Retrospective analysis of cohort risk-factors and feeding phase timing associated with non-infectious heart disease deaths in US fed cattle

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Abstract

Heart disease, specifically, congestive heart failure has become of increased interest to geneticists and cattle feeders. Data on cohort associations of risk factors related to heart disease and when heart disease deaths occur in US feedlot cattle are limited. The study objectives were to 1) determine potential associations between feedlot cohort demographics and the risk of at least one non-infectious heart disease (NIHD) death occurrence and 2) determine potential association between feedlot cohort demographics and the timing of NIHD deaths during the feeding phase. Data were downloaded from commercial feedyard software and analyzed by constructing a generalized linear mixed model for both analyses. A binomial and Gaussian distribution for risk of NIHD death and timing of NIHD were utilized as link functions for their respective models. Our study population consisted of 28,950 cohorts (representing 4,596,205 cattle) that were placed in 22 US commercial feedlots from January 01, 2016, to January 01, 2019. There were 3,282 cases of NIHD deaths from a population of 75,963 cattle that died during the three-year study period. Average cohort arrival weight’s effect on NIHD probability was influenced by arrival quarter and arrival year of placement (P < 0.01). Cohorts with steers were associated with a greater probability of at least one NIHD death (2.38%) compared to heifers (1.95%; P < 0.01). Increasing cohort size was associated with an increased probability of a cohort having at least one NIHD death (P < 0.01). The probability of at least one NIHD death in a cohort increased from 1.51%, to 2.12%, and 2.87% in d on feed categories 100-175, 176-250, and 251-326 respectively. Cattle > 326 d on feed were no different in the probability of a NIHD death compared to the other feeding categories. Timing of a NIHD death had a mean and median occurrence of 110 d on feed with an interquartile range of 64 to 153 d on feed. The effect of arrival weight on d at death was influenced by year placed with heavier cattle generally
decreasing the model adjusted means of d on feed at NIHD death. Arrival quarter was influenced by year placed on model adjusted means on the timing of a NIHD death. Steers with NIHD died later compared to heifers (P < 0.01) diagnosed with NIHD. In conclusion, multiple factors are associated with probability and timing of a NIHD death. Probability of having at least one NIHD death within a cohort was low and half of the deaths occurred before 110 d on feed.

**Keywords**

brisket disease, cattle, congestive heart failure, feedlot, heart disease
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List of abbreviations

AIP, acute/atypical interstitial pneumonia
BRD, bovine respiratory disease
CHF, congestive heart failure
DOF, days on feed
GI, gastrointestinal
LCL, lower confidence limit
NIHD, non-infectious heart disease
RHF, right heart failure
UCL, upper confidence limit
UID, unique identification number
US, United States
Introduction

Heart disease, specifically congestive heart failure (CHF) or right heart failure (RHF), have been investigated recently (Neary et al., 2013; Neary et al., 2016; Heaton et al., 2019; Krafsur et al., 2019) in finishing cattle. Research has identified increases of cases classified as heart disease over time suggesting that prevalence of heart disease may be increasing. Neary et al., 2016 reported the risk of right heart failure from 2000 to 2012 doubled from 0.21 to 0.40 per 1,000 head placed. Some individual producers in the Western Plains had annual losses exceeding $250,000 (Heaton et al., 2019). Previous research stated animals that succumb to heart disease in the feedlot tended to die later in the feeding phase (Neary et al., 2015; Neary et al., 2016). Neary et al., 2016 found a median d on feed for a right heart failure death was 132 d for Canadian cattle and 133 d for US cattle. Due to the economic value of heart disease animals, including the cost of animal plus operational costs, and feed cost, there is a need to further investigate data to better understand heart disease risk and underlying factors that may influence heart disease. The purpose of this research is two-fold, 1) determine the risk of at least one non-infectious heart disease (NIHD) death within a cohort and the associated cohort demographics that may influence risk of heart disease in the population 2) evaluate when a NIHD death occurs during the feeding period and evaluate cohort demographics that influence the timing of heart disease deaths.
Materials and Methods

Animal Care and Use Committee approval was not obtained for this study due to retrospective data being obtained from existing privatized databases from commercial feedyards.

Data Source

Data used for analysis were under confidential agreement with participating feedyards. Cohort and individual mortality data were collected from cattle placed in 22 commercial US feedyards from January 1, 2016, to January 1, 2019 located throughout the mid and southern plains. After confirming that inclusion criteria were met, a total of 4,596,205 cattle were received comprising of 28,950 cohorts and 75,963 mortalities. A cohort is defined as a group of cattle that were acquired, managed, and marketed similarly but not necessarily commingled in the same physical location (pen) for the feeding phase. Data were exported from commercial feedyard systems and subsequently imported into R (R Core Team, 2020) for analysis.

Risk of NIHD cohort by enrollment criteria:

Enrolled cattle (Fig. 1) were categorized by animal identification, lot identification, average lot arrival weight (“in-weight”), arrival date to feedlot (“in-date”), death date (event date), d on feed at death, sex, pen at death, number of cattle received in cohort, cause of death (“diagnosis”), and organization number (arbitrary identification number representing a unique feedyard). A unique identification number (UID) was created to distinguish animals within cohorts from their respective feedyard due to separate feedyards having similar cohort identification number systems. The UID was comprised of the organization identification number, feedyard identification number, and cohort identification number. Total d on feed was calculated as ship date less arrival date (total d on feed = ship date – arrival date). Estimated ship date was used
when an actual ship date was not provided as the final date on feed for that lot in the total days on feed calculation. If no known ship date or estimated ship date were recorded, then the observation was omitted from the data set.

Included cohorts must have completed their respective feeding phase and be considered a closed cohort. Review of the data found multiple cohorts that had cattle remaining not shipped when they logically should have been (e.g., 3 cattle remaining in a cohort after multiple years since ship date). Thus, a new variable was created “current pen size” to evaluate for cohorts being closed. The following equation was used to calculate the parameters of current pen size: \[ \text{Current Pen Size} = \text{cattle received} - (\text{cattle shipped} + \text{cattle railed} + \text{cattle dead}) = 0 \]. Cattle shipped is defined as cattle who finished their feeding period and were shipped to a harvest facility. Cattle railed is defined as cattle who were removed and not finishing their respective cohorts feeding period due to health-related reasons (i.e., muscular skeletal injury, lack of thriving). Data evaluation revealed that multiple cohorts remained with -1 or ≤ 7 cattle in current pen size when they should have been 0 due to shipment date and time to data download with no new entries. Thus, authors deemed data acceptable to include a current pen size range from -1 to 7 cattle as a “closed pen” to accommodate for a likely accounting error.

Cohort inclusion criteria included: greater than 39 cattle were placed, cohort with current pen size at close-out of -1 to 7, average arrival weight was greater than or equal to 182 kg and less than or equal to 545 kg. Cohorts were limited to a sex listed as heifer or steer. Other options under the sex category including mixed sex, bulls, or Holstein were not included. Cohorts must have been on feed at least 100 d before shipping to harvest. For cohorts that met the inclusion criteria, a placement-quarter variable was created from the arrival month of placement. The
following criteria was used to create the placement quarter variable: 1 = January through March; 2 = April through June; 3 = July through September; and 4 = October through December.

Individual mortality data used in this analysis were gathered from their respective feedyard health software. Multiple diagnosis categories were utilized to define specific diseases common in fed cattle. For the purpose of this paper, entered diagnosis were evaluated and condensed into five disease categories: Acute/Atypical Interstitial Pneumonia (AIP), Bovine Respiratory Disease Complex (BRD), Gastrointestinal disease + Bloat (GI+Bloat), Non-Infectious Heart disease (NIHD), and Other (any diagnosis that was not AIP, BRD, GI+Bloat, or NIHD).

Days on feed analysis of heart deaths:

Cohorts meeting the inclusion criteria had their individual mortality data analyzed for when a NIHD death occurred during the feeding phase. A new variable was created and called “event days on feed”. This was calculated by using the following formula [Event DOF (days) = Death date – Arrival date]. Individual deaths categorized for NIHD were included in the analysis. Infectious heart disease cases were removed from the heart disease category prior to analysis. Table 1 shows the diagnosis codes that comprised the heart disease category.
Statistical Analysis

Risk analysis for any non-infectious heart disease death within a cohort:

A generalized linear mixed-model was fit into R Studio (R Core Team, 2020) using the ‘lme4’ package (Bates et al. 2015) and ‘glmer’ function. Feedyard was included as a random intercept to account for lack of independence of cohorts within feedyard. A binomial outcome of 0 or 1 for heart death in lot was created, 0 = no NIHD deaths within the cohort and 1 = at least one NIHD death within cohort, for the outcome variable and fixed effects included: arrival quarter, days on feed, arrival weight, sex, arrival head received (lot size by quartiles), and arrival year. To avoid violating the assumption of linearity, total received head in each lot was categorized into four equal groups using the dplyr::ntile function in R (Wickham et al., 2019). Using this method there is the possibility of overlapping values in the groups; however, authors wanted to keep the groups as equal as possible with respect to the number of lots in each group. A univariate analysis was performed and only significant factors (P ≤ 0.05) were included. All factors of the model were found to be significant and a second model was created incorporating interactions. All possible 2-way interactions were incorporated and only significant 2-way interactions were included (P ≤ 0.05). The final risk model was created utilizing a backwards elimination process (Dohoo et al., 2012), where all factors and interactions were included then eliminated when found to be non-significant (P > 0.05).
Days on feed of heart death individual analysis:

Individual heart disease mortalities (n = 3,282) and their associated cohort data were exported from 19 US commercial feedlots, three of the feedyards from the 22 used with the risk analysis reported no NIHD deaths and thus were not included in the NIHD on feed analysis. A generalized linear mixed-model was fit in R Studio (R Core Team, 2020) using the ‘lme4’ package (Bates et al. 2015) and ‘lmer’ function to assess the association of head received, arrival quarter, gender, arrival weight and arrival year on the outcome on feed at the time of a NIHD. Feedyard was included as a random intercept to account for the lack of independence within feedyards. The final model was created by initially including all covariates and interactions, then a backwards variable elimination process was used to remove non-significant interactions and covariates (P > 0.05).

Results

Descriptive Statistics

The final data set consisted of 28,950 cohorts; 11,927 cohorts were heifers and 17,027 were steers. The total cattle received during the three-year observational study was 4,596,205. Figure 2 shows the total cattle received to the feedyards which died, (n = 75,963 cattle), during the feeding phase of various diseases expressed as a percent of total cattle received. Death loss for NIHD was 0.07% or a 7 in 10,000 cattle across all 22 feedyards over the three-year period. This number was calculated by total NIHD deaths divided by total cattle received (3,282 cattle / 4,596,205 cattle). There were 457 NIHD deaths in 2016 out of a population of 1,081,903 cattle accounting for 0.04% or 4 in 10,000 cattle. In 2017 NIHD accounted for 1,283 deaths out of a population of 1,637,876 cattle accounting for 0.078% or 8 in 10,000hd of cattle. Finally, in 2018
1,542 cattle died due to NIHD in a population of 1,876,426 cattle representing 0.08% (8 in 10,000 cattle). Non-infectious heart disease deaths accounted for approximately 4% of the total dead population (3,282 / 75,963). Variables significantly (P < 0.05) associated with the probability of having at least one NIHD death in a cohort included sex, cohort size, and cohort feeding length (d on feed) and the 2-way interactions between arrival weight and arrival year, arrival weight and quarter of placement. Variables significantly (P < 0.05) associated with influencing timing of NIHD death include sex and cohort size, and the 2-way interactions arrival year and arrival quarter, arrival year and arrival cohort average weight.

Association of cohort risk of at least one heart death within cohort:

The effect of cohort weight on the probability of a cohort having at least one NIHD death was influenced by cohort arrival quarter and year of placement. The association of arrival weight category with the risk of having a cohort with at least one NIHD death generally decreased with heavier weights influenced by arrival quarter (Fig. 4). Cattle placed in the second quarter had the same risk of NIHD death across all weight groups. The greatest risk of having a NIHD death within a cohort was found in the 273-318kg cohorts placed in the 4th quarter compared to all other cattle placed at all other quarters. Cohorts placed in the first quarter at 182-227kg had the lowest risk (0.005% probability). However, the lighter weight cattle in our study (182-227kg) did not differ in the risk from the heavier placed cattle (445-500kg). The association of arrival weight with the probability of at least one NIHD death in a cohort was influenced by placement year (Fig. 6). In 2016, all placement weight categories had no differences in cohort probability of a NIHD death. Cattle placed in 2017 and 2018 had no differences in probabilities of a NIHD death across weight category except for 2018, 182-227kg placed cattle had a lower probability
(0.009, LCL 0.003 UCL 0.02) of a NIHD death within cohort compared to 2017 (0.037, LCL 0.012; 0.11 UCL).

Additionally, steer cohorts were associated with having a greater model estimated means probability of a NIHD death compared to heifers [2.38% (LCL 1.0%, UCL 5.8%) vs 1.95% (LCL 0.78%, UCL 4.7%), respectively] (P < 0.01). The model estimated means probability of NIHD increased linearly with cohort size quartile from the lowest probability of 1.12% in quartile 1 to 3.82% in quartile 4. Quartile 4 was not different from quartile 1 but was different than quartile 2 and 3 (1.93% and 2.57% respectively).

The model estimated means probability of at least one NIHD death in a cohort increased with increasing d on feed for cohorts from 1.51% to 2.87% for cattle fed 100-175 d and 251-326 d respectively. Model estimated means estimate probability decreased to 2.33% in cattle that were fed > 326 d, which was not (P = 0.90, P = 0.9985, P = 0.99) different compared to the 100-175, 176-250, and 251-326 categories of d on feed, respectively.

Timing of non-infectious heart disease death modeled results:

Variables significantly (P < 0.05) associated with the d on feed of NIHD death in the final model were cohort size and sex and the 2-way interactions of arrival weight and arrival year, and arrival year and arrival quarter.

Cattle that died from NIHD died on average at 110 days on feed (Fig. 3). The median days on feed death was also found to be 110 days. The interquartile range of a NIHD death occurred between 64 and 153 days on feed in this study. Cattle placed at heavier weights tended to have a lower model estimated days-on-feed at NIHD death (Fig. 6) with the effect being influenced by placement-year. Placement-quarter’s effect of when a NIHD death occur was also influenced by
placement-year (Fig. 7). The effect of gender indicated that steers died later compared to heifers (P < 0.01). Steers that died due to NIHD died at model estimated means of 114 d, ± 4 d compared to heifers with a NIHD death at 102 d, ± 5 d. Lastly, cattle placed from cohorts’ sizes of 60 to 101 cattle died approximately 8 d earlier (LCL 91 d, UCL 111 d) than other placement groups (P < 0.01).

**Discussion**

A problem with operational feedyard data is a lack of consistent standardized reporting of data across feedyards (Corbin and Griffin, 2007). Our retrospective data includes many case definitions of NIHD, which can be specific to a feedyard and/or organization and potentially differ among trained personnel. Each feedyard entered a diagnosis for health data for their respective system for cause of death. To accommodate the inconsistent case definition of what defined heart disease, our study case definition included all non-infectious diseases that affected the heart which was labeled the primary cause of death.

Previous literature has described the individual risk of RHF and factors that affect risk of RHF in Canadian and US feedlot cattle (Neary et. al., 2016). Bassett (2019) performed an epidemiological investigation on CHF of one feedyard in western Nebraska over six years, which looked at number of CHF cases per 100,000 cattle head days and the timing of CHF diseases during the feeding period. The current study evaluated potential associations of cohort factors on the probability of at least one NIHD death and the timing of NIHD during the finishing phase. Our showed that the risk of NIHD death doubled from 4 per 10,000 cattle received in 2016 to 8 per 10,000 cattle received in 2017 and 2018. Differences from 2016 compared to 2017 & 2018 could be due to more contributing feedyard data during 2017 & 2018, cattle type procured at
each respective feedyard, or other unknown reasons. Neary et al. (2016) estimated the incidence of RHF in cattle to be between 4-17 per 10,000 cattle entering US feedyards and reported an increase in mean risk per 1,000 Canadian cattle for RHF from 0.21 in 2000 to 0.4 in 2012. Bassett (2019) found that the proportion of cases of CHF doubled from 2011 to 2016. One concern with operational feedlot data is the accuracy of which the data is measured, stated that accuracy of measured health outcomes is a potential source of differential error. The question of whether NIHD deaths are increasing or are veterinarians and feedlot personnel getting better at diagnosing them, is still a valid confounding concern. Albeit the data presented here and saw increases in the number of cases throughout multiple different time periods and locations.

The effect of arrival weight on the probability of a NIHD death was influenced by quarter of feedyard placement in our data. Average cohort placement weight had the numerically lowest model estimated probability of a NIHD death in the 182 kg to 227 kg groups, while the 273kg to 318kg average cohort placement weights had numerically greater probability of a heart death when placed in the 4th quarter compared to other placement-weights and placement quarters. Cattle placed in the 2nd quarter had similar probability of a NIHD death across all weight classes. Light weight cattle had similar probability of a NIHD death to cattle placed at 445kg to 500 kg. Neary et al. (2016) reported that increasing weights at feedyard placement did not increase the risk of a RHF, with the assumption more weight to gain means more days on feed. Bassett (2019) evaluated cohort percent finish, which was defined as “Degree of Finish (% Finish) = d on feed at diagnosis / (lot end date – lot start date)”, at the time of individual CHF death and reported that there was potential for clustering, but CHF was distributed throughout the feeding period and heavily skewed with increased deaths in greater percent finished cohorts. “Degree of finish” variable was designed to be a representation of an approximate degree of fattening with
respect of timing to their respective cohort at the time of death. Our data found that that lighter weight (181kg-227kg) cattle had relatively similar probability of a heart disease death within cohort as heavier placed cattle (409-455kg). In addition, our data also found that weight was also affected by the year of placement into feedyard. In 2016, our data saw a numerically lower probability of a heart disease death across all weight classes compared to 2017 and 2018 data. Neary et al., 2016 found year to year variation in RHF with an overall 2-fold increase in risk from 2000 to 2012. Bassett, 2019 evaluated CHF in one feedyard over six years and saw increased number of cases per 100,000 cattle head-days from 2011 through 2016. Our data showed a numeric increase in a probability of at least one NIHD death within a cohort from 2016 to 2018, suggesting that some potential factor (i.e., cattle type) within year is influencing cattle dying of NIHD.

Steer cohorts had a greater probability of a cohort having at least one NIHD death compared to heifers (P < 0.01). Neary et al. (2016) found that steers in the US had 39% greater odds of RHF compared to heifers, but no differences were observed in Canadian cattle sexes. Our data showed that steers had a 22% (2.38% vs 1.95%) greater probability of at least one NIHD death compared to heifers diagnosed with NIHD. A field investigation by Moxley et al., (2019) followed heart failure deaths over a 15-month period at one feedyard and found steer were overrepresented (16 steers) and one heifer. The steers originated from one herd located immediately adjacent to the feedlot and the one heifer originated from Cokeville, WY. Data suggests that gender plays a role in heart disease cases in finishing cattle.

It was hypothesized that increasing heavier finishing weight increases heart failure risk by increasing fat deposits around the cardiopulmonary structures (Krafsur et al., 2019). This would suggest there would be a longer average time from arrival at the feedyard to death due to NIHD.
Our data found that median time from arrival to NIHD death (110 d) was shorter compared previous literature (Neary et. al., 2016) at 133 d. Our observation of near-normal distribution of time from feedlot arrival to at least one death due to NIHD, reinforces the finding that NIHD was not found to increase over the feeding phase. Bassett (2019) reported a relatively normal distribution of percent finished at time of death due to CHF, meaning approximately one-half the cases happened before the cohort was 50%-60% finished. These data suggests that NIHD is not necessarily a late-day disease in finishing cattle. However, our analysis found increasing d on feed for a cohort was associated with increased probability of having at least one NIHD death within the cohort from 100 to 326 d finishing periods. There was an increase in model estimated mean cohort probabilities of a NIHD death from 100 (1.51%) to 326 (2.87%) d on feed. Feeding greater than 326 d showed no evidence of being different from other d on feed categories with a model estimated mean probability of 2.33%, meaning risk was no different in cattle fed for a considerable length of time compared to cattle earlier in the finishing period. These data are consistent with Neary et al. and Bassett (2016, 2019) where they found CHF throughout the feeding period. Furthermore, we found that half of the NIHD deaths occurred before 110 d. Neary et. al., 2016 found half of their heart disease deaths occurring after 19 weeks (> 133 d) on feed. Bassett (2019) showed that CHF cattle died in the greatest proportion between 121 d and 181 d after arrival to the feedyard. Thus, assessment of timing of NIHD deaths across multiple studies has shown that cattle dying from a heart disease event are not strictly dying during the later d of the feeding period where heavier and more fatten cattle would be represented.

In addition, the current study looked at average cohort arrival weight’s effect on timing of NIHD death. Arrival weight category was significantly associated with the timing of NIHD death with heavier weights having a general trend of lower d on feed when they died. Heavier placed cattle
had a model estimated means on feed that was numerically lower than lighter placed cattle, however, there was considerable variation in the point estimate. This was likely due to having fewer cattle placed in heavier weight categories and consequently fed for a shorter period. However, one could argue they are not at risk for the same amount of time during the feeding period compared to a lighter (282-227 kg) placed cattle.

The results of this study indicated that multiple factors were associated with increased probability of having at least one NIHD death within a cohort. The current study’s investigation found that interactions of the studied cohort factors have a role in the biology of risk of NIHD. Additionally, the association of timing of a NIHD death was found to have a near normal distribution throughout the feeding period with half of the deaths occurring before 110 d. Overall, the risk associated with NIHD was very low in the current study and several factors were found to be associated with the probability of at least one NIHD death within a cohort. However, the probability of a cohort having at least one NIHD death was relatively minimal.

Even at a low prevalence, heart disease in feedlot cattle remains troubling due to animals dying throughout the feeding phase, the financial impact of NIHD, and the lack of a clear causal pathway.
Limitations

In observational studies, there tends to be a lack of consistent, standardized reporting of data across feedyards (Corbin and Griffin, 2006). In our retrospective study, certain limitations need to be addressed. One is that our study was conducted on data that was entered from multiple feedyards having different personnel diagnose the diseased animals at necropsy with various training backgrounds. As previously stated, case definition varied between yards (Table 1), which carries the potential of misclassification bias. To help control some of this bias multiple heart disease categories were lumped into one category of NIHD. Additionally, the risk factors evaluated were not randomly dispersed among cohorts, as with all observational studies, and were subjected to unknown confounding factors. To help address bias and confounding, our analysis was set up as a multivariate mixed effects and had feedyard set as a random intercept. Thus, the results and conclusions are limited to the data presented and the cattle that fit our inclusion criteria.
Acknowledgments

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Conflict of Interest Statement

Authors declare no conflicts of interest.
Works Cited

Bassett, Adam, "Evaluating the Epidemiology and Management of Bovine Congestive Heart Failure" (2019). Dissertations & Theses in Veterinary and Biomedical Science. 27. https://digitalcommons.unl.edu/vetscidiss/27Doi:10.18637/jss.v067.i01


Table and Figure Legend

Table 1. Disease diagnosis categories incorporated into non-infectious heart disease (NIHD) case definition.

Figure 1: Data filtering from inclusion criteria applied to 22 US feedyard data download to working data set.

Figure 2 Percent of diagnosis per disease category expressed as percent of total cattle received (AIP = Atypical/Acute interstitial pneumonia, BRD = Bovine respiratory disease, GI+ Bloat = Gastrointestinal disorders and bloat, NIHD= Non-infectious heart disease, Other = All other non-categorized diseases)

Figure 3 Count of non-infectious heart disease deaths by days on feed at the time of death, mean and median = 110 d; totaling 3,282 non-infectious heart disease deaths observed over three years from 19 US feedyards.

Figure 4 Model estimated means with one standard error probability of at least one non-infectious heart disease death by cohort arrival weight (x-axis) and cohort arrival quarter (shape)

Figure 5 Model estimated means with one standard error of at least one non-infectious heart disease death by cohort arrival weight influenced by cohort arrival year (shape)
Figure 6 Model estimated mean estimates with one standard error of a non-infectious heart disease death event (days on feed) effected by average cohort arrival weight influenced by arrival year (shape)

Figure 7 Model estimated mean estimates with one standard error of a non-infectious heart disease death event (days on feed) effected by cohort arrival year influenced by arrival quarter (shape)
Table 1. Disease diagnosis categories incorporated into non-infectious heart disease (NIHD) case definition.

<table>
<thead>
<tr>
<th>Condition</th>
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<tbody>
<tr>
<td>Congestive Heart Failure</td>
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<td>HD HEART DISEASE</td>
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<tr>
<td>INFECTIOUS HEART FAILURE</td>
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<tr>
<td>CONGESTIVE HEART FAILURE</td>
</tr>
</tbody>
</table>
Figure 1: Data filtering from inclusion criteria applied to 22 US feedyard data download to working data set

108,046 cohorts comprised of 13,537,466 head of cattle

- Only cohorts > 39 head received

87,984 cohorts

- Arrival time set January 1, 2016 through January 1, 2019

48,591 cohorts

- Cohort feeding length (days on feed) limited to 100 through 360 d

43,591 cohorts

- Only steers and heifer cohort; no mixed genders or Holsteins labeled in gender category.

40,572 cohorts

- Current pen size (number of cattle received – number of cattle shipped - number of cattle died - number of cattle railed): limited to 1 through 7 head

36,538 cohorts

- Arrival weight limited to 181-500kg

35,936 cohorts

- Removal of unknown organization/yard identification cohorts

28,950 cohorts comprised of 4,596,205 head of cattle
The diagram shows the death percent of total cattle received in different disease categories.

- AIP: 0.16
- BRD: 0.7
- GI + Bloat: 0.31
- NIHD: 0.07
- Other: 0.41

The x-axis represents the disease category, and the y-axis represents the death percent, ranging from 0.00 to 1.00.