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Longevity and the association with cattle health in Dutch dairy farms

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A R T I C L E I N F O

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A B S T R A C T

Longevity of a herd is defined as the average age of all cattle over two years old at the moment of death (either natural, by euthanasia or by slaughter), and is increasing since 2018. The aim of this study was to evaluate the association between longevity and cattle health indicators in Dutch dairy herds. Anonymized census data were available for 16,200 Dutch dairy herds (~98 % of the dairy herds) between 2016 and 2020. All herds were categorized into one of six longevity groups: herds with a high longevity (>seven years old), increasing longevity (mean increase of one year and two months between 2017 and 2020), median longevity (~five years and eight months, without major fluctuations in longevity), decreasing longevity (mean decrease eight months), low longevity (<four years and ten months) and a varying longevity of ~five years and eight months, with fluctuation in longevity throughout the study period. Data were aggregated to herd and quarter of the year level. Cattle health parameters were analysed with multivariable population-averaged models with health indicators as dependent variables, and longevity and other management and herd level factors as explanatory variables. Belonging to the group of herds with a high longevity was associated with lower calf- and cow mortality, a higher percentage of cows with a high somatic cell count (HSCC), fewer inseminations per pregnancy for heifers and more inseminations for cows, a higher antibiotic use in adult dairy cows and a lower antibiotic use in calves compared to the average Dutch dairy herd. Further analysis showed that the higher percentage of cows with a HSCC could be explained by the higher share of older cows. Herds with a low longevity had a higher calf- and cow mortality, a lower percentage of cows with a HSCC, more inseminations for heifers and fewer for cows, lower antibiotic use in cows and higher antibiotic use in calves compared to the average Dutch dairy herd. To conclude, there were differences in cattle health between groups of herds with a different longevity.

1. Introduction

In 2017, a legal constraint has been set in the Netherlands to reduce the amount of phosphate emission per farm (MLNV, 2017 in: (Kulkarni et al., 2021)). These regulations led to a reduction in dairy herd size by reducing the share of young stock for replacement and an increased milk production level per cow (Jongeneel et al., 2017; McCullough, 2018). As a result, longevity in dairy herds in the Netherlands started to increase from 2018 on. Longevity of a dairy herd is defined in this paper as the mean age at the moment of death, either through natural death, euthanasia or slaughter of cows older than two years.

In 2018, the average longevity was at 5 years and eight months and at the end of 2020, it had increased up to six years of age. Furthermore, increasing longevity leads to lower replacements rates, which is important in the reduction of greenhouse gas emissions at herd level (Lehmann et al., 2014). Replacement heifers contribute with 21–26 % to the total enteric emission of methane in a herd (Wall et al., 2012). Moreover, increasing longevity in dairy herds may be economically beneficial given the lower share of replacement costs (Heikkilä et al., 2008) and because dairy cows become profitable from their third lactation onwards (Boulton et al., 2017). Nevertheless, sufficient replacement heifers have to be available in case of involuntary culling of a dairy cow, otherwise total milk production of the herd is reduced or cattle has to be purchased.

In the Netherlands, the Dutch Cattle Health Surveillance System (CHSS) (Santman-Berends et al., 2016) is in place. One of the components in this surveillance system is the Trend Analysis Component (TASC), in which near census data of about 98 % of the dairy herds are routinely collected and analysed to monitor trends and developments in numerous cattle health indicators. From 2018 on, the results of TASC showed an increase in the overall dairy cow mortality (the number of death cows >1 year relative to the total number of cows at risk in dairy

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herds). However, the data indicated that the higher mortality was associated with the increased share of older cows, which have a naturally higher probability of dying compared to younger cows, and not with increased mortality in the different age groups. Nonetheless, TASC also showed that herds with a high longevity did not necessarily have a higher mortality. The data from the monitoring system provided the possibility to analyse the association between longevity of dairy cattle herds and cattle health and indicated that cattle mortality was lower in herds with a high longevity, compared to herds with a low longevity. Whether this was because of better cattle health or different culling management is unknown. Most studies so far have focussed on reasons for early culling (Rostellato et al., 2021). Little is known about differences in cattle health between groups of farms with a different longevity. Therefore, the aim of this study was to evaluate the association between longevity and cattle health parameters in Dutch dairy herds.

2. Materials and methods

2.1. Study population and available data

For this study, anonymized near census data was available from approximately 98 % of the Dutch dairy herds in the study period between 2016 and 2020, that agreed to use their routinely collected data for monitoring of cattle health (Santman-Berends et al., 2016). Initially, data were available from 17,591 Dutch dairy herds. After validation and given that we are performing a complete case analysis, eventually data from 16,200 dairy herds remained for analysis. The data from the remaining 1391 dairy herds were excluded because they stopped farming during the study period.

Data were available from six different data sources. Registrations on cattle movements, including registrations of births, purchase, slaughter, and mortality were available from the national identification and registration database (RVO, Assen, the Netherlands). Cattle mortality data were obtained from the rendering plant and included the number of rendered cattle per herd and date (Rendac, Son, the Netherlands). Milk recording records were available from approximately 75 % of the herds that participate in the CHSS and were available from the Royal Dutch Cattle Syndicate (CRV, Arnhem, the Netherlands). Herd health statuses were available from Royal GD (Deventer, the Netherlands) and Qlip laboratories (Zutphen, the Netherlands). Finally, data of veterinary registrations on deliveries of antimicrobials were available per product, age category of cattle at herd level and date of supplying the antimicrobials to the herd (MediRund, Zuivel NL, the Hague, the Netherlands).

2.2. Definitions of longevity groups

Six groups of herds were defined based on differences in longevity. Descriptive results of these groups (including number of herds, criteria and longevity) can be found in Table 1. The groups were defined based on data and expert opinion. Each group consisted of a minimum of 750 herds, to ensure anonymity and statistical power. The first group was defined as ‘herds with a high longevity’ (n = 2016). The criterium for this group of herds was that the average longevity belonged to the 75th percentile of longevity in dairy herds in at least four out of five years. The second group was defined as ‘herds with an increasing longevity since 2017′ (n = 785). The reference year was 2017 because in that year new phosphate regulations were implemented in the Netherlands that had an effect on the size of the herds and preceding years before the regulation came into effect would not be a good reference. The herd life of the 10 % of herds with the highest increase in longevity increased on average one year between the reference year and 2020. Therefore, an absolute increase in longevity of one year was chosen as the threshold for herds in the group “highest increase in longevity”. The third group was defined as ‘herds with a median longevity’ (n = 2022), the cows in these herds had a longevity between the 25th and 75th percentile during the whole study period. The fourth group was defined as ‘herds with a decrease in longevity since 2017′ (n = 966). This group included the 10 % of herds with the highest decrease in longevity. The longevity of cows in these herds decreased with, on average, five months in 2020, relative to 2017. Therefore, an absolute decrease in longevity of five months was chosen as the threshold. The group of ‘herds with a low longevity’ (n = 1632) belonged to the 25th percentile of longevity in at least four out of five years. The remaining herds were classified in the group with a ‘varying longevity’ (n = 10,170), they did not meet the criteria of any of the previously described groups.

Table 1
Description of the six defined longevity groups, including the number of unique herds in each group, the criteria for each group and these criteria expressed in actual longevity.

Longevity groups	N herds	Criteria	Longevity
High longevity	2016	At least 4 of 5 years in the 75th-percentile	75th -perc.: > 6 years and 3 months
Increasing longevity	785	10 % herds with highest increase in longevity	Increase > 1 year
Median longevity	2022	5 of 5 years between in the 25th and 75th-percentile	5 years and 3 months – 6 years and 3 months
Decreasing longevity	966	10 % herds with highest decrease in longevity	Decrease > 5 months
Low longevity	1632	At least 4 of 5 years in the 25th-percentile	25th -perc.: < 5 years and 3 months
Varying longevity	10,170	Herds that didn't match the criteria in the other groups	

2.3. Data analysis

Data validation was conducted using SAS® version 9.4 (SAS, 2021). Data from the previously mentioned six data sources were combined on unique animal and herd number. Biologically impossible outliers were removed. Thereafter, the dataset was aggregated on herd and quarter of the year level. The following cattle health indicators were evaluated for their association with longevity:

- Calf mortality (moment of tagging-14 days old): the number of deaths from the moment of ear tagging until the age of 14 days divided by the total number of ear tagged calves (Santman-Berends et al., 2019).
- Calf mortality 15–55 days old: the number of deaths of calves between 15 and 55 days old, divided by the total number of calves present in the herd corrected for the time that they were present (days at risk) (Santman-Berends et al., 2019).
- Cow mortality (>one year old): the number of deaths of cows that are at least one year old, divided by the total number of cows that are at least one year old, corrected for days at risk.
- Percentage of cows with high somatic cell count (SCC): the number of cows with a high SCC (>150,000 cells/ml for primiparous cows, >250,000 cells/ml for multiparous cows), divided by the number of lactating cows per herd.
- Bulk milk somatic cell count (SCC): number of somatic cells per millilitre in bulk milk.
- Age at first calving (in months).
- Number of inseminations per heifer, regardless of successful pregnancy.
- Number of inseminations per cow, regardless of successful pregnancy.
- Being certified free or unsuspected in the IBR or BVD control program (yes/no) (Santman-Berends et al., 2021).
- Mean antibiotic use in adult dairy cows: the yearly moving average animal defined daily dose (ADDD/Y) applied in adult dairy cows (>two years), presented per herd per quarter of the year.
- Having a high antibiotic use in dairy calves (yes/no): herds are classified as not having a high use according to a moving average of

antibiotic use of ≤ 9.25 ADDD/Y and as a high use when having a DDD/Y of > 9.25. The cut-off value of 9.25 is the DDD/Y 75th percentile value in the reference year 2013.

Stata® 17 was used for analyses and generating tables and figures (Stata, 2021). Descriptive statistics were used to plot the longevity of dairy herds over time, per quarter of the year over the period 2016–2020 and to compare the defined longevity groups. Multivariable population-averaged generalized estimating equations (PA GEE) models with the appropriate distribution (e.g. gaussian, binomial or poisson) and link function (identity, logit or log), which corrected for repeated measures per herd, were used for analyses. The cattle health indicators were included as dependent variable and the longevity group variable was added as an explanatory variable. In order to find the best fitting model, correlation analysis was performed between the independent variables. Replacement rate was highly correlated (r > 0.5) with longevity and therefore excluded from the models. Subsequently, all explanatory variables were forced into a full model. Then, the non-significant variables were excluded one by one and the best fitting model was chosen based on the Quasilikelihood under the Independence model Criterion (QIC) value (Pan, 2001; Cui, 2007) closest to zero. None of the excluded explanatory variables changed the other estimates with more than 25 %, so no confounders were retained. Only the estimates for the longevity variable are provided and discussed in detail. The estimates for the other significant explanatory variables can be found in Appendix 1.

Other categorized explanatory parameters that were included in the models were herd size, growth in herd size, location represented by province, milk production level, season, milk price, price of calves, open or closed farming system (i.e. purchase cattle or not), status (free vs. non free) for endemic diseases such as salmonellosis, leptospirosis, BVDV, BHV-1 and paratuberculosis and milking parlour (regular vs. automated milking system). A continuous explanatory variable was the trend in time. The variables herd size, growth in herd size and milk production level were categorised into four categories (10 % smallest, 40 % smaller, 40 % larger and 10 % largest). The categorization of explanatory variables allowed for comparison of the relative importance of those variables in explaining variation in the dependent cattle health variables. Given the large amount of census data, there was sufficient degrees of freedom for categorisation of the continuous variables. For the categorized variables, the mean of the whole population was included as the reference category, which is thus dynamic. Only the variables that explained most variation will be presented in this paper. Results were presented as an Incidence Rate Ratio (IRR), Odds Ratio (OR) or as a value. A conservative *P*-value below 0.01 was considered significant because of the large numbers of observations in the model.

3. Results

3.1. Descriptive results

The mean longevity on dairy farms increased for five out of six defined groups of herds during the study period. The longevity only decreased in the group of herds selected for a decreasing longevity. The mean longevity in herds that were classified as having a high longevity was seven years, and in herds with a low longevity four years and ten months. The mean longevity increased with on average one year and two months in the group of herds with an increasing longevity. The mean longevity decreased on average eight months in the group of herds with a decreasing longevity. Both the group of herds with a median and fluctuating longevity had a mean longevity of five years and eight months at the end of 2020 (Fig. 1).

3.2. Multivariable results

Full models for each dependent variable are provided in Appendix A.

Calf mortality in the age group from the moment the calf was tagged until 14 days old (zero-14 days old) was on average 3.4 %, in the age group 15–55 days old calf mortality was on average 0.85 %. The mean cow mortality of cattle over 1 year old was 0.82 %. The group of herds with a high longevity was significantly associated with lower mortality of calves between zero-14 days old, calves between 15 and 55 days old (IRR = 0.87 and 0.88, respectively) and cow mortality compared to the average Dutch dairy herd (IRR = 0.89). Increasing longevity was also associated with lower cow mortality (IRR = 0.89).

On the contrary, belonging to the group of herds with a fluctuating and low longevity was associated with a significantly higher mortality of calves between zero-14 days old, calves between 15 and 55 days old and adult cows (IRR = 1.05, 1.04 and 1.01 (fluctuating longevity), IRR = 1.09, 1.14 and 1.15 (low longevity), respectively). A decreasing longevity was also significantly associated with higher cow mortality (IRR = 1.07) (Fig. 2).

The average percentage of cows with a high SCC in Dutch dairy herds was 16.4 % between 2016 and 2020. Belonging to the group of herds

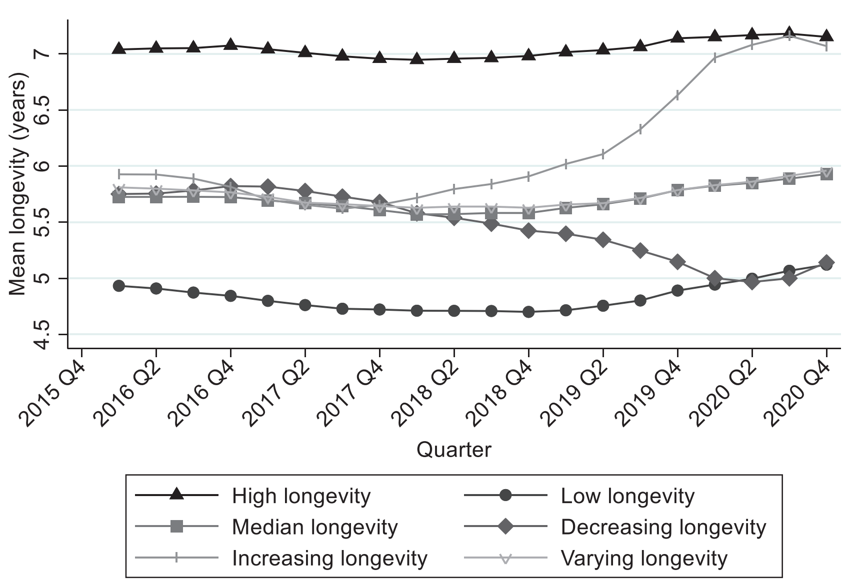

Fig. 1. Trend in the mean longevity in Dutch dairy herds, per longevity group in the study period between 2016 and 2020.

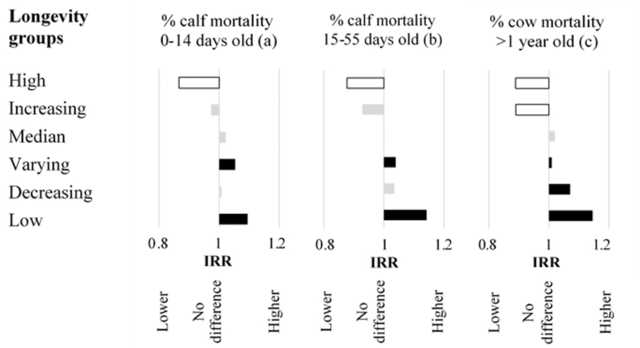

Fig. 2. Incidence rate ratios (IRR) of mortality of calves between 0 and 14 days old (a), calves between 15 and 55 days old (b) and adult cows older than one year (c) in Dutch dairy herds between 2016 and 2020, per longevity group (corrected for other explanatory variables in a multivariable model). White bar: favourable effect, black bar: unfavourable effect and grey bar not significant (all at P < 0.01).

with a high longevity was associated with a significantly higher prevalence of cows with high SCC compared to the average Dutch dairy herd (1.1 % higher). Herds with a high longevity also had a higher bulk milk SCC (9.12 $*10^3$ cells/ml higher) than the average bulk milk SCC (180 $*10^3$ cells/ml between 2016 and 2020 in Dutch dairy herds). Herds with a median longevity were also associated with a higher bulk milk SCC (1.00 $*10^3$ cells/ml higher). Herds with a low, increasing and decreasing longevity had a lower high SCC prevalence (0.6 %, 0.3 % and 0.3 % lower, respectively). The herds in these groups were also associated with a lower bulk milk SCC (6.11 $* 10^3$, 1.16 $* 10^3$ and 2.88 $* 10^3$ cells/ml lower, respectively) (Fig. 3).

Milk production level showed the strongest association with high SCC prevalence and bulk milk SCC, where low producing herds were associated with a higher high SCC prevalence (6.1 % higher than the average Dutch dairy herd) and a higher bulk milk SCC (45.14 $* 10^3$ cells/ml higher than the average Dutch dairy herd).

A higher proportion of cows with a high SCC in herds with a high longevity may be explained by more udder infections or by a larger number of older cows with a naturally higher SCC. This issue was further investigated by comparing the percentage of cows with a high SCC (>150 $* 10^3$ cells/ml in primiparous cows, >250 $*10^3$ cells/ml in multiparous cows,) per age category between longevity groups. Fig. 4 shows that the percentage of cows with a high SCC increased with age. Only 6.5 % of the two to three year old primiparous cows had a high SCC while this was 22.9 % in the seven to eight year old multiparous cows. The percentage of cows with a high SCC was comparable between each longevity group, in each age group. The difference between the low- and high longevity group was the highest in the age group of cows between five to six years old. Herds with a low longevity had on average 20.3 % cows between five and six years old with a high SCC, followed by herds with a median longevity (18.8 %) and herds with a high longevity (17.7 %). Thus, the higher percentage of cows with a high SCC in herds with a high longevity was due to a larger number of older cows, rather than a poorer udder health for cows of a certain age.

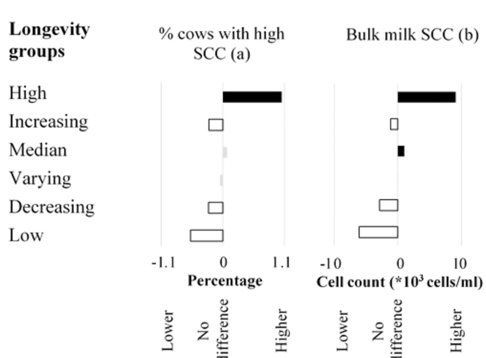

Fig. 3. The percentage of cows with a high somatic cell count (SCC) (a) and bulk milk somatic cell count (bulk milk SCC) (b) in Dutch dairy herds between 2016 and 2020, per longevity group (corrected for other explanatory variables in a multivariable model). White bar: favourable effect, black bar: unfavourable effect and grey bar not significant (all at P < 0.01).

The age at first calving was on average 25.9 months (25 months and 27 days), the average number of inseminations was 161 per 100 heifers and 189 per 100 cows in Dutch dairy herds. The group of herds with a high longevity was associated with a higher age at first calving (11 days older), fewer inseminations for heifers (two days less per 100 heifers), but more inseminations for cows (two more per 100 cows). On the contrary, low longevity herds were associated with a lower age at first calving (nine days less) and fewer inseminations for cows (two less per 100 cows) (Fig. 5).

Milk production level was stronger associated with/explained more variation in age at first calving compared to longevity, i.e. the 10 % lowest producing herds had a one month and 20 days higher age at first calving compared to the average Dutch dairy herd.

About 70 % and 66 % of the Dutch dairy herds had a free or unsuspected herd status for IBR and BVD between 2016 and 2020, respectively. Herds with a high, increasing and decreasing longevity were associated with a significantly higher odds of being a certified IBR free or unsuspected herds (OR = 1.18, 1.23 and 1.05, respectively). Increasing longevity herds were also associated with a higher odds of being certified BVD free or unsuspected herds (OR = 1.14). Herds with a median, fluctuating and low longevity were associated with a lower odds to be either IBR free or unsuspected (OR = 0.90, 0.95 and 0.77, respectively). Moreover, low longevity herds were associated with a lower odds of BVD free or unsuspected certification (OR = 0.92) (Fig. 6). The association between longevity and leptospirosis, paratuberculosis and salmonella status was very weak and therefore these results were not presented.

Milk production level and being an open or closed herd showed a stronger association with IBR status than the longevity status of the herd. The 10 % highest producing herds were associated with a higher percentage of certified IBR free and unsuspected herds (OR = 1.99). Closed herds were also associated with a favourable IBR status (OR = 2.07).

Between 2016 and 2020, the average antibiotic use in adult dairy cows in the Netherlands was 2.68 animal defined daily dose per year (ADDD/Y), and the mean percentage of herds with a high antibiotic use in calves (>9.25 ADDD/Y) was 27.3 %. The group of herds with a high, increasing and median longevity was associated with higher antibiotic use in adult dairy cows (0.11, 0.07 and 0.03 ADDD/Y higher, respectively). Herds with a high and increasing longevity had a lower odds of being classified as having a high antibiotic use in calves (OR = 0.80 and 0.95, respectively). An opposite result was found for herds with a decreasing and low longevity, these groups were associated with a lower antibiotic use in adult cows (0.10 and 0.12 ADDD/Y lower, respectively) but a higher odds for a high antibiotic use in calves (OR = 1.11 and 1.22, respectively) (Fig. 7).

4. Discussion

The aim of this study was to determine the association between herd longevity and cattle health indicators. The focus was on herds with a high longevity, because the public opinion favours cows that are kept for a longer period before moving to slaughter. This study shows that many cattle health indicators were associated with herd longevity. There was a tendency that herds with a high longevity had better cattle health parameters. The exception was udder health and antibiotic use: older cows more often had a high SCC, which probably explained the slightly higher use of antibiotics in adult cows in high longevity herds. Nyman et al.

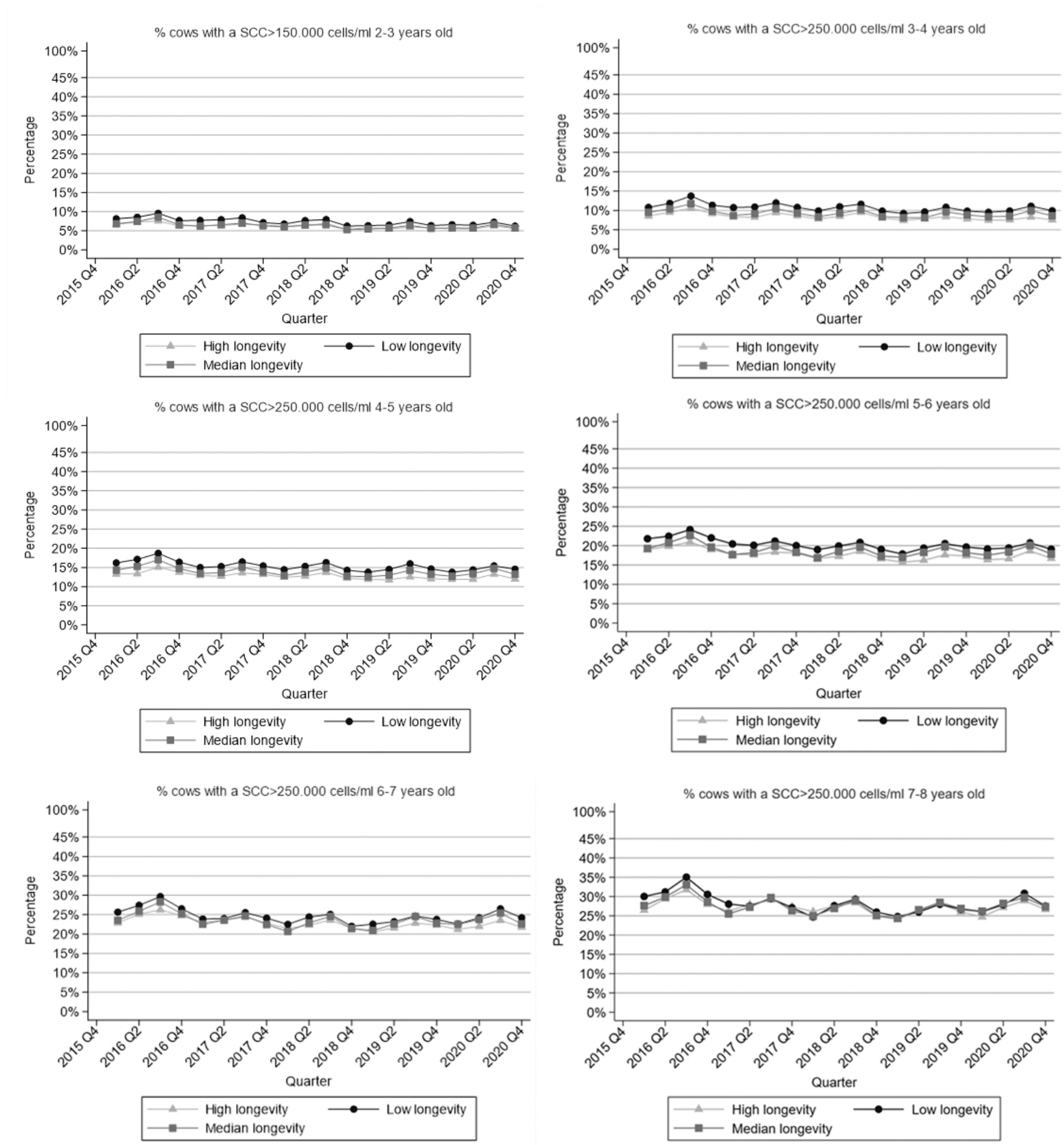

Fig. 4. The mean percentage of cows with a SCC> 150 * 10^3 cells/ml (primiparous cows) or a SCC> 250 * 10^3 cells/ml (multiparous cows), in six different age groups in the study period between 2016 and 2020 in Dutch dairy herds, for the groups of herds with a high, median and low longevity.

(2014) studied the association of udder health indicators with cow factors, and also found a significantly higher SCC in fifth parity cows in comparison to first parity cows.

Herds with a high longevity were associated with lower calf and cow mortality. The negative association might be related to the fact that longevity is partly determined by cows that die. However, the far majority of cows, leave the herd for slaughter (Olechnowicz et al., 2016). The association is more likely due to better health leading to lower mortality and an older age at culling. The age at culling increases when the cattle in the herd are healthier and do not need to be involuntary culled for health reasons. An increase in parity is often associated with a continuous drop in culling frequency, with the highest culling rate in parity one to three (Chiumia et al., 2013). Nevertheless, high longevity herds were associated with a higher percentage of cows with a high SCC and a higher bulk milk SCC. Yet, stratified for cattle of the same age, the probability of having a high SCC appeared comparable between the high, median and low longevity herds. This implies that more cows with a high SCC in high longevity herds is a result of a larger number of older cows rather than a poorer udder health management. Our finding was supported by Bradley and Green (2005) who also observed that older cows tend to have higher SCC, irrespective of infection status. Another finding was that herds with a high longevity differed in fertility indicators. Farmers from high longevity herds tended to inseminate their heifers at a later age, with the consequence that the age at first calving was higher, while a lower number of inseminations was needed to impregnate them. The higher age at first calving was therefore, hypothesized be a consequence of management decisions, rather than a compromised fertility. In these high longevity herds, more inseminations were needed for cows. In a previous study, the chance of a successful first insemination decreased with parity (Inchaisri et al., 2010). This can explain why more inseminations were used for cows, because high longevity herds have more and older multiparous cows. In addition, farmers with high longevity herds may accept more inseminations to get a cow pregnant, compared to farmers with low longevity herds. First-parity pregnant cows with a long time to conception (>390 days) were more likely to be culled in comparison to

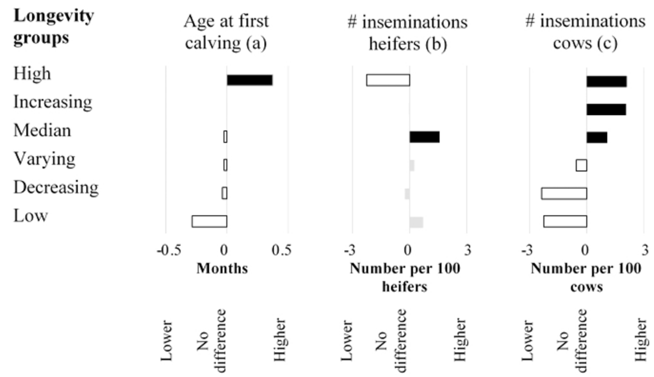

Fig. 5. Coefficients for the age at first calving in months (a) the number of inseminations per 100 heifers (b), the number of inseminations per 100 cows (c) in Dutch dairy herds between 2016 and 2020, per longevity group (corrected for other explanatory variables in a multivariable model). White bar: favourable effect, black bar: unfavourable effect and grey bar not significant (all at P < 0.01).

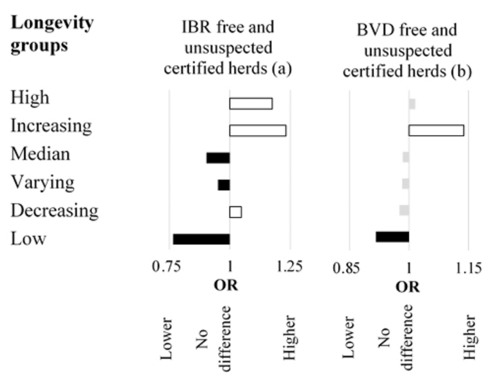

Fig. 6. The odds ratio (OR) of certified IBR (a) and BVD (b) free or unsuspected Dutch dairy herds between 2016 and 2020, per longevity group (corrected for other explanatory variables in a multivariable model). White bar: favourable effect, black bar: unfavourable effect and grey bar not significant (all at P < 0.01).

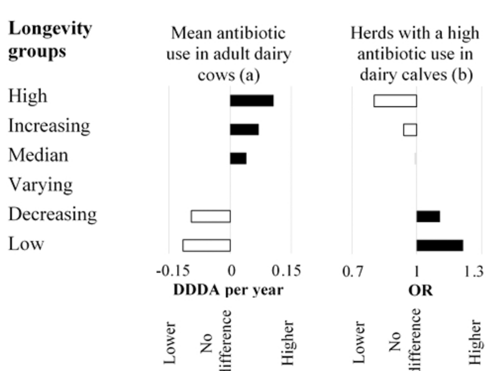

Fig. 7. The coefficient of the mean antibiotic use in adult Dutch dairy cows (a) and the odds ratio (OR) for a high antibiotic use in Dutch dairy calves younger than 8 weeks (b) between 2016 and 2020, per longevity group (corrected for other explanatory variables in a multivariable model). White bar: favourable effect, black bar: unfavourable effect and grey bar not significant (all at P < 0.01).

pregnant older cows with a long time to conception (De Vries et al., 2010), suggesting a higher tolerance towards reduced fertility in older cows. The antibiotic use in adult cows was higher in high longevity herds, probably because farmers more often decide to treat instead of cull cows with an infection. Moreover, older cows are more likely to be dried off with antibiotics because they have a SCC that exceeds the threshold for which dry cow treatment is advised in the Netherlands (KNMvD, 2013). On the contrary, antibiotic use in calves was lower in these herds and together with the lower calf mortality, this indicates a better calf health.

Herds with a low longevity had higher calf and cow mortality compared to the average Dutch dairy herd. The percentage of cows with a high SCC and bulk milk SCC was lower, which can be explained by a lower share of older cows, but may also be due to culling of high SCC cows rather than treating them. Heifers had a lower age at first calving in low longevity herds, but more inseminations were needed for impregnation. Possibly, heifers have not reached the optimal age for insemination yet, and therefore more inseminations were needed. Kuhn et al. (2006) found that conception rate was lower for breedings at less than 15 months of age in comparison to heifers that were inseminated between 15 and 16 months of age. The cows in low longevity herds received a lower number of inseminations than the average Dutch dairy herd. Perhaps farmers are less tolerant to cows that return to service, and decide to cull the cow when fertility was deemed suboptimal. Antibiotic use in calves was higher, and lower in adult dairy cows. Possibly, farmers treat the cows less often, and choose to cull the cow instead.

Some differences in cattle health indicators were found for herds with a median and varying longevity group. In the median longevity group, cattle health indicators were significantly different from the average Dutch dairy herd for bulk milk SCC, the age at first calving, the number of inseminations in heifers and adult dairy cows, IBR status and antibiotic use in adult dairy cows. Longevity in the median longevity group was fairly constant. In the fluctuating longevity group, the longevity varied considerable between years, therefore, as expected, very few differences with the Dutch average dairy herd were detected. Herds with fluctuating longevity differed in calf mortality, number of inseminations per cow and IBR status from the average Dutch dairy herd.

The strength of the association between longevity and animal health indicators varied and was sometimes fairly low with small differences between the longevity groups. Other herd characteristics such as milk production levels or herd size may explain more variation in the cattle health parameters. In this study, only routinely available anonymized near census data were used. Management strategies and motivations of farmers were not available. Nevertheless, our results indicated differences in farmers' management and decision making related to longevity and it would therefore be relevant to be able to include attitude and motivations of farmers. Such information could provide more insight in the relationship between longevity and animal health indicators. Another interesting topic for further investigation is comparison of the total lifetime production per defined longevity group. Standardized production parameters showed a lower milk production per cow per day in high longevity herds (results not shown). However, it may be that lifetime production does not differ between high and low longevity herds. Further studies on this topic may help to disprove the argument that it is not economically beneficial to focus on a high longevity. Vredenberg et al. (2021) studied the effect of longevity on economic return in dairy herds and concluded that there was no difference in economic return between high and low longevity herds. However, in their study the variation in longevity was smaller (a difference of approximately one year in longevity). Longevity can be influenced by factors such as milk prices and other costs. Milk price was included in the multivariable models, and therefore the multivariable results were corrected for this factor. Milk price was not a confounder for longevity. Fluctuations in other costs, such as feeding costs and other herd management factors that were unknown in this study, may also have had an influence on longevity. To include herd management factors that are not routinely available in census data, further studies are required.

Definitions of longevity vary among studies e.g. length of the productive life, (productive) herd life, true or functional staybility and true or functional longevity (Schuster et al., 2020). Longevity also differs between high-producing countries. For example, the length of the productive life (length of time between first calving and culling) in the Netherlands was 1.5 times lower compared to New Zealand, but 1.67 times higher compared to Canada. Milk production in the Netherlands was 2.3 times higher compared to New Zealand, and comparable with Canada. The difference in milk production is mainly due to different systems, where cattle in the Netherlands and Canada are mainly housed indoors in winter months and are fed concentrates and silage, with all year grazing and hardly any additional concentrates or silage in New Zealand. In a review of Dallago et al. (2021) the productive life of a cow was compared between countries and they found the productive life in the Netherlands comparable to Ireland, Italy and Germany, higher than the United States of America, Brazil, France and Canada and lower compared to Poland and New Zealand in the 2010 s

5. Conclusion

To conclude, this study showed differences in cattle health between herds that differ in longevity. In general, the high longevity herds seemed to have better cattle health than low longevity herds. However, the consequence of having older cows is a higher risk for a high SCC, which can lead to more antibiotic use. Thus, aiming for a high longevity can be in conflict with a pursuit of low antibiotic use and low bulk milk SCC. The motivations and goals of farmers in different longevity groups should be investigated in a follow-up study to determine the success factors of a high longevity in combination with good cattle health.

Conflict of interest

In this paper, no conflict of interest is declared.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.prevetmed.2022.105797.

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