution of the 500 herds from the current study (year ending 31st August 2019).

Each blue square represents one of the 500 study herds. The very strong correlation (R^2=0.727) is clearly evident giving a very clear message. If you have a high level of chronic cows in your herd you are also very likely to have a high herd SCC with all the costs and penalties associated with that.

Figure 25. The relationship between herd average SCC and the % chronic high SCC cows

The Relationship between Herd Somatic Cell Count and the Percentage of Chronic Cows
(NMR 500 herds for the year ending August 2019)
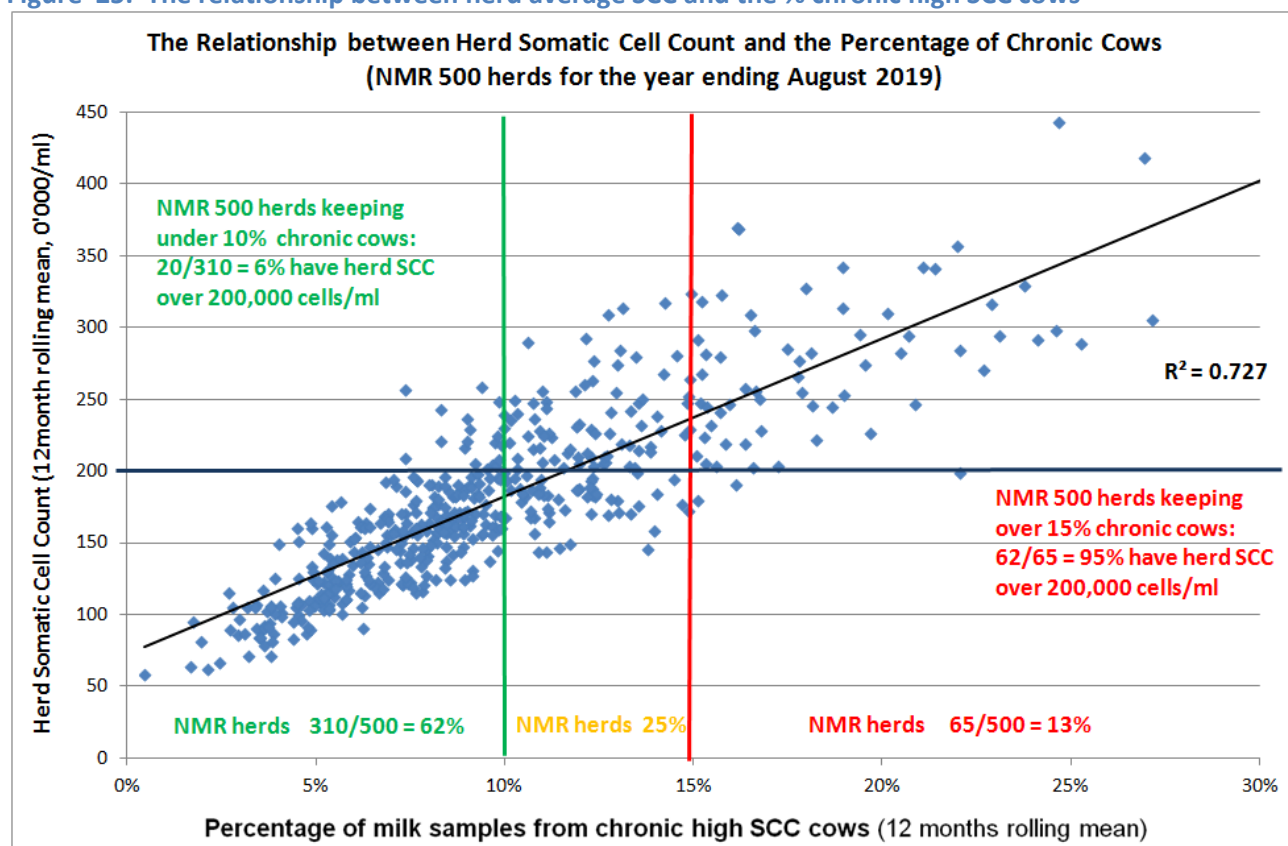
In addition to the correlation the graph shows that in herds where over 15% of the milk is from chronic cows the vast majority are penalised for having a high herd SCC. In 2019 there were 65 herds of this type and 62 (95%) of them also had a high herd SCC (averaging greater than 200,000 cells/ml). In contrast, there were 310 herds with less than 10% chronic cows of which only 20 (6%) also had a high herd SCC.

This strong correlation has been evident in all the 10 annual KPI studies. Table 3 shows the enormous gains that the UK dairy industry has made in tackling high herd SCCs. The 62% of the herds (310/500) in the most recent study that qualify as "Low levels of chronic cows" (less than 10% chronic cows), are a dramatic improvement on the 24% of herds in the original study in 2010. Over the same time

interval the % of herds keeping high levels of chronic cows (≥15% of the herd) has dropped from 41% of herds in 2010 to just 13% in 2019.

Table 3. Percentage of herds with low (<10%) and high (≥15%) levels of chronic high SCC samples, in the KPI studies from 2010 to 2019

KPI study year	Low levels of chronic cows (<10% of milking cows)	High levels of chronic cows (≥15% of milking cows)
2010	24% of herds	41% of herds
2011	32% of herds	35% of herds
2012	34% of herds	30% of herds
2013	36% of herds	29% of herds
2014	42% of herds	24% of herds
2015	44% of herds	21% of herds
2016	51% of herds	18% of herds
2017	51% of herds	17% of herds
2018	56% of herds	12% of herds
2019	62% of herds	13% of herds

In contrast to the strong correlation between herd SCC and the level of chronic cows, there is no clear correlation between the level of mastitis incidence and the herd SCC. Figure 26 shows the poor correlation observed in 2019. Similar poor correlation observed in the previous study (2018).

Figure 26. The relationship between herd average SCC and mastitis incidence
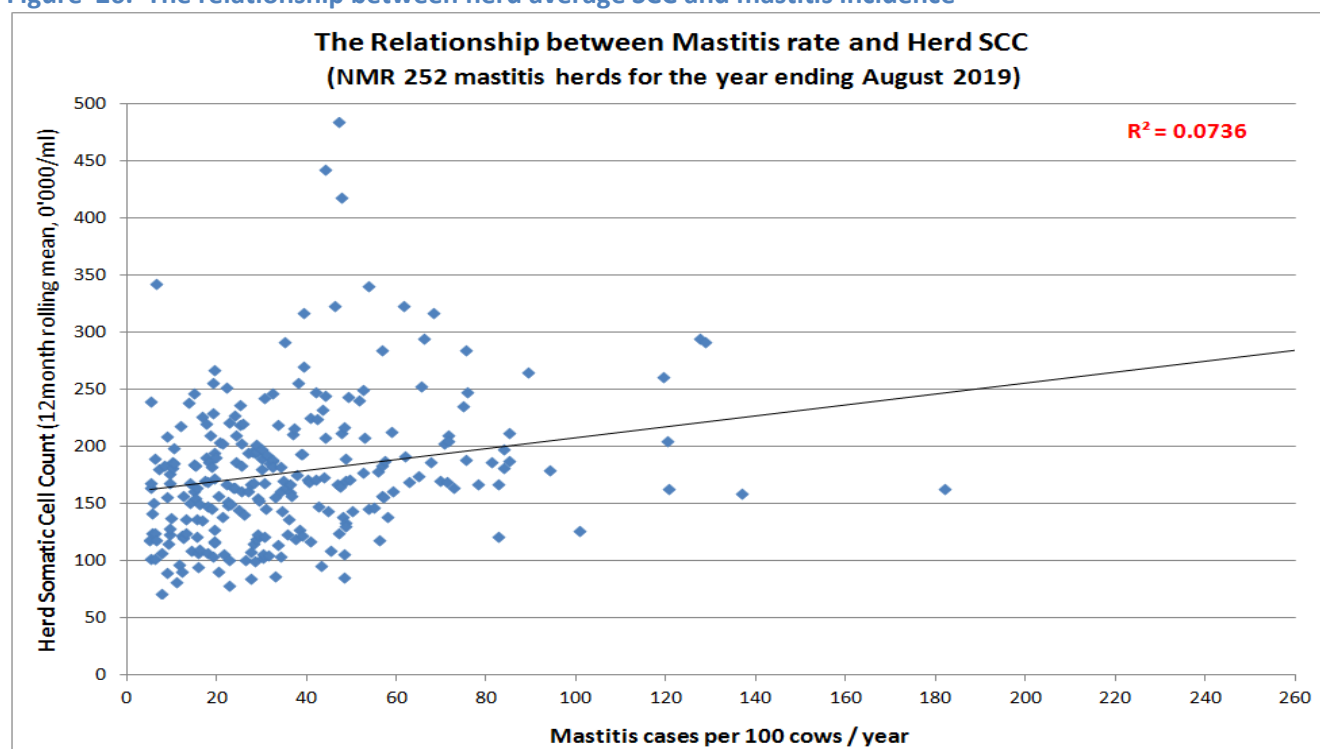
Appendix 1. Key Performance Indicators for Johne's Disease (JD) sero-prevalence.

The graphs below are derived from results for a sub-set of 233 herds (within the "500 herds" in the current study) that had regular quarterly 'whole herd' JD testing for the 2 years previous to 01 October 2019. The precise criteria applied for herds to qualify for this sub-set were:
- The herd must have had at least seven 'whole herd' milk JD tests in the previous 2 years, with the most recent herd test being within 6 months previous to 01 October 2019, and;
- In order to qualify in the count of 'whole herd' tests at least 50% of cows present in the herd (regardless of lactation status) should have been tested on the same date.

The sub-set includes all the 233 herds that satisfied these criteria.

The milk ELISA carried out by National Milk Laboratories gives a continuous quantitative result (optical density: OD) based on a colour reaction. The quantitative result is interpreted and reported as either 'negative' or 'positive', with the OD 'cut-off' of <30 = 'negative' and ≥30 = 'positive'.

InterHerd plus (IH+) and NML/NMR have different schemes for categorisation of cows based on their individual JD test history.

InterHerd plus (IH+) uses three classes, and a 'no test' category:
- **NEG**… cow has been tested negative and has never had a positive test;
- **pNEG**… cow has had a positive result in the past (never two in a row), but most recent test was negative;
- **POS**… most recent test was positive, or has had two positives in a row (remain 'POS' for life);
- '**no test**' for untested cows or cows that were NEG but have not been tested for >12 months.

NML/NMR uses six 'J' categories, plus a 'no test' category and a 'lapsed' category:
Categorisation is based on up to the last four tests in the individual cow's history.

J0	<u>**Repeat ELISA negative**</u> – **minimum two tests** (within the 2 year qualifying window).	**NOT had a positive test among the most recent 4 tests / *or within 2 years of most recent test*.**
J1	<u>**ELISA negative**</u> - **one test only** (within the 2 year qualifying window).	
J2	<u>**Single ELISA positive followed by at least two negative**</u> – 2 negative recent and consecutive tests negative, but with a **single** positive test in the previous 4 tests (within the 2 year qualifying window).	**Had a single positive test among the most recent 4 tests. NEVER had 2 x positive tests within a sequence of 4 tests.**
J3	<u>**Single ELISA positive followed by one negative**</u> – The last test negative and last-but-one positive. Also, if there are more tests, there can be only one positive in the recent 4 (within the 2 year qualifying window).	
J4	<u>**First ELISA positive**</u> – most recent test is the first positive test within a sequence of 4 tests.	
J5	<u>**Repeat ELISA positive**</u> - two or more positive results in any four consecutive tests at any time in individual cow test history. Once J5, J5 for life.	**Had 2 x positive tests within a sequence of 4 tests at any time in lifetime test history.**

In addition, '**no test**' is used for cows that have never been tested while '**lapsed**' is used for cows that were previously J0 or J1, but have not been tested for >12 months.

The following KPIs are based on the JD categorisation of cows present in the 233 herds on 01 October 2019. The KPIs calculated are:

- **Percent of cows in J5 category**… % of cows in the herd classed as J5 (NMR classification).
- **Percent of cows in J2, J3, J4, J5 category**… % of cows in the herd classed as J2, J3, J4, or J5 (i.e. cows that have had a positive test in the previous 4, or two positives within 4 tests any time in test history).
- **Percent of cows with MORE THAN TWO Positive JD tests in lifetime**… % of cows in the herd that have more than two positive milk ELISA JD tests in their entire test history (over any time frame).
- **Percent of POS cows**… % of cows in the herd classed as POS (IH+ classification)
- **Percent of POS or pNEG cows**… % of cows in the herd classed as POS or pNEG (IH+ classification)

The charts below show the distribution of each parameter for the 233 herds (each bar is one herd). The data are sorted in ascending order (low is always 'better'). The green, black and red bars show (approximately) the positions of the best quartile, median, and the worst quartile respectively.
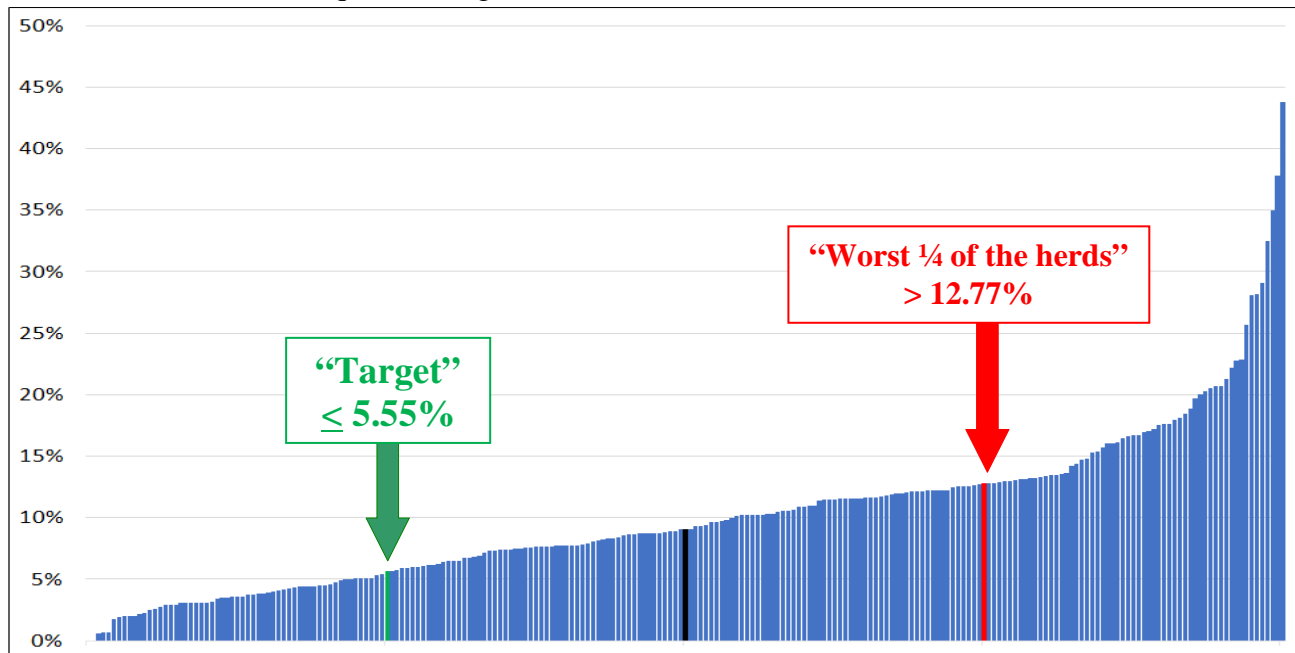
Percent of cows in J5 category in 233 NMR herds:

	This year's sample of 233 herds	*Last year's sample of 222 herds*
Target (top ¼ of herds' level):	**1.14%**	*1.29%*
Median:	3.23%	*3.51%*
75% level:	5.39%	*5.44%*
Inter-quartile range:	4.25%	*4.15%*
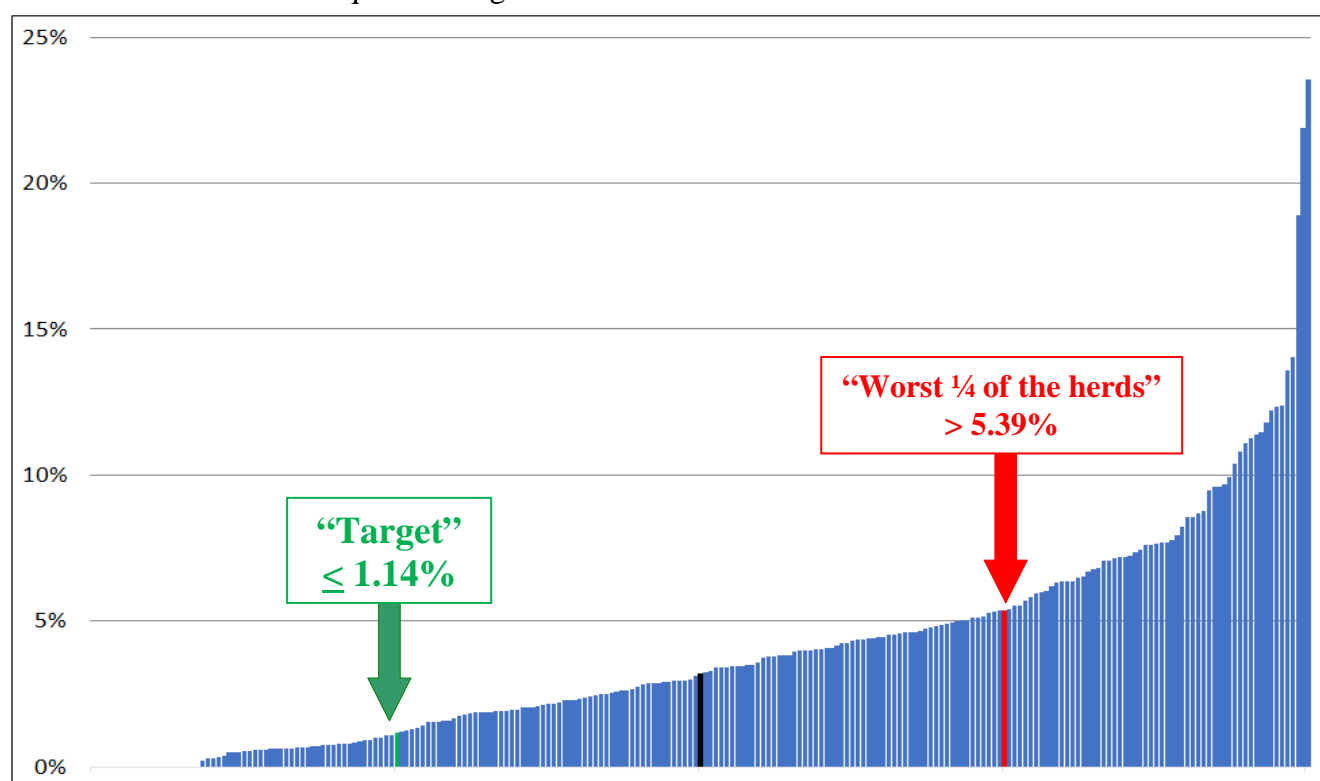
It is worth noting that 21 of the 233 herds (9%) had zero J5 cows on the analysis date. Among these, 16 herds had cows that had tested positive for the first time (J4) at their most recent test and only two of the 21 herds had no cows in any of the positive classes (J2, J3, J4, J5).
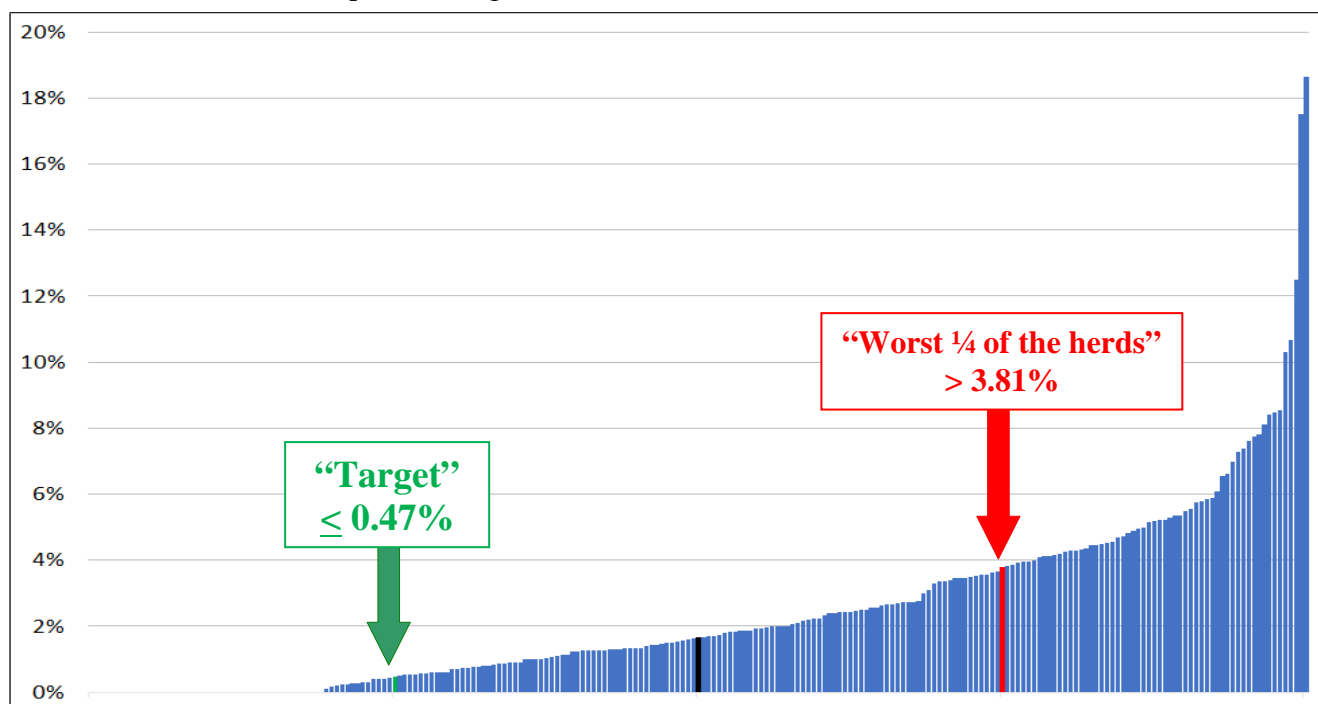
Percent of cows in J2, J3, J4, J5 category in 233 NMR herds:

	This year's sample of 233 herds	*Last year's sample of 222 herds*
Target (top ¼ of herds' level):	**5.55%**	*4.41%*
Median:	9.09%	*8.56%*
75% level:	12.77%	*12.10%*
Inter-quartile range:	7.22%	*7.69%*

Percent of cows with more than two Positive JD tests in lifetime in 233 NMR herds:

	This year's sample of 233 herds	*Last year's sample of 222 herds*
Target (top ¼ of herds' level):	**0.47%**	*0.73%*
Median:	1.66%	*2.00%*
75% level:	3.81%	*3.75%*
Inter-quartile range:	3.34%	*3.02%*

45 of the 233 herds (19%) had zero cows with more than two positive JD tests in their lifetimes.

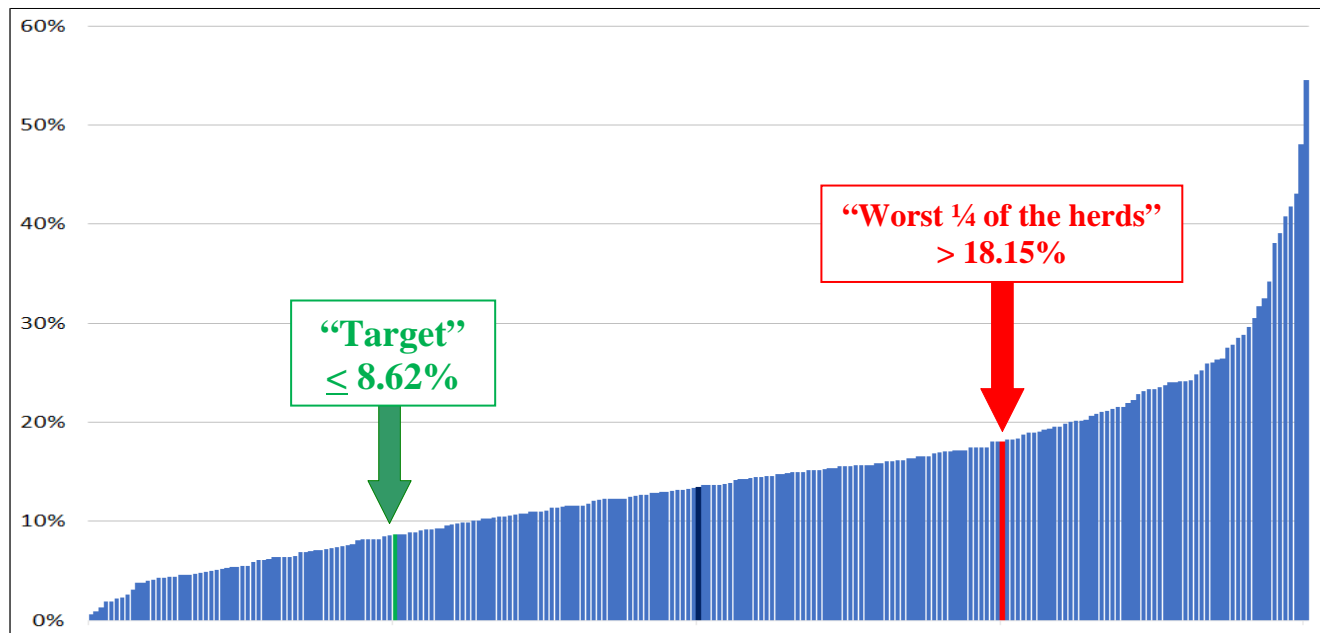**Percent of POS or pNEG cows in 233 NMR herds:**

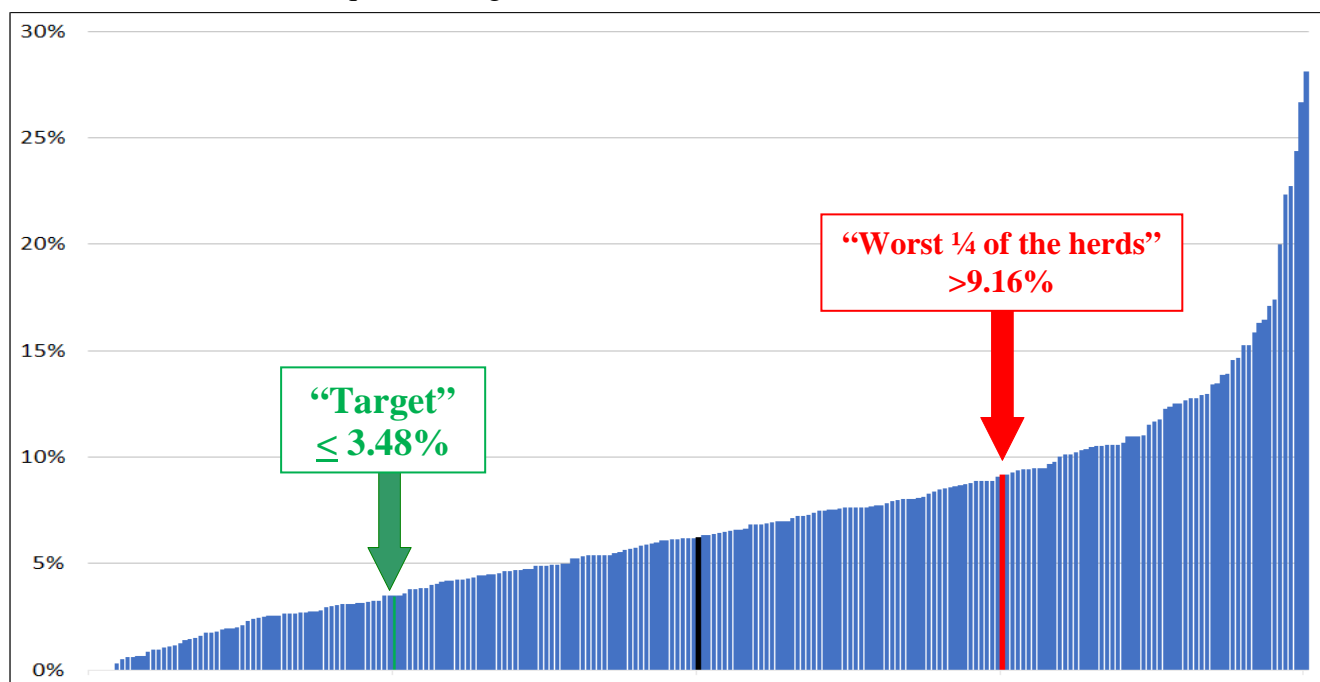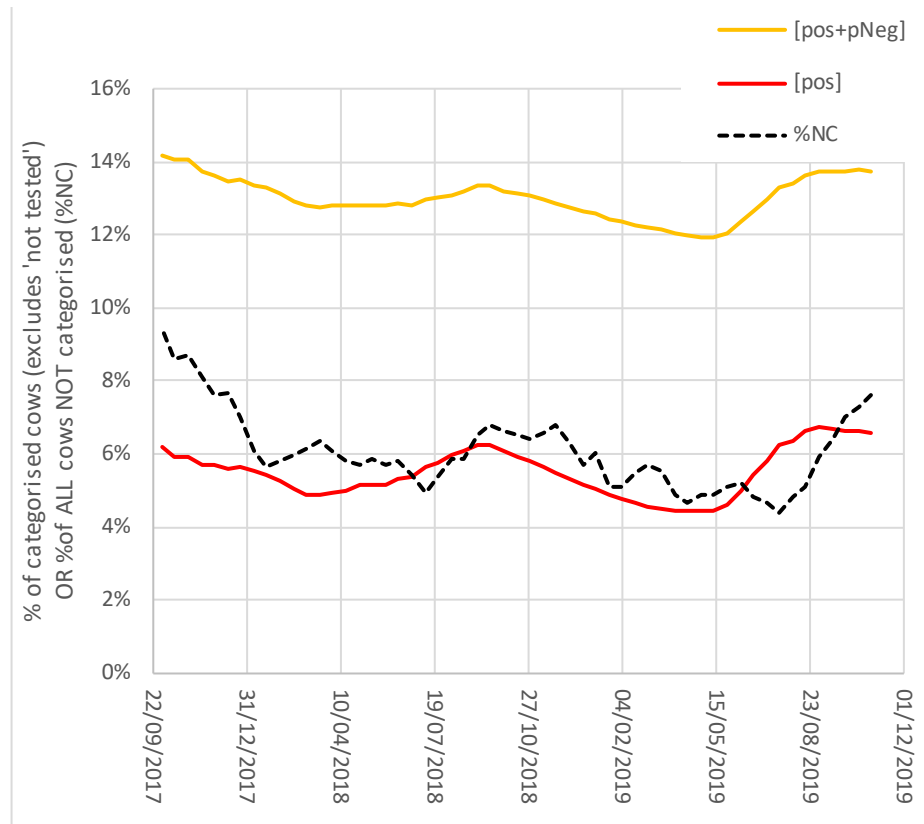|	*This year's sample of 233 herds*	*Last year's sample of 222 herds*
Target (top ¼ of herds' level):	**8.62%**	*7.57%*
Median:	13.43%	*11.93%*
75% level:	18.15%	*17.67%*
Inter-quartile range:	9.53%	*10.10%*

Percent of POS cows in 233 NMR herds:

|	*This year's sample of 233 herds*	*Last year's sample of 222 herds*
Target (top ¼ of herds' level):	**3.48%**	*2.99%*
Median:	6.22%	*6.10%*
75% level:	9.16%	*8.58%*
Inter-quartile range:	5.68%	*5.59%*

Trend over time (SHORT/MEDIUM TERM: previous 2 years)

The following charts (A and B) show the percentages of all categorised cows in the 233 herds (analysed as one group) that were in the various sero-positive categories.

A) InterHerd+ JD categories   B) NMR JD classification
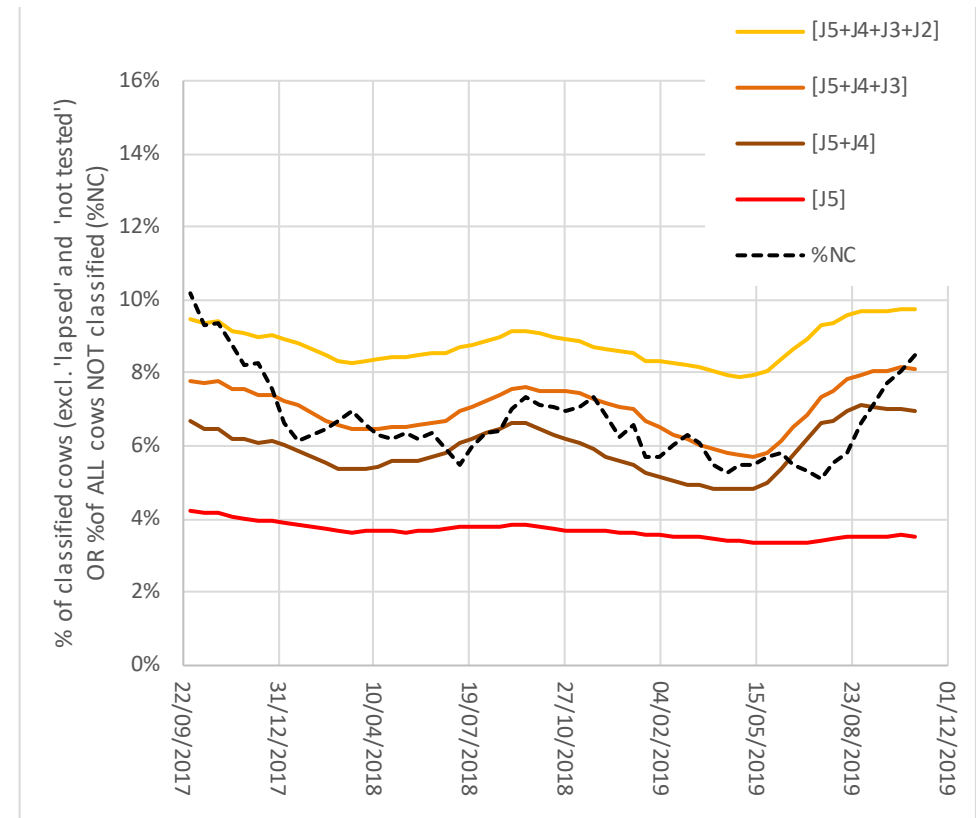
IH+ 'pos' category broadly includes NMR classes J5 (cows had 2 pos in any 4 tests – J5 for life) and J4 (first time positive at most recent test)… so those two lines have the same shape… but the 'pos' line in the left (IH+) chart is slightly lower than the brown (J5+J4) line on the right (NMR) chart because to be 'pos' for life in IH+ requires 2x consecutive positive but to be J5 for life in NMR requires 2x positive in any 4 tests) – so some of the NMR J5s will be pNeg in the IH+ categorisation. In the NMR system cows with positive tests can revert to J0 (equivalent to 'neg') if they have a run of more than 4 negative tests… in IH+ these cows remain pNeg for life… therefore the brown (pos+pNeg) line on the left (IH+) chart is higher than the top line (J5+J4+J3+J2) on the right (NMR) chart.

An interesting feature is the apparent increase in the J4 class (single recent test positive) from May to August 2019 (approximately). A similar increase in J4 class was noted in last year's sample, though over a longer period from about April to September 2018. This is also visible in the charts above.

It is difficult to know exactly why this occurs, but it does appear to be a seasonally-related effect and could be associated with turnover in the milking herd, and/or perhaps some seasonal link with the sero-conversion of infected cows.

New heifers entering the 'cow' population as calving heifers or bought-in cows will be unclassified until they have their first milk JD test in the herd. In the charts above we have added a dashed black line showing the percentage of cows present that are not classified (most of these have not yet had a JD test, but a small proportion are cows that have 'lapsed' and not been tested for 12 months or more). The % 'not classified' starts at a high of around 10% in the early part of the analysis period, likely because some of the herds in the dataset had only just started testing at that time. The % 'not classified' comes down to fluctuate between 5% and 7%, but there is a sharp increase from about August 2019. The data show that this increase in 'not classified' cows is coincident with an increase in total cows present in the herds. It is fair to assume that the additional 'not classified' cows seen over this time are in large part new cows entering the herds that have not yet been tested (or have an unknown test history). The fact that this increase in 'not classified' cows occurs *after* the rise in J4 indicates that introduction of new cows is not a direct cause of the increase in positive JD testing cows.

Trend over time (LONG TERM: previous 7-8 years)
Since milk JD testing has now been offered for over 10 years, we explored the 500 herd dataset to identify herds with evidence of regular whole herd testing for 7 to 8 years. The precise criteria applied for herds to qualify for this sub-set were that the herd must have had at least 28 'whole herd' (>50% cows tested) milk JD tests in the previous 8 years, with the most recent herd test being within 6 months previous to 01 October 2019. The 105 herds satisfied these criteria.

The following charts show the percentages of all categorised cows in the 105 herds (analysed as one group) that were in the various sero-positive J-classes as defined by NMR. There is also a dashed black line showing the percentage of cows present that are not classified. The lower section of the charts shows the total numbers of cows present and numbers that were classified (NMR J-class) (i.e. the numbers with test histories).

Looking at the pattern in J-class from about the beginning of 2013, when the % 'not classified' has fallen to around 7%, the % of cows in J5 or J4 was just over 7% and remained at that level until about June 2014.

From June 2014 to May 2015 the % of cows in J5 or J4 rose to just over 10%, and stayed at that level till October 2015. This increase in J4/J5 is not associated with any consistent parallel change in the % 'not classified' (i.e. the increase in positives cannot easily be attributed to increased intensity if testing).

However, the increase in J4/J5 does follow a fairly sharp rise in total cow numbers in these 105 herds from 23,000 to 26,000 between the end of May 2013 to September 2015. It could be speculated, based on this coincidence, that the increase in J4 and thence J5 could be a result of herds buying-in infected cows to increase their milking herds (*it must be stressed that this is speculation*).

Since October 2015 the % of J4/J5 decreased, with % J5 alone decreasing from mid-2016. This suggests that the rate of new sero-conversion to J4 was at least slowed and herd managers could have begun targeting J5 cows for removal from their herds. The decrease in % J5 has continued to fall although there is a 'levelling-off' at just over 3% in the recent year.

The 'seasonal hump' in J4 noted above is visible in the longer time frame in the last three years, peaking around August in 2017, 2018 and 2019. The latest peak in 2019 is higher than 2018, which in part accounts for the fact that some of the JD KPIs shown in the first part of this appendix are slightly 'worse' than last year.

Trends in JD classification and cow numbers in 105 regularly testing herds over the previous 7-8 years

51
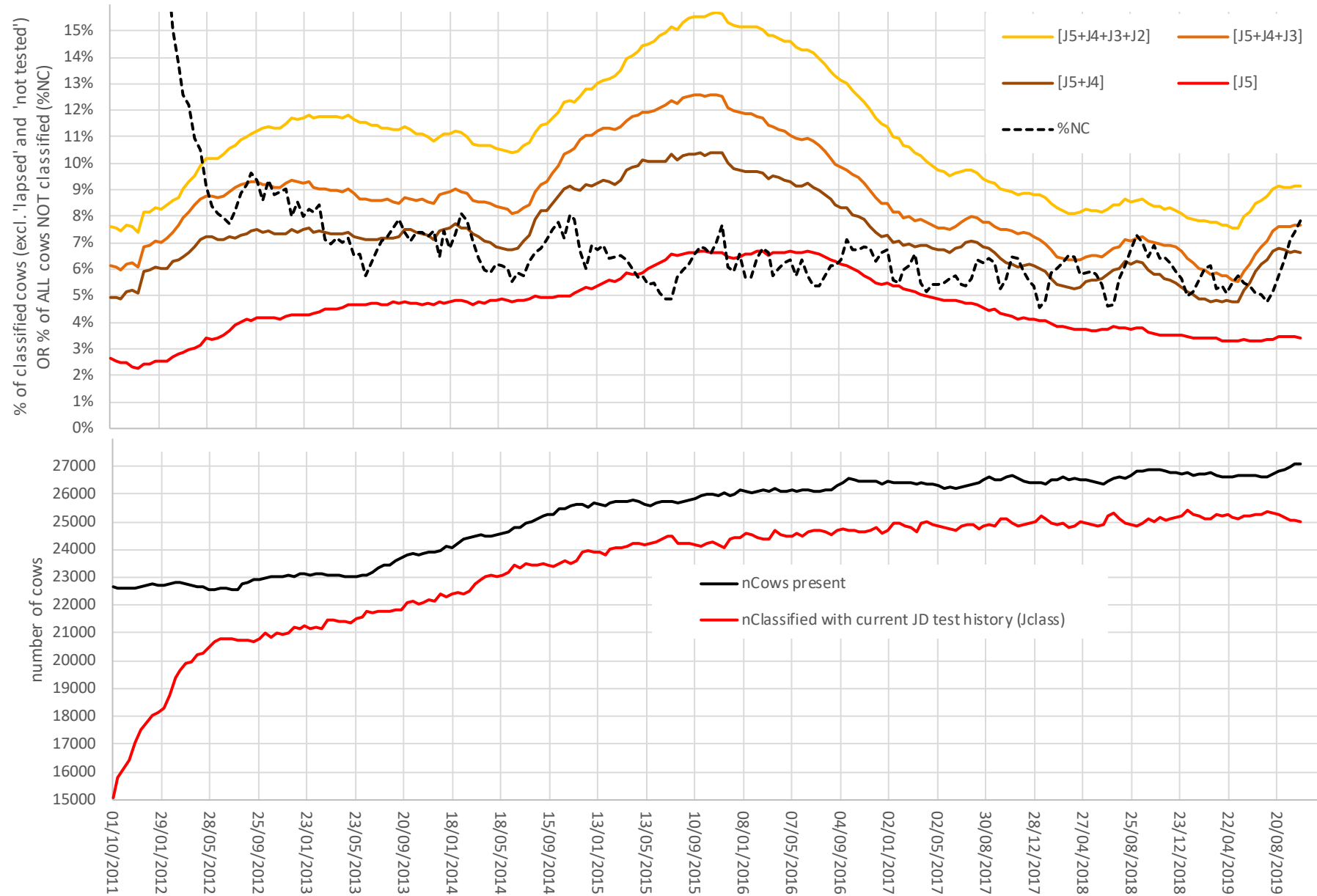
What do the data suggest about progress in control of JD
Among the 105 herds regularly testing for at least 7 years, the percentage of cows with more than a single high test result peaked close to 7% between August 2015 and July 2016. Since then the prevalence has more than halved to the current level below 3.5%. This suggests that in these regularly testing herds there has been some focus on removing multi-positive cows, with success in reducing the prevalence of these cows. However, there are still numbers of 'first time positives' revealed each year, and some of these will go on to become multi-positive cows, leading to a potentially static disease situation. In the sample of 233 herds there were 21 herds (9%) that had no cows with more than one high test. These herds are perhaps those that are most intensely targeting removal of multi-positive cows. However, there were just two herds (<1%) that had no cows with any high test result(s), suggesting that new infections are continuing to occur, even in these herds.

The take-home message of this is that removal of multi-positive cows can reduce the level of JD affected cows in a herd to a certain level, but to continue to reduce the level towards total elimination of disease from a herd will require increased efforts to prevent new infections, by paying detailed attention to hygiene in the calving pens and using protocols such as 'snatch calving' and colostrum management. It is also important to stress that any changes in JD situation of herds is a long term undertaking that takes years to achieve results.

Appendix 2.   Key Performance Indicators definitions

In the following definitions the average population of cows is calculated using animal days. Every day that animal is present in the population at risk during the period of study is a 365th of an animal year. The total animal days is divided by 365 to give animal years, which equates to the average population at risk.

Parameter	Description
A. Culling rate	The number of cows dying or culled during the 12 month period expressed as a percentage of the average cow population for the same 12 month period.
B. Percentage culled / died 100 days after calving	The percentage of heifers/cows calving during the 12 month period that exit within 100 days after calving.
C. Age at exit (years)	The average age (in days) of cows culled/died in the analysis period, divided by 365.24
D. Age at exit by lactations	The average number of lactations completed by cows culled/died in the analysis period.
E. Percentage Served by day 80	The percentage of cows reaching the 80th day after calving that have been served at least once.
F. Percentage conceived 100 days after calving	The percentage of cows reaching 100 days after calving that have conceived.
G. Calving to 1st service interval (days)	The average days between calving and 1st service for all cows served for the first time in a lactation during the analysis period.
H. Calving interval (days)	The interval between calvings, in days, for all re-calvings recorded in the analysis period.
I. Age at 1st calving (years)	The age at first calving for all cows calving for the first time during the analysis period.
J. Conception rate	The number of conceptions as a percentage of the total number of services (services to cows culled are included) during the analysis period.
K. Percentage service intervals at 18-24 days (Heat detection)	The percentage of all service intervals for cows returning to service during the analysis period that are between 18 and 24 days (equating to one oestrous cycle after the previous service).
L. Percentage service intervals >50 days	The percentage of all service intervals for cows returning to service during the analysis period that are over 50 days.
M. Percentage of cows eligible for service that were served (Submission rate)	The percentage of cows that are eligible for service (42 days+ after calving and not barren or already pregnant) during the analysis period that are served per 21 day (oestrous cycle) period.
N. Percentage of cows eligible for service that conceived (Pregnancy rate)	The percentage of cows that are eligible for service (42 days+ after calving and not barren or already pregnant) during the analysis period that conceive per 21 day (oestrous cycle) period.
O. Lifetime milk / cow/day (kg)	The total milk produced per cow and heifer place in the year. The total milk produced in the year, divided by the average population of cows (both in milk and dry) and heifers (including heifer replacements being reared elsewhere), divided by 365.
P. Milk / cow / year (kg)	The total milk produced per cow place in the year. The total milk divided by the average population of cows (both in milk and dry).
Q. Average protein%	The weighted average protein% of all milk recorded during the analysis period.

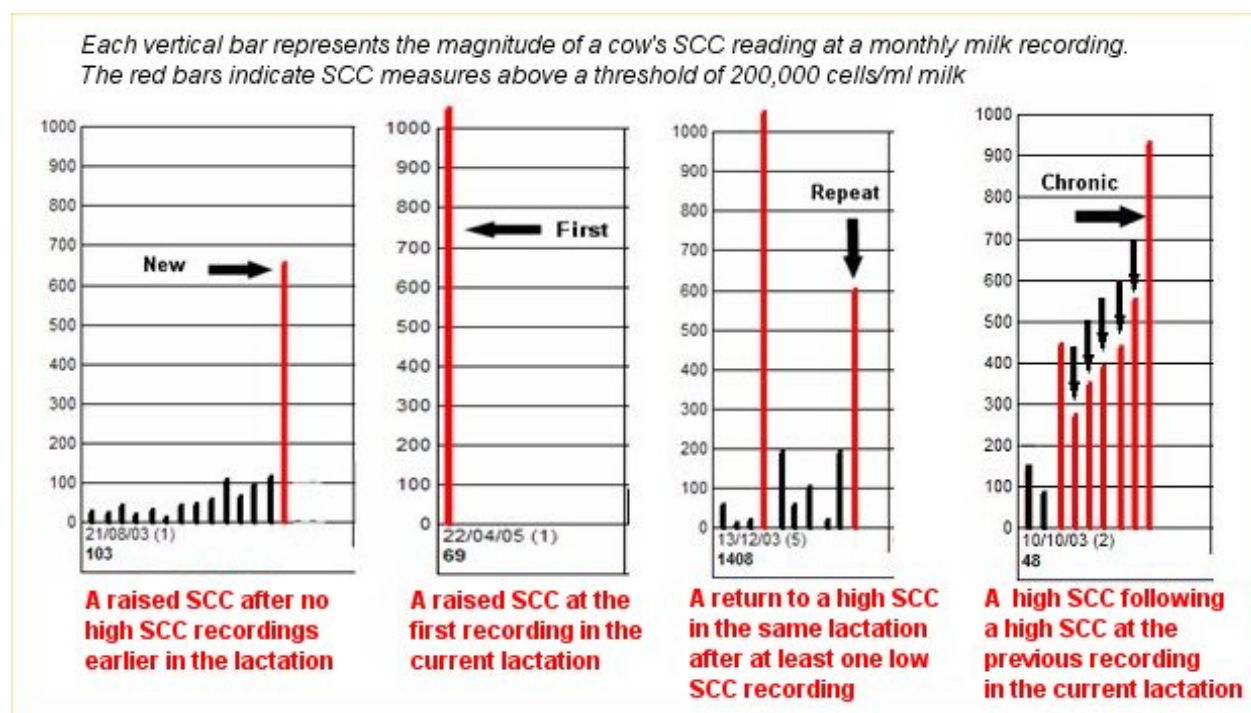| Parameter	Description
R. Average fat%	The weighted average fat% of all milk recorded during the analysis period.
S. 305 day yield (kg)	The average 305 day production for all cows reaching 305 days after calving during the analysis period.
T. 305 day protein (kg)	The average 305 day production of milk protein for all cows reaching 305 days after calving during the analysis period.
U. 305 day fat (kg)	The average 305 day production of milk fat for all cows reaching 305 days after calving during the analysis period.
V. Average SCC ('000 cells/ml)	The weighted average somatic cell count of all milk recorded during the analysis period.
W. Percentage SCC ≥200,000 cells/ml	The percentage of all recorded milk samples during the analysis period that had an individual SCC reading of 200,000 cells/ml or higher.
X. Percentage SCC ≥500,000 cells/ml	The percentage of all recorded milk samples during the analysis period that had an individual SCC reading of 500,000 cells/ml or higher.
Y. Percentage 1st recording SCC ≥200,000 cells/ml	The percentage of all cows starting new lactations that had a high SCC (≥200,000 cells/ml) reading at the first milk recording in the lactation.
Z. Percentage chronic SCC ≥200,000 cells/ml	The percentage of all milk samples taken in the analysis period that originated from chronic SCC cows where the current and previous milk samples both had SCC levels of 200,000 cells/ml milk or greater.
ZA. Percentage Dry period cure (High:Low)	Of re-calving cows recorded starting a new lactation during the analysis period: the percentage of cows ending the previous lactation with a HIGH SCC (≥200,000 cells/ml) that started the new lactation with a LOW SCC (<200,000 cells/ml).
ZB. Percentage Dry period protection (Low:Low)	Of re-calving cows recorded starting a new lactation during the analysis period: the percentage of cows ending the previous lactation with a LOW SCC (<200,000 cells/ml) that also started the new lactation with a LOW SCC (<200,000 cells/ml).
ZC. Percentage Low at end of previous lactation (SCC<200,000 cells/ml)	Of re-calving cows recorded starting a new lactation during the analysis period: The percentage that had a LOW SCC (<200,000 cells/ml) at the last milk recording in the previous lactation.
ZD. Percentage New SCC ≥200,000 cells/ml	The percentage of all recorded milk samples that were of the "New" SCC Category, namely the first HIGH SCC (≥200,000) in a lactation following one or more low SCC samples.
ZE. Percentage Dried-off with no SCC ≥200,000 cells/ml	The percentage of cows completing a lactation without recording a high SCC (cows recording only LOW SCC samples (<200,000 cells/ml) in the previous lactation).
ZF. Threshold Index new high / new low	Of cows with consecutive milk records in the same lactation, the number of cows changing from Low SCC at the previous to High SCC at the next recording divided by the number of cows going from High SCC at the previous to Low SCC at the next recording.
ZG. Recovery percentage of new/first/repeat infections	Of HIGH SCC cows (≥200,000cells/ml) that at the previous recording were either low SCC or not yet in milk, the percentage that were LOW SCC (<200,000 cells/ml) at the following recording.

Parameter	Description
ZH. Recovery percentage of chronic infections	Of CHRONIC High SCC cows (High SCC cows that at the previous recording were also High SCC), the percentage of those milked that were LOW SCC (<200,000 cells/ml) at the following recording.
ZI. Percentage drying off with no mastitis cases	The percentage of cows completing a lactation without recording a mastitis case.
ZJ. Mastitis rate (cases/100 cows in milk per year)	The total cow cases of mastitis recorded divided by the average population of cows in milk, represented as a % (cases/100 cows in milk).
ZK. Index mastitis case by Day 30	The percentage of cows calving during the 12 month period that recorded a mastitis case by day 30 of the lactation.
ZL. Index mastitis rate after Day 30	The incidence rate of *index* mastitis cases in cows that have passed 30 days since calving.

Appendix 3.   Herd Companion High SCC Categories

The web-based Herd Companion program (**www.nmr.co.uk/Herd-companion**) was introduced by NMR in 2003 primarily to support the use of milk recording data to control somatic cell counts (SCC) in dairy herds.

Herd Companion focuses more on the duration of a high SCC infection rather than the magnitude of an individual milk sample. Using a threshold of 200,000 cells/ml milk to indicate infection, the program aims to balance the ability of many cows to self-cure with the need to assist cows where infection is becoming established. While in the region of 50% of cows self-cure after an initial raised SCC this recovery rate falls to less than 20% once a cow has recorded a second high SCC. It is these persistent high SCC cows that require attention before they are damaged irretrievably by a sustained period of infection.

The development of Herd Companion led to the definition of four main categories of high cell count cow, as illustrated below. Each vertical bar represents the magnitude of the SCC at each milk recording in a lactation. Where the bar is black the SCC is below the threshold of 200,000 cells/ml milk. A red bar indicates a SCC level above the threshold.

Each vertical bar represents the magnitude of a cow's SCC reading at a monthly milk recording. The red bars indicate SCC measures above a threshold of 200,000 cells/ml milk

NEW: The "New" category describes cows recording their first high SCC in the lactation, having recorded one or more low SCCs at earlier recording(s). An infection acquired in the lactation.
FIRST: The "First" category describes cows that are HIGH SCC at their First milk recording in the current lactation. This is an infection that may be related to the dry period.
REPEAT: The "Repeat" category describes a possible re-infection (or failure to cure). A cow that had high SCC recording(s) earlier in the current lactation recorded a LOW SCC in the previous month(s) but has returned to a High SCC at the latest recording.
Chronic: The "Chronic" category describes a cow that is High SCC at the latest recording AND was also High SCC at the PREVIOUS recording(s). So she was high SCC last time and failed to recover. In the example above the cow has 7 consecutive high SCC recordings so has been defined as Chronic for the last 6 months of consecutive high SCC recordings.

Appendix 4. Changes in Key Performance Indicators between 2010 and 2019 in herds included in every study over 10 years

Throughout the years of carrying out this annual study, wherever possible the same herds were kept in the sample used each year. If necessary, herds with poorly recorded fertility data and herds no longer recording were replaced with randomly selected new herds. Within the sample of the 2019 study, there remain 154 herds that have been included in all the 10 studies between 2010 and 2019.

As a check to confirm that replacement of some herds and retention of others has not introduced any unexpected bias in the sample, the table below shows the changes observed in KPIs over 10 years (2010 vs. 2019) for the 'changing sample' of 500 each year alongside the changes seen in the 154 herds common to all 10 years. The table shows similar trends in the 'common 154' herds to the trends on the 'whole 500' herd samples. Overall, these results do not suggest that significant bias has been introduced by the year-on-year partial replacement of herds in the sample.

	500 herds groups		154 common herds	
	Median value		Median value	
Parameter *Year of the study*	2010	2019	2010	2019
A. Culling rate	24%	27%	24%	27%
B. Culling / death rate in first 100 days of lactation	7%	5%	6%	5%
C. Age at exit (years)	6.6	6.0	6.6	5.9
D. Age at exit by Lactations	3.9	3.6	4.0	3.5
E. Percentage Served by day 80	46%	58%	48%	62%
F. Percentage conceived 100 days after calving	26%	34%	27%	34%
G. Calving to 1st service interval (days)	105	81	101	79
H. Calving interval (days)	424	401	423	400
I. Age at 1st calving (years)	2.4	2.3	2.4	2.3
J. Conception rate	32%	35%	31%	35%
K. Percentage service intervals at 18-24 days	30%	37%	32%	36%
L. Percentage service intervals >50 days	32%	21%	29%	20%
M. Percentage eligible for service that served	27%	39%	30%	42%
N. Percentage eligible for service that conceived	9%	14%	10%	14%
O. Lifetime milk / cow / day (kg)	10.5	13.0	11.6	12.5
P. Milk / cow / year (kg)	7,665	8,737	8,140	8,582
Q. Average Protein%	3.27%	3.32%	3.26%	3.33%
R. Average Fat%	3.96%	4.02%	3.94%	4.03%
V. Average SCC ('000 cells/ml)	210	171	194	171
W. Percentage SCC >=200,000 cells/ml	24%	17%	23%	18%
X. Percentage SCC >500,000 cells/ml	9%	7%	8%	7%
Y. Percentage 1st recording SCC >=200,000 cells/ml	20%	16%	18%	16%
Z. Percentage chronic SCC >=200,000 cells/ml	14%	9%	12%	9%
ZA. Percentage Dry period cure (High:Low)	74%	77%	75%	76%
ZB. Percentage Dry period protection (Low:Low)	84%	85%	85%	85%
ZC. Percentage Low SCC at end of previous lactation	60%	74%	63%	74%