

Benchmarking animal handling outcomes on cow-calf operations and identifying associated factors

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ABSTRACT

The assessment of animal handling is commonly included in cattle care programs. The guidelines set in the National Cattlemen's Beef Association Beef Checkoff funded Beef Quality Assurance (BQA) program are often used for assessing handling on feedlot, stocker, and cow-calf operations. There is limited information about animal handling on cow-calf operations. Thus, the objectives of this study were to: (1) quantify handling outcomes on cow-calf operations and compare them to national BQA program thresholds, and (2) investigate factors associated with handling outcomes. Researchers visited 76 operations across the United States to observe the following outcomes, adapted from the BQA program, during the processing of cows or yearling heifers: Prod Use, Miscatch, Vocalization, Jump, Slip/Stumble, Fall and Run. One hundred cows or less (depending on herd size) were observed moving through a restraint system at each operation. Other information specific to the animal type, facilities, and management were also gathered to be explored as potential predictors of handling outcomes. Data were summarized using descriptive statistics on an operation basis and analyzed with multi-predictor ANOVA or Kruskal–Wallis tests to assess the relationship between outcomes and possible explanatory factors. Predictors included in the final analyses were: BQA certification (BQA), animal temperament (TEMP), region (REGION), chute style (CHUTE), and visual contact with humans (VISUAL). The 76 operations were sampled in 24 states (Central, $n = 17$; East, 30; West, 29), with herd sizes ranging from 10 animals to more than 5,000 animals. A total of 4,804 animals were observed. There were a substantial number of operations exceeding BQA thresholds for Prod Use (34.0%, 26), Miscatch (46.0%, 35), and Fall (31.6%, 24); the averages of these outcomes also exceeded the BQA thresholds (< 10%, 0%, and 2%, respectively). There was an association between Prod Use and several explanatory factors, including SIZE ($P = 0.072$), TEMP ($P = 0.001$), VISUAL ($P = 0.027$), and BQA ($P = 0.104$). Miscatch, Vocalization, and Fall all had single associated factors (REGION, $P = 0.019$; REGION, $P = 0.002$; VISUAL, $P = 0.002$, respectively). The VISUAL and TEMP factors had an association with the majority of outcomes. The findings suggest an opportunity for improving handling outcomes, which could be achieved through education and training support regarding the importance of animal handling on-farm. Future work should consider additional aspects of facilities and management that could impact cattle handling outcomes.

Key words: animal handling, beef cattle, beef quality assurance, operation, temperament

INTRODUCTION

Consumers are becoming increasingly invested in animal welfare (Stull et al., 2005; Crony and Anthony, 2010; Kehlbacher, et al, 2012). Several studies have indicated that certain segments of the public in developed nations are willing to pay for what they perceive are products associated with improved animal welfare (Mench, 2008; Olynk et al., 2021; Kehlbacher, et al., 2012; Fernandes et al., 2021). These products are often identified using verified labels on product packaging indicating producer compliance with third-party animal care verification programs (Eicher, 2006; Fraser, 2006). Concerned consumers can also affect legislation regarding livestock husbandry practices by successfully petitioning lawmakers to mandate conditions such as space requirements for living conditions for livestock and poultry (Mench, 2008; Crony and Anthony, 2010; Coleman, 2018; McKendree, et al., 2018; Chang, 2020). However, this increased consumer concern with animal welfare is concurrent with the consumer having less direct connection than ever before to animal

agriculture but increased exposure through media (Grandin, 2014), often through undercover recordings of animal abuse (Crony and Anthony, 2010).

Although cattle care programs have existed in the United States for some time, this increased societal pressure regarding animal welfare has led to the creation of various new assurance and verification programs and the incorporation of animal handling parameters into existing programs across the cattle supply chain (Stull, et al., 2005; Eicher, 2006; Fraser, 2006; Edwards-Callaway, 2018). The National Cattlemen's Beef Association (NCBA) Beef Quality Assurance (BQA) Program represents an industry program that provides educational materials for cattle producers along with assessment tools specific for different industry sectors: feedlot (NCBA, 2021a), cow-calf (NCBA, 2019a), transport (NCBA, 2021b), and stocker (NCBA, 2019c). Current NCBA data indicates that there are close to 130,000 potential BQA certifications within the cow-calf sector; there are over 50,000 online cow-calf specific certifications and approximately 74,000

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in-person certifications which include cow-calf producers in addition to other industry sectors (e.g., stocker and feedlot; J. Fitzsimons, personal communication). In addition to the BQA program (NCBA, 2019a, b, c; 2021a, b) there are third-party verified programs that cover the entire cattle supply chain such as the Global Animal Partnership (GAP, 2020), Certified Humane (HFAC, 2021), and American Humane Certified (AHC, 2017).

Evaluation of animal handling is often a component of these audits and verification programs. Animal handling outcomes such as prod use, vocalization, and slipping are measured because they can be indicative of stockmanship and facility condition which can both have an impact on animal welfare (Grandin, 2010; Edward-Callaway, 2018). These programs often set upper limit thresholds for animal handling outcomes that must not be exceeded when evaluating program compliance. Measurement of animal handling outcomes for audits has been successfully applied across feedlots (Woiwode et al., 2016; NCBA, 2021a) and packing plants (Grandin, 1998; NAMI, 2021). However, the cow-calf segment has not as readily adopted these measurements, in part due to the fact that requirements for third-party audits as seen in the other sectors are not as extensive. In addition, opportunities to assess animal handling during cow-calf operation audits is often limited due to the reduced frequency of processing and subsequent scheduling challenges, as compared with other cattle supply chain sectors. The expansive nature of the cow-calf segment, as measured by the number of operations (NASS, 2019) paired with accessibility, creates difficulties in outreach to cattle owners about animal handling program guidelines. Subsequently, there are difficulties in adequately evaluating and reevaluating those standards of animal handling (Simon et al., 2016a). These challenges have resulted in limited information about the rates of animal handling outcomes in cow-calf operations and how different factors such as facility design, BQA certification, frequency of processing/handling, and stock person training may impact the outcomes.

Surveys have been utilized to gather cow-calf producer perspectives and self-reported practices related to animal handling and welfare (Martin, et al., 2019a, b; McKendree et al., 2018) but there is limited research assessing animal handling on cow-calf operations through observation (Simon et al., 2016a, b). Simon et al. (2016a) were able to collect the prevalence of outcomes measured in the BQA program (e.g., electric Prod Use, Miscatch, and Vocalizations) along with management factors such as training and herd health management on cow-calf operations in California. While able to capture a range of different factors such as herd size, age of operation, and stockperson training, the study population was limited to operations from one state and therefore there is an opportunity to expand upon this area of research.

Often cattle care programs involve evaluating animal handling by quantifying and setting thresholds for acceptable frequencies of animal-based outcomes. Establishing thresholds is a critical part of an assessment scheme to ensure compliance and generate public trust in the standards (Huxley et al., 2004). Despite this, little research has been conducted about the value and practicality of the thresholds and the various factors that could affect them in cow-calf operations. Thus, the objectives of this study were to: (1) quantify handling outcomes on cow-calf operations and compare them to national BQA program thresholds, and (2) investigate factors associated with handling outcomes, such

as geographic region, BQA certification status, or overall herd size.

MATERIALS AND METHODS

Because all measurements were observational, an exemption petition was filed and granted with the Colorado State University Animal Care and Use Committee (#1128).

Cow-Calf Operation Selection

The recruitment process to identify cow-calf operations to participate in this study involved connecting with NCBA staff, State BQA coordinators, county extension agents, university professors, veterinarians, trade-publications, and trade organizations along with networking in the local community and at cattle industry meetings and conventions to find potential participants. The effort dedicated to finding potential participating operations was extensive and a considerable number of contacts were made by a group of collaborating individuals. From these sources, a list of potential producers was compiled and contacted to inquire about interest and availability to participate in the study. Researchers made efforts to obtain contact information from operations of all different sizes and locations across the United States. Selection criteria for the cow-calf operations were limited to having a minimum of 10 total cows and/or yearling heifers and required that the operation use a cattle restraint chute during the observational period. Calves, steers, and bulls were not observed for this study.

Observer Selection and Training

Due to various logistical challenges, including a large number of cow-calf operations and the vast geographical range of this study, nine total observers assisted with data collection for this study with nine primary observers performing the majority of operation visits. All observers had previous experience with assessing cattle handling outcomes in a professional capacity as either an extension agent, veterinarian, or other industry/academic position. Each observer was provided with a training module to be completed before their first operation visit. The module consisted of two parts: written definitions of handling outcomes and temperament with labeled video examples of handling outcomes provided by BQA staff, and a simulated mock cow-calf operation visit with 47 videos of cows being processed through the chute and a data sheet to record observations of handling outcomes.

Cattle Handling Observations

Researchers visited operations between September 2020 and November 2021. Each visit occurred over a 1-day period with a single trained observer recording cattle handling outcomes during processing. The exact location of the observer varied by operation, but the observer stood in a position to be able to watch the animals moving through the single file alley and into and out of the chute. When breeding boxes were used, the observer would move from multiple locations to observe the focal cow as she moved from the single file alley into the chute and then out of the chute and breeding box.

At operations processing more than 9 but less than 100 cows or yearling heifers, observations were made on all animals. At operations processing greater than 100 cows or yearling heifers, observations were made on 100 consecutive animals as they were handled. A sample of 100 animals was

chosen as the upper limit for observations to remain consistent with the BQA Cow-Calf Assessment (NCBA, 2019a) guidance for handling observations. Criteria for assessing the observed handling outcomes were adapted from the existing BQA Cow-Calf Assessment (NCBA, 2019a) with the addition of measurement for trot and measurement for down (Table 1) which were added to assist with outcome differentiation. Definitions were created for outcomes that did not include a detailed description of the behavior or action in the BQA assessment (e.g., Run and Jump). The additional description was added to some definitions to assist with the data collection process. For example, the BQA assessment indicates that prod use only counts when the prod is energized. In this study, prod use was counted when a prod touched an animal, which is generally how this is audited during third-party verifications, as it is very challenging to actually assess whether or not a prod is energized during animal handling. The presence (or absence) of each handling outcome was recorded for each individual animal. The majority of observations were made on animals in the single file chute right before the entrance of the chute through an exit from the chute, for a distance of three strides beyond the chute exit.

Each operation was assigned to a region (REGION) based on the state it was located: West (AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, WA, WY, UT), Central (IA, IL, KS, MN, MO, ND, NE, OK, SD, TX, WI), and East (AL, AR,

CT, DE, FL, KY, GA, IN, LA, MA, MD, ME, MI, MS, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WV; NAHMS, 2020). Each operation was additionally assigned to a category based on total herd size (SIZE) using operation size categories from the 2017 Ag Census data (NASS, 2019). The breed classification (BREED) of each herd was recorded as either purebred or mixed breed, as reported by the owner. A herd was classified as a mixed breed if the herd consisted of multiple purebred animals from various breeds and/or animals with crossbred lineage. Temperament scores (TEMP), based upon the Beef Improvement Federation guidelines (BIF, 2018), were assigned on a herd level and determined based on a collective assessment of the herd temperament. An additional category, not included in the BIF scale, called “mixed” was created to address herds that had approximately equal temperaments represented within the group. The type of procedure (PROC) being performed on cattle during processing was recorded and subsequently categorized as either reproductive or non-reproductive. A group of procedures were categorized as reproductive if a procedure such as pregnancy-checking was performed even if other procedures such as ear-tagging were also performed. The number of unique procedures (#PROC) performed on an animal during restraint was additionally recorded. Facility information that was recorded included chute style (CHUTE) i.e., hydraulic, manual (headgate closed from external force from stockperson), or self-catch (headgate closed from force of animal triggering headgate). The facility construction material of the pens and alleyways (FAC) were grouped as metal, mixed, or wood while the ground material at the exit of the chute (EXIT) was either cement, rubber, earth, or mixed. Management factors that were recorded included self-reported BQA certification status (BQA; yes/no), whether handling tools were BQA approved as described in the BQA Manual (NCBA, 2019b; TOOL) along with a total number of handling implements used collectively by all of the handlers during the observation period (#TOOL), and the total amount of stockpeople (#STOCK) engaged in handling cows during the observational period. BQA certification status was self-reported by participants and was not verified. Operations were included as “Yes” if the operation had at least one BQA-trained individual. Due to the small number of individuals who were not currently certified within the last three years ($n = 6, 0.09\%$), these individuals were grouped with currently certified individuals for analysis purposes. Additionally, BQA certification status was based upon individuals’ previous BQA training and not upon facility certification status. Other management factors recorded were the presence of distractions that could impact animal handling and movement (DISTRACT; yes/no). The type of distractions present was as a comment on the data collection sheet and included things such as the presence of dogs, children, and yelling. Type of distraction was based on low-stress handling guidelines presented in the BQA manual (NCBA, 2019b). The average frequency that producers and/or workers interacted with animals annually was recorded; this information was gathered from an individual present on the day of data collection. These interactions included physical interactions during chute handling (HANDLING) and visual contact throughout the year (VISUAL); visual contact included seeing humans (i.e., fixing a fence in a pasture that cattle are in, performing daily checks) but not actively moving them or working with them. Both factors were

Table 1. Definitions of cow handling outcomes.

Outcomes	Definitions
Prod Use	The touching of an animal with an electric prod whether energized or not. Prod use is counted only once per animal even if the prod contacts the animal twice.
Miscatch	Performing any processing activity on an animal in any position where the animal is not firmly and safely secured in the chute. An animal caught in the tail gate and an animal caught in the headgate simultaneously counts as a miscatch.
Vocalization	Any audible vocalization (moo, bellow) after chute restraint has been initiated but before processing activity occurs.
Down	Any position other than fully upright for majority of time in chute. A deliberate movement of the cow in her body position, not an involuntary fall.
Jump	Upon release from the chute, the animal deliberately bends front knees with front lower joints (pasterns) tucked under the animal and/or tucked back legs. Straight leg vertical jumps should also be considered as an additional form.
Slip/Stumble	Lost contact between a foot and the ground in a non-walking manner and/or a portion of the animal’s leg (front or rear) other than foot (knee/hock) contacts the ground. The animal’s topline will drop with sudden motion.
Fall	A sudden loss in upright position and any body part other than the feet touch the ground.
Trot	A gait of moderate speed that is in between a walk and a run.
Run	Sustained, fast paced movement with elevated tailhead when exiting the chute lasting at least 3 strides.

categorized as: daily, weekly, 1–2× per month, and 2–6× per year. Additionally, observers recorded any extra pertinent information or observations not captured elsewhere on the data-sheet.

Statistical Analysis

Data were analyzed using R Statistical Software (v4.1.2; R Core Team, 2021). For analysis, the observations were grouped at the operation level, and data were first analyzed using several summary statistics. The percent frequency of observed handling outcomes, the total number of operations exceeding BQA outcome thresholds (NCBA, 2019a), and frequencies for each predictor level were calculated and summarized (mean, median, min, max, and SD). Correlations were calculated between all handling outcomes using Spearman's rank correlation coefficients due to the non-linearity of data based on diagnostic scatterplots. The outcomes of Down and Trot were not included in the analysis as they are not included in BQA guidelines (NCBA, 2019a).

One-way analysis of variance (ANOVA) models were used to analyze the relationship between outcomes (Prod Use, Miscatch, Vocalization, Jump, Slip/Stumble, Run, and Fall) and predictor variables (BQA, BREED, CHUTE, DISTRACT, DTYPE, EXIT, FAC, SIZE, #TOOL, #STOCK, PROC, REGION, TEMP, HANDLING, and VISUAL; ANOVA v3.0.12; Fox and Weisberg, 2019). All outcomes were square root transformed to satisfy modeling assumptions. Predictors were selected for each outcome in the ANOVA analysis based on previous subject matter knowledge. Relationships between predictors were analyzed using contingency tables and by performing Pearson's Chi-square test of independence. Many of the predictor variables were found to be related to one another. Predictors were excluded from further analysis if they were found to not have a relationship (P -value > 0.05) with handling outcomes. The predictors excluded were the #PROC, PROC, FAC, EXIT, #TOOL, #STOCK, DISTRACT, DTYPE, and HANDLING.

Model selection was used to explore multi-predictor ANOVA models. Only ranches with complete sets of measured predictors were used for the modeling analyses ($n = 65$). Model selection for multiple regression was based upon Aikake Information Criterion (AIC; MuMin v1.43.17; Dohoo et al., 2009; Windmeyer et al., 2014). Models with the lowest AIC were selected as the final model and used for further analysis. Final models were analyzed using Type III F-tests. Regression models were fit with pairwise interactions between several predictors. However, due to limited operations falling within certain category subset combinations or strong associations between predictors, the majority of predictor pairs were unable to be analyzed. Pairwise comparisons were calculated for all parametric models using estimated marginal means (emmeans v1.7.1.1; Lenthe, 2021).

Models with response variables that did not meet ANOVA assumptions (Miscatch, Vocalization, and Fall) were analyzed using the Kruskal–Wallis test (v4.1.2; R Core Team, 2021). Pairwise comparisons for non-parametric models were calculated using the Wilcoxon rank sum test with Benjamini-Hochberg adjustment (v4.1.2; R Core Team, 2021).

RESULTS

Operation Characteristics

A total of 81 operations were recruited from across the United States, representing 24 states (AR, CA, CO, FL, GA, HI, IN, KS, KY, MN, MO, MT, NC, ND, NE, NJ, NM, NV, OK, OR, PA, SD, WV, and WY). Some of the larger cattle producing states were not included in this study due to sampling challenges. (NASS, 2019). Attempts were made to sample from all states with the exception of Alaska. Five operations were removed from the final analysis because the total number of cows and/or yearling heifers being processed during the observational period was fewer than 10 cows. A total of 76 operations were used for descriptive statistics and correlations, representing a total of 4,804 animals. One observer visited 46% ($n = 35$) of the operations while two other observers each visited 18% of the operations ($n = 14$). Three observers visited 1 operation each (1%) and three observers visited three or four operations each (4% and 5%, respectively). Sixty-five operations had complete sets of measured variables and were used for modeling analyses.

Operation characteristics are found in Table 2. Researchers attempted to sample equally from regions of the United States (NAHMS, 2020) but due to challenges with recruitment were unable to sample equally from each region (n , %; West = 29, 38.2%; Central = 17, 22.4%; East = 30, 39.5%). Herd size of participating operations ranged from 10 animals to greater than 5,000 animals. The initial sampling plan was to represent the distribution of operations by herd size reported in the 2017 Census of Agriculture (NASS, 2019), the largest percentage being herds between 10 and 49 animals. In the current study, most herds were sampled from the 50 to 99 animal category ($n = 21$, 27.6%). There were 28 purebred herds (36.8%) sampled including Black Angus, Red Angus, Hereford, and British White. The majority of herds were recorded as docile ($n = 43$, 56%) with very few aggressive and very aggressive herds ($n = 2$, 2.6% and $n = 1$, 1.3%, respectively). The majority of operations had at least one BQA trained individual ($n = 53$, 69.7%). Most participants indicated having daily visual contact with their herds ($n = 36$, 47.4%).

Handling Outcome Frequencies

Table 3 includes a summary of overall animal handling outcome frequencies. Mean Prod Use was $18.1 \pm 28.9\%$ (mean \pm SD). This observed mean exceeded the acceptable BQA threshold (<10%) for prod usage. Twenty-six operations (34%) had 10% or greater Prod Use. Mean Miscatch was $2.6 \pm 5.14\%$, also in excess of the BQA threshold of 0%. Thirty-five operations (46%) were outside of the Miscatch threshold. Mean percentages of Vocalization, Jump, Slip/Stumble, and Run were all within acceptable BQA thresholds. The mean of Fall ($2.5 \pm 4.2\%$) slightly exceeds the acceptable BQA threshold of less than 2.0%. Twenty-eight operations (37%) had excessive mean frequencies of Falls (>2.0%).

Correlations

Spearman rank correlations are presented in Table 4. The majority of outcomes had a negligible correlation with each other ($r = 0$ –0.30; Hinkle et al., 2003). Jump and Run were moderately correlated ($r = 0.50$; $P < 0.05$).

Table 2. Summary of predictors and associated levels for the entire sample population ($n = 76$).

Predictor	Description	Predictor levels	Operations (n)
REGION ¹	Location of operation within the United States	Central East West	17 30 29
SIZE (number of animals)	Size of the operation based on the 2017 Ag Census classifications (NASS, 2019)	10–49 50–99 100–199 200–499 500+ No response	12 21 9 17 15 2
BREED	Breed classification of the herd as provided by one of the individuals present	Purebred Mixed breed	28 48
TEMP ²	Temperament of the herd based on the behavior of the majority of the animals following the Beef Improvement Federation guidelines (BIF, 2018)	Docile Restless Nervous Flighty Aggressive Very aggressive Mixed No response	43 15 7 3 2 1 2 3
PROC	The type of procedure being performed on the animal during assessment.	Reproductive Non-reproductive	57 19
#PROC	The number of procedures performed on an individual animal basis during the assessment	Continuous	1.6 ± 0.8
CHUTE	The type of restraint chute used during processing	Hydraulic Manual Self-catch No response	26 33 14 3
FAC	The type of materials that the pens and alleyways were constructed with	Metal Wood Mixed No response	31 2 37 6
EXIT	The ground material at the exit of the chute	Cement Rubber Earth Mixed No response	15 10 42 7 2
BQA	BQA certification status of at least one individual present involved in animal handling	Yes No No response	53 18 5
TOOL	The use of BQA-approved handling tools as described in the national manual (NCBA, 2019b)	BQA-approved tool Not BQA-approved tool No response	61 8 7
#TOOL	The number of handling tools being used by all stockpeople during data collection	Continuous	1.7 ± 1.0
#STOCK	The number of stockpeople handling the animals during data collection	Continuous	4.8 ± 1.9
DISTRACT	The presence of distractions that could impact animal handling and movement	Yes No No response	31 43 2
HANDLING	The number of times the animals were physically handled on an annual basis	Continuous	55.0 ± 273.8
VISUAL	The number of times animals had visual contact with humans on an annual basis	Daily Weekly 1–2× per month 2–6× per year No response	36 22 7 7 4

¹West (AZ, CA, CO, ID, MT, NM, NV, OR, WA, WY, UT) Central (IA, IL, KN, MN, MO, ND, NE, OK, SD, TX, WI) East (AL, AR, CT, DE, FL, KY, GA, IN, LA, MA, MD, ME, MI, MS, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WV) (NAHMS 2020).

² Based on Beef Improvement Federation (2018) system. One additional category, Mixed, was added to describe herds that equally displayed behaviors of two sequential temperaments.

Table 3. Descriptive statistics for animal handling outcomes for the cow-calf operations included in this observational study ($n = 76$ operations). The thresholds for outcomes included in the BQA Cow-Calf Assessment are included for reference. Additionally, the percentage of operations within the sample population performing above the thresholds is reported.

Measurement	Animal Handling Outcomes Frequency (%)						
	Prod Use	Miscatch	Vocalization	Jump ²	Slip/ Stumble	Fall	Run ²
Min	0	0	0	0	0	0	0
Max	100	30.8	36.0	38.0	42.9	19.0	71.7
Mean	18.1	2.6	3.8	7.5	6.3	2.5	7.7
Median	2.8	0	0	3.0	3.0	0	2.06
SD	28.9	5.1	7.6	10.0	9.1	4.2	13.8
BQA threshold ¹	10.0	0	5.0	25.0	10.0	2.0	25.0
Operations above BQA thresholds % (n)	34.0(26)	46.0(35)	21.0(16)	19.7 (15)	23.7(18)	31.6(24)	19.7(15)

¹Beef Quality Assurance Cow-Calf assessment thresholds. Acceptable frequencies are below the listed numerical threshold (NCBA, 2019a).

²The handling outcomes of Jump and Run must have a combined total less than 25.0% to be within acceptable levels (NCBA, 2019a).

Outcomes and Predictors

Prod Use The mean frequency of Prod Use was associated with the predictors VISUAL ($P = 0.027$), TEMP ($P = 0.001$), SIZE ($P = 0.072$) and BQA ($P = 0.104$; Table 5). Herds experiencing VISUAL 2–6 times per year ($48.2 \pm 13.8\%$) had greater Prod Use as compared to herds with weekly contact ($17.4 \pm 6.3\%$, $P = 0.025$) and daily contact ($6.9 \pm 2.9\%$, $P = 0.030$; Figure 1a). For the one very aggressive herd, there was a numerically greater prod use (92%) than for nervous ($3.4 \pm 1.7\%$) and flighty ($8.0 \pm 8.0\%$) herds. There was no difference between BQA certification levels in mean Prod Use ($P = 0.104$; Figure 1d). Mean Prod Use was additionally influenced by the interaction of VISUAL and BQA ($P = 0.009$; Figure 1e). A difference between certification statuses was identified in herds that had weekly VISUAL ($P = 0.002$; Yes: $6.5 \pm 4.3\%$; No: $40.8 \pm 14.3\%$) and herds that had VISUAL 2 to 6 times per year ($P = 0.057$; Yes: $87.3 \pm 10.3\%$; No: $32.6 \pm 13.2\%$).

Miscatch The only predictor that had an association with the rate of Miscatch was the REGION where the operation was located ($P = 0.019$; Table 5). Mean frequency of Miscatch was greater in the Central region ($4.0 \pm 1.9\%$) as compared to both the East region ($1.2 \pm 0.4\%$) and West regions ($3.0 \pm 0.9\%$; $P = 0.023$ and $P = 0.044$, respectively; Figures 2).

Vocalization Vocalization was found to have only one significant predictor, which was TEMP ($P = 0.002$; Table 5). Flighty herds vocalized more than docile herds ($22.5 \pm 13.5\%$ and $1.4 \pm 0.6\%$, respectively; $P = 0.014$). Figures 3

Jump The mean frequency of Jump was influenced by the factors of SIZE ($P = 0.002$), REGION ($P = 0.006$), and VISUAL ($P = 0.018$; Table 5). There was a difference in jumping between herds in the 500+ animal category ($13.7 \pm 3.2\%$) and herds in the 10 to 49 animal category ($3.3 \pm 1.5\%$, $P = 0.009$) and the 50 to 99 animal category ($2.9 \pm 1.0\%$, $P = 0.017$). Operations in the Central REGION had lower jumping than operations in the Central REGION ($2.9 \pm 1.3\%$) and operations in the East ($7.3 \pm 2.1\%$, $P = 0.004$) and West REGIONS ($10.8 \pm 2.1\%$, $P = 0.014$; Figure 4b). In addition, there was evidence for a difference in mean rates of Jump between herds that had daily VISUAL contact ($3.9 \pm 1.0\%$) and herds that had VISUAL contact 2 to 6 times per year ($18.1 \pm 5.5\%$, $P = 0.017$; Figure 4c).

Slip/Stumble Predictors that impacted the rate of Slip/Stumble were CHUTE ($P = 0.001$) and VISUAL ($P = 0.123$; Table 5). Self-catch chutes ($2.0 \pm 1.4\%$) had lesser mean rates of Slip/Stumble from hydraulic chutes ($8.1 \pm 1.6\%$, $P = 0.001$) and manual chutes ($4.9 \pm 1.1\%$, $P = 0.026$; Figure 5a). However, there was not enough evidence to conclude a difference ($P > 0.05$) in mean rates of Slip/Stumble between herds experiencing different frequencies of VISUAL with handlers (Figure 5b).

Fall The mean rate of Fall was impacted by only one of the recorded predictors, VISUAL ($P = 0.002$; Table 5). Pairwise comparisons identified differences between herds that had VISUAL contact 2 to 6 times per year ($7.7 \pm 2.4\%$) and herds that had daily contact ($1.3 \pm 0.4\%$, $P = 0.005$). In addition, there was a difference in mean rates of Fall ($P = 0.009$)

Table 4. Spearman correlations exhibiting the relationships between handling outcomes for the sample population ($n = 76$).

Outcome r P^1	Prod use	Miscatch	Vocalization	Down	Jump	Slip/ Stumble	Fall	Trot	Run
Prod Use	1.0	0.21 **	0.19 **	0.14	0.38 *	0.19 **	0.36 *	0.54 *	0.34 *
Miscatch		1.0	0.11	0.10	0.21 **	0.28 *	0.12	0.26 *	0.21 **
Vocalization			1.0	0.06	0.24 *	0.05	0.01	0.19	0.21 **
Down				1.0	0.05	-0.07	0.00	0.20	0.04
Jump					1.0	0.42 *	0.18	0.45 *	0.50 *
Slip/Stumble						1.0	0.45 *	0.25 *	0.22 **
Fall							1.0	0.36 *	0.27 *
Trot								1.0	0.44 *
Run									1.0

¹indicates p-value < 0.05, ** indicates p-value 0.05-0.10

Table 5. Summary of animal handling outcomes and associated predictors selected based on Aikake Information Criterion (AIC). Operations with complete sets of measured predictors were used in the modeling analyses ($n = 65$).

Predictors and category levels (n)	Outcomes							
	Prod Use	Miscatch	Vocalization	Jump	Slip/Stumble	Fall	Run	
BQA Yes (49) No (16)	X							
Chute Hydraulic (22) Manual (30) Self-catch (13)					X			
Size 10-49 (11) 50-99 (17) 100-199 (8) 200-499 (14) 500+ (15)	X			X				
Region Central (16) East (25) West (24)		X		X				
Temp Docile (39) Restless (14) Nervous (5) Flighty (2) Aggressive (2) Very Aggressive (1) Mixed (2)	X		X				X	
Visual Daily (31) Weekly (21) 1 to 2x per month (6) 2 to 6x per year (7)	X			X	X	X	X	

between herds that had VISUAL contact 2 to 6 times per year ($7.7 \pm 2.4\%$) with herds that had weekly contact ($2.0 \pm 1.0\%$; [Figure 6](#)).

Run The mean frequencies of Run were impacted by VISUAL ($P = 0.004$; [Figure 7a](#)) and the overall TEMP of the herd ($P = 0.053$; [Figure 7b](#)). Pairwise comparisons showed differences

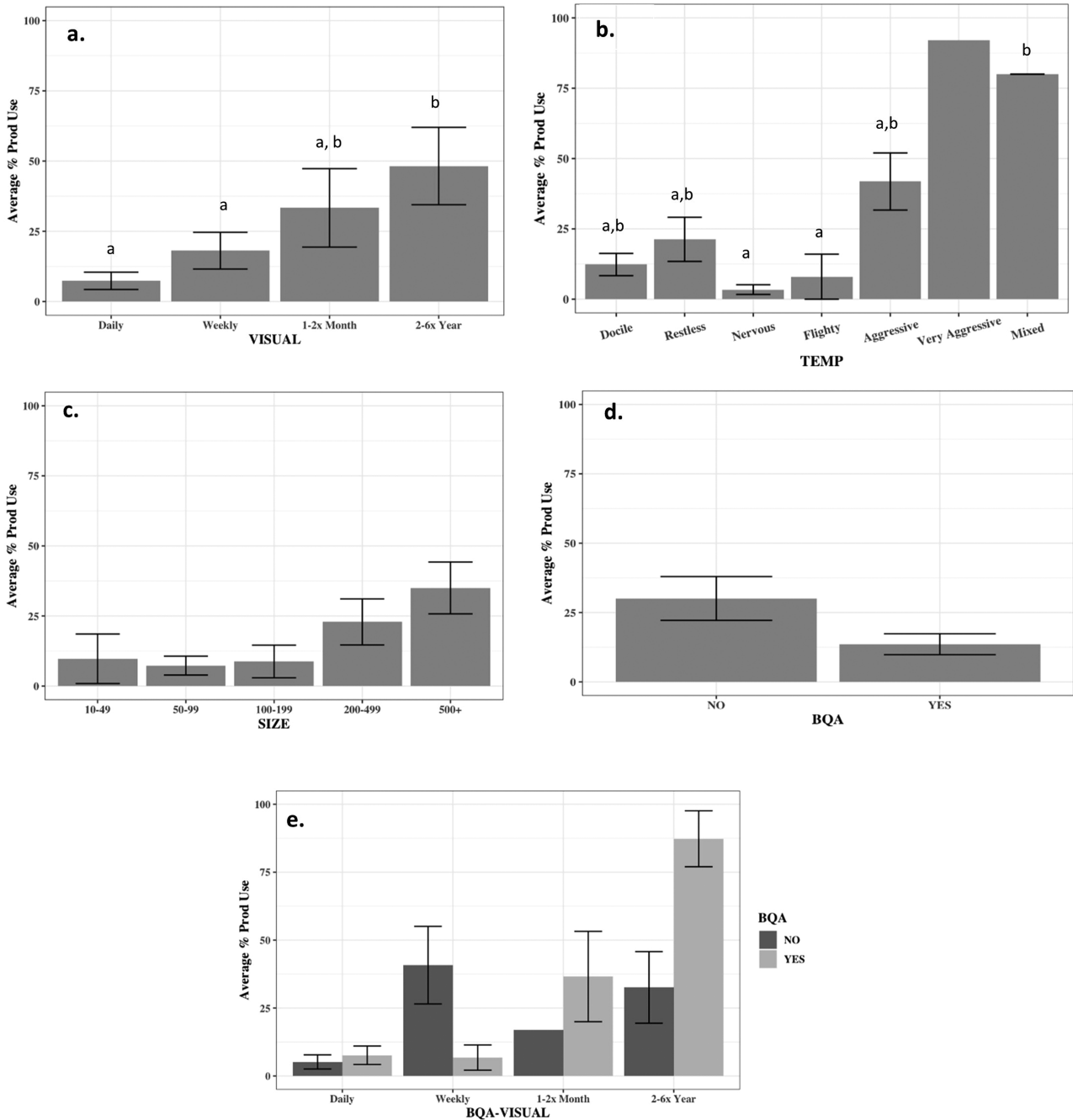


Figure 1. a–e. Frequencies (mean \pm SEM) of Prod Use by VISUAL ($P = 0.027$), TEMP ($P = 0.001$), SIZE ($P = 0.072$), BQA ($P = 0.104$), and BQA-VISUAL ($P = 0.009$; $n = 65$). Predictors were selected based upon AIC ($n = 65$). Means with different letters differ, $P < 0.05$. A standard error was not calculated for the Very Aggressive category as there was only one operation in that group.

between herds who had VISUAL contact 2 to 6 times per year ($21.6 \pm 5.5\%$) both with herds that had daily contact ($2.2 \pm 0.6\%$, $P = 0.002$) and weekly contact ($5.6 \pm 1.7\%$, $P = 0.029$).

DISCUSSION

Although there is limited research on animal handling in cow-calf operations, there is an abundance of information on husbandry approaches related to low-stress animal handling practices (Gill, et al., 2013; Grandin, 2017, 2019; NCBA, 2019b). The purpose of this study was to summarize animal

handling outcomes on cow-calf operations across the United States and to benchmark animal handling on a national scale and determine any factors that may be associated with on-farm handling outcomes. Currently, the BQA Cow-Calf Assessment program guidelines (NCBA, 2019a) are used as the standard for animal handling on cow-calf-operations. The rates of Prod Use, Miscatch, and Fall documented in this study exceeded BQA standards. Rates of Vocalization, Jump, Slip/Stumble, Run were within the thresholds established in the BQA Cow-Calf Assessment (NCBA, 2019a).

The sample population of operations was distributed across 24 states with slightly less representation from the

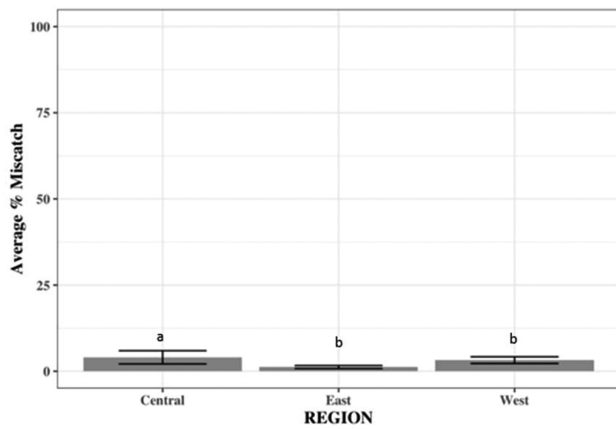


Figure 2. Frequency (mean ± SEM) of Miscatch by REGION ($P = 0.019$; $n = 65$). Predictors were selected based upon AIC. Means with different letters differ, $P < 0.05$.

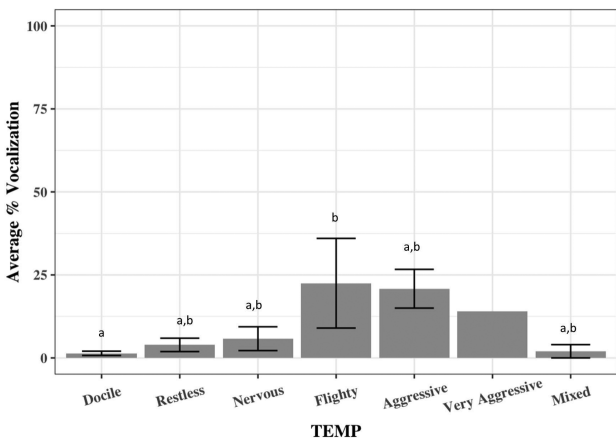


Figure 3. Frequency (mean ± SEM) of Vocalization by TEMP ($P = 0.002$; $n = 65$). Predictors were selected based upon AIC. Means with different letters differ, $P < 0.05$. A standard error was not calculated for the Very Aggressive category as there was only one operation in that group.

Central region of the United States. Attempts were made to include operations from large cattle producing states but due to recruitment challenges some of these prominent states were not included in the project, for example, Texas. It will be important for future work to examine ways to improve recruitment methods. Additionally, the original sampling scheme was created to include operations representative of the herd size distribution reported in the 2017 Ag Census data (NASS, 2019), i.e., a larger proportion of smaller operations (less than 49 cows) as compared with larger operations (200+ cows) based on total cattle in the herd. Again, due to available contacts, the interest level in operations, and scheduling logistics, the study population overrepresents larger operations. Lastly, many of the contacts made had some connection to the BQA program and therefore this particular group of participants may have a larger base knowledge of BQA guidelines and standards as compared to the national cow-calf producer population. The data presented are still valuable to the cow-calf industry, but these limitations should be considered when interpreting the results of this project.

There are other studies that have reported handling outcomes in cattle operations (Simon et al., 2016a; Woiwode

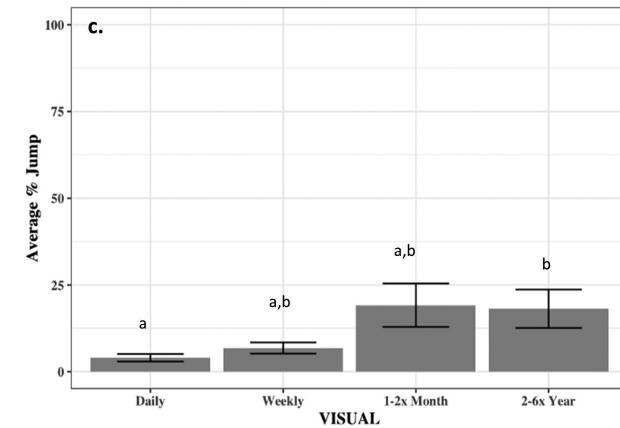
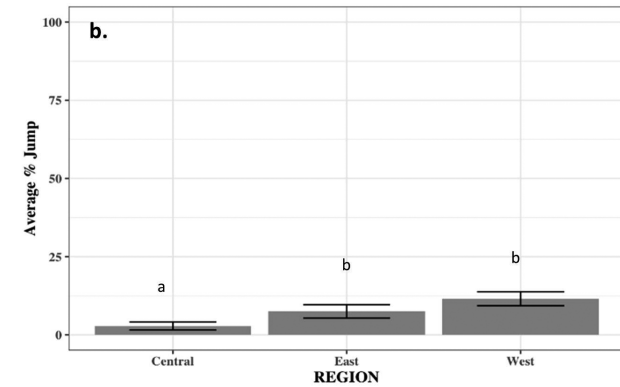
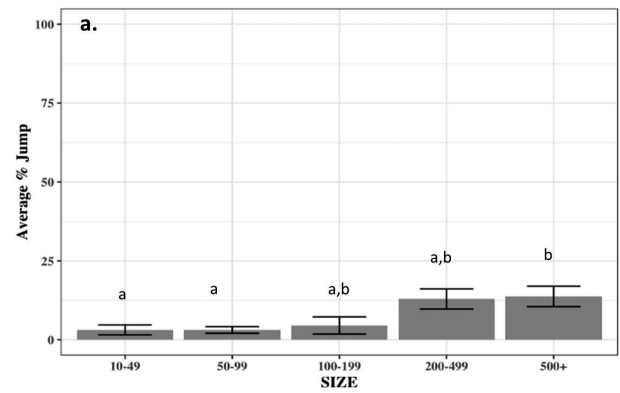


Figure 4. a–c. Frequencies (Mean ± SEM) of Jump by SIZE ($P = 0.002$), REGION ($P = 0.006$), and VISUAL ($P = 0.018$; $n = 65$). Differences are identified at $\alpha < 0.05$. Predictors were selected based upon AIC. Means with different letters differ, $P < 0.05$.

et al., 2016). It should be noted that although similar, some animal handling definitions differ across studies which could explain some of the differences found. Simon et al. (2016a) quantified animal handling in cow-calf operations located in California. Similar to Simon et al. (2016a), the current study found that mean incidences of Prod Use exceeded the acceptable BQA threshold (<10.0%). This is in contrast to Woiwode et al. (2016) observing only 3.6% prod usage at feedlots; Woiwode et al. (2016) only counted prod usage when the prod was energized which could explain the lower rate. However, in the current study it was only one-third of operations that were driving this finding ($n = 26$, 34%). Despite the majority of operations meeting BQA guidelines for Prod Use ($n = 50$, 66%), the substantial number of operations with prod use in

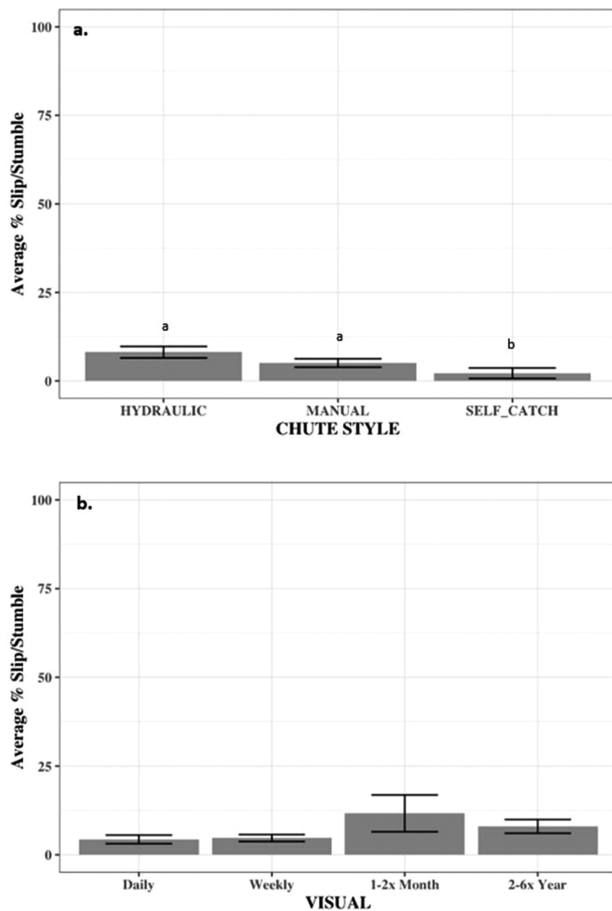


Figure 5. a-b. Frequencies (mean \pm SEM) of Slip/Stumble by CHUTE STYLE ($P = 0.001$) and VISUAL ($P = 0.123$; $n = 65$). Predictors were selected based upon AIC. Means with different letters differ, $P < 0.05$.

excess of BQA thresholds ($n = 26$, 34%) deserves attention; there were 13 operations that had Prod Use rates greater than 50%. In the current study, mean rates of Miscatch exceeded BQA standards (2.6% vs. 0%) with almost half of operations in the current study exceeding the standards ($n = 34$, 45%) which was a similar finding in Simon et al. (2016a). Woiwode et al. (2016) reported a 14.5% Miscatch rate but included instances when the animal was improperly caught on the first attempt, regardless, of readjustment which is different than the BQA definition. In contrast to Simon et al. (2016a), who reported a 0.9% fall frequency, in the current study mean incidences of Falling slightly exceeded BQA thresholds (2.5% vs. <2.0%) with 23 operations (30%) exceeding the Fall threshold. The relatively great proportion of operations exceeding the BQA thresholds for the aforementioned handling outcomes is significant and warrants attention. The results of this study can help inform future producer education and outreach initiatives to address some of these animal handling concerns.

Observed mean frequencies for Slip/Stumble (6.3%), Jump (7.5%), and Run (7.7%) were within BQA guidelines (<10.0% and <25.0%, respectively; Run and Jump are a combined category in BQA). This is in line with Slip/Stumble frequencies (4.7%) and Run frequencies (12.8%) reported by Simon et al. (2016a) but in stark contrast to Woiwode et al., (2016), who reported a Run frequency of 28.7% at

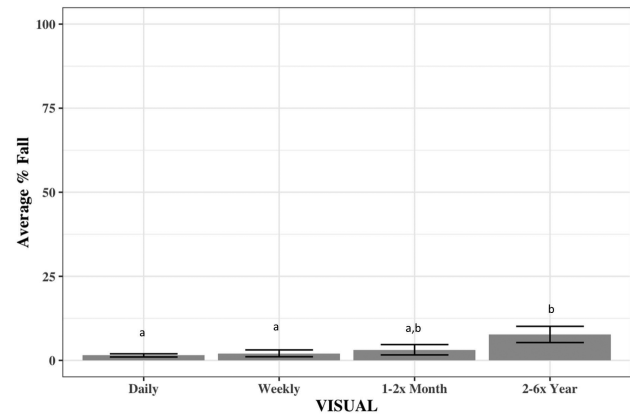


Figure 6. Frequency (mean \pm SEM) of Fall by VISUAL ($P = 0.002$; $n = 65$). Predictors were selected based upon AIC. Means with different letters differ, $P < 0.05$.

feedlots. This discrepancy could be due to cows on cow-calf operations being handled more frequently over the span of their lifetimes vs. typically younger animals at feedlots who are generally more naive to processing events. Simon et al. (2016a) reported Vocalization frequencies slightly in excess of BQA thresholds (5.2% vs. <5.0%). In the current study observed mean frequencies of Vocalization were within acceptable BQA levels (3.8%). During animal handling assessments, Vocalization is not scored during the actual procedure that is occurring (e.g., pregnancy diagnosis, vaccinations, branding, etc.) and individuals not familiar with animal handling auditing may not realize this distinction. Anecdotally, vocalizing may occur during procedures, but as shown by the results of this study, cows do not often vocalize in response to the handling or restraint specifically, which is what is scored during an assessment.

Visual contact (VISUAL) had an association with 5 out of 7 of the handling outcomes assessed in this study. This is consistent with studies that have reported that increased visual contact can result in calmer cattle (Grandin, 1993a; Hemsworth and Barnett, 2000). Interestingly, though, the amount of handling (measured as the amount animals that were physically handled through the chute in a calendar year) in this study did not have an association with any of the animal handling outcomes. This finding seems to contradict studies indicating that repeated chute handling can acclimate animals to that handling event (Andrade et al., 2001; Grandin and Shively, 2015; Parham et al., 2019). This could be due to the fact that the majority of participating operations ($n = 52$, 68%) reported handling their cattle through the chute less than 6 times per year, far fewer than amounts in previous research that tend to focus on more frequent handling events. On operations that reported daily visual contact with their herds, there were lower rates for most outcomes. This finding is consistent with previous studies that indicate domesticated animals possibly utilize human interactions in any form to generate schemas about their environment and caretakers (Boivin et al., 1998; Rybarczyk et al., 2001; Schmeid et al., 2010; Rault et al., 2020). There is a growing interest to understand the connection between animals and caretakers (Rault et al., 2020). The current study suggests that human interaction not involving physical contact can impact cattle behavior. On several cow-calf operations, handling through the chute typically occurs in seasonal spring and fall clusters

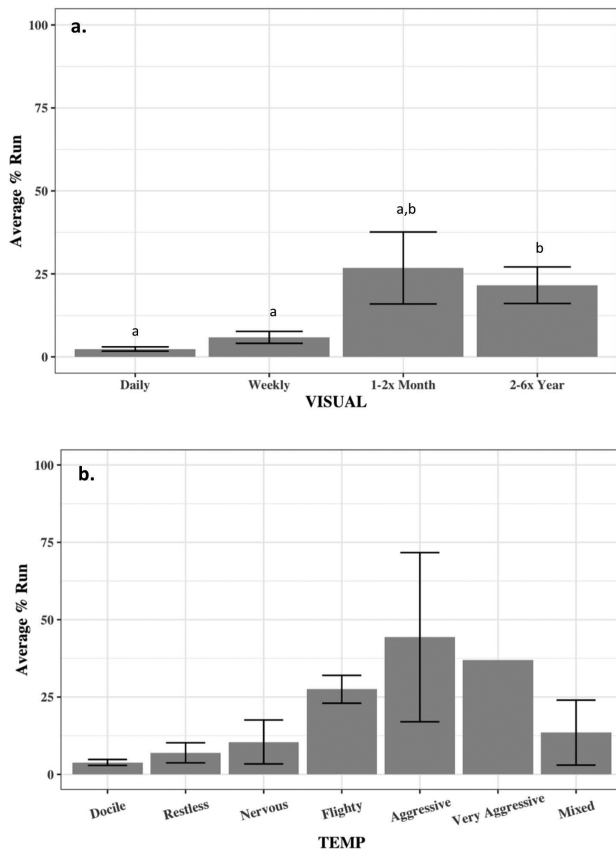


Figure 7. a–b. Frequencies (mean \pm SEM) of Run by VISUAL ($P = 0.004$) and TEMP ($P = 0.053$; $n = 65$). Predictors were selected based upon AIC. Means with differing lower-case letters indicate significant differences between categories $P \leq 0.05$. A standard error was not calculated for the Very Aggressive category as there was only one operation in that group.

based around breeding (Larson and White, 2016), but cattle may interact with humans more frequently throughout the year during herd health checks, movement between pastures, and being fed hay in the winter. Logistically, certain management systems do not allow for frequent visual contact with cow herds, so future research should focus on the minimum amount of visual contact needed to cause a change in animal behavior during handling. In addition, operations may work with cattle using different techniques, such as in a vehicle or ATV, on foot, or on horseback thus future studies could explore the impact that different types of visual contact have on animal handling outcomes. It should be additionally noted that Prod Use, Jump, Slip/Stumble, and Run all had multiple impacting factors (not just visual contact), and therefore it may be more feasible to focus future extension efforts on additional associated factors when and if increasing visual contact with herds is not practical.

Cattle temperament (TEMP) had an association with 3 out of 7 outcomes: Prod Use, Vocalization, and Run. In this study, it was noted that an increase in TEMP level from docile to very aggressive often coincided with increased mean frequencies of handling outcomes. For example, docile herds displayed less Vocalization and fewer instances of Run than herds that were categorized as any other TEMP category. This finding is in accordance with previous studies indicating that increasingly aggressive behavior makes handling more difficult, can increase worker injuries, and can lead to decreased production

attributes due to the relationship between temperament and fear response to humans (Fordyce, et al., 1982; Grandin, 1993, 2010; Burrow, 2001; Blanco, et al., 2009; Sant’Anna et al., 2013). Thus, the importance of temperament selection in certain breeding and genetic improvement initiatives has been recognized (Friedrich et al., 2015; Phocas et al., 2006; Parham et al., 2019; Chang et al., 2020). One such initiative is the TEMP scoring scale used in the current study, created by the Beef Improvement Federation (BIF, 2018).

An exception to this observation between TEMP levels and outcome frequency is Prod Use, for which herds in the nervous and flighty categories experienced lower mean frequencies of Prod Use as compared to all other categories. One potential explanation for this finding is that nervous or flighty animals may move quickly through the handling facilities not needing to be persuaded with handling tools or handling pressure, ultimately resulting in lower electric Prod Use. This reasoning would also explain the increased mean rates of Run associated with the increase in TEMP score. However, as indicated by this study, the number of factors impacting Prod Use demonstrates the complexity of explaining Prod Use in cow-calf operations. A limitation of the use of TEMP scoring in this study was the small selection of herds in the aggressive ($n = 2$, 0.03%) and very aggressive ($n = 1$, 0.01%) categories. Future research should attempt to recruit a greater number of herds across all TEMP levels and/or explore TEMP on an individual animal basis to analyze how TEMP and Prod Use impact one another. For example, Simon et al. (2016b) reported that animals who experienced prod use were at greater risk for other behaviors such as balking, vocalizing, and running out of the chute, all behaviors that may be related to temperament as well.

Herd size (SIZE) was found to have an association with rates of Prod Use and Jump. Greater mean frequencies for both outcomes were observed on operations with larger herd sizes (200–499 and 500+ animals). Larger herds can often result in a greater ratio of animals per stockperson and land needed to support animals (Beggs et al., 2019). The combination of the findings from the current study and those of Beggs et al. (2019) on the inverse relationship between outcome frequencies and the level of VISUAL could explain the differences in observed frequencies and herd sizes. It is logistically more difficult to interact with every animal in a larger herd as it requires more labor and the animals are often on larger expanses of range land. Therefore, future research on herd size effects should incorporate similar aspects to that included in visual contact amounts.

The location of the operation (REGION) had an association with Miscatch and Jump. There were significant differences between REGIONS in outcome frequencies but not enough information related to management processes and procedures was captured in this study to explain the reasoning behind these differences. This relationship should be further investigated to see if there are region-specific attributes such as different management procedures and/or approaches that could affect handling outcomes.

In this study, approximately half of the operations had an individual that was either currently or previously BQA certified suggesting that this sample of producers may be more heavily involved in the BQA program than the larger national population of cow-calf operations; rough estimates of potential cow-calf producer BQA certifications is around 130,000 individuals (J. Fitzsimons, personal communication).

Considering some of the opportunities in handling outcomes observed in this study among a group of individuals with a relatively high BQA certification rate highlights the need for further education initiatives around the importance of animal handling in general and these outcomes in particular. Additional studies could implement operation sampling schemes that recruit both BQA and non-BQA certified individuals across some of the other important predictors, such as VISUAL, TEMPERAMENT, and REGION. Refining the outcome definitions listed in the Cow-Calf Assessment (NCBA, 2019a), ensuring standardization in on-site assessments by BQA personnel, and increased focus on handling aids included in BQA training materials could increase compliance of BQA certified individuals with BQA guidelines.

The single outcome associated with a facility condition (CHUTE) was Slip/Stumble. There were significant differences between self-catch style chutes with both manual and hydraulic chutes. Self-catch chutes had the greatest observed mean instances of Slip/Stumble, however, self-catch chutes were also the least sampled chute type. The greater rates of Slip/Stumble in self-catch chutes may have been due to chute design and construction. Observed self-catch chutes were anecdotally noted as smaller than hydraulic or manual chutes and based on additional observer comments recorded during data collection, more cattle were observed having difficulty exiting this style of chute due to their body size, requiring greater force on the part of the animal to exit. Interestingly, ground material at the exit (EXIT) of the chute was not found to have an impact on Slip/Stumble. This is in contrast with previous research studies that flooring material impacts rates of slipping (Grandin, 1998; Uetake et al., 2008; Gregory et al., 2009). However, these studies often occur on areas of slick concrete or ramps at slaughter plants or during transport (Grandin, 1998; Uetake et al., 2008; Gregory et al., 2009) whereas in this study the majority of EXIT materials were rubber mats or earth ($n = 61$, 80%).

In addition to measured predictors, many qualitative observations were recorded during the operation visits. Many of the noted observations included instances of inappropriate handling implementation usage. For example, inappropriate prod usage, as defined by both NCBA (2019b) and other industry-recognized animal handling guidelines (NAMI, 2021), is no prod should be applied to sensitive areas such as the vulva, face, and/or udder or on non-ambulatory cattle. Unfortunately, this was observed at multiple operations during the study. Additionally, non-electric handling aids were also observed being applied with excessive force and to sensitive areas. Beef Quality Assurance guidelines clearly state that animals should not be struck with handling aids (NCBA, 2019b). Further education directed towards livestock producers is needed focusing on identifying acceptable and unacceptable handling tools, as well as using acceptable handling tools correctly when handling livestock.

Although the intent of this study was not to evaluate facility design, the observers had many opportunities to watch cattle move through different types of handling facilities. Only a few facility components were recorded in this study but other observational comments noted during data collection could inform future study inclusions. For example, here are some observer notes that were not included in the formal analysis: alleys that were too wide, alleys with large gaps in siding, chutes that were not secured to the alleyway, and chutes that were too small for the current herd. These

identified facility challenges could cause animals to turn around, escape, or balk, making handling more difficult. Due to the large variety in facility design aspects, future focus should be on creating a system to categorize design aspects to better analyze any relationships between outcomes and facilities. Individuals who perform BQA assessments can assist in this process by making observations on facilities and perhaps creating visual examples to aid in training and continuing education.

Another interesting observation made during data collection was the involvement of veterinarians and veterinary staff in processing. There were several instances noted in which the veterinarian was not using proper cattle handling techniques. Veterinarians are not only a critical part of cattle care by attending to and balancing the needs of the animals and producers, but increasingly, expectations of the general public (Sumner et al., 2018a; b; 2020). Veterinarians can also serve as examples to their clients as to acceptable handling practices. However, studies have consistently shown a wide variety of attitudes and empathy towards animals among veterinarians and the effects that have on their assessment of animal pain and treatment (Paul, E. S., and Podberscek, 2000; Norring et al., 2014; Schoenfeld-Tacher et al., 2017). As producers are often very limited with the selection of large animal veterinarians, especially in rural areas (NIFA, 2020), future research into veterinarian perspectives on large animal handling should be conducted along with an evaluation of future opportunities for continuing education about animal welfare and handling topics.

CONCLUSION

This study found that mean frequencies of Prod Use, Miscatch, and Fall all exceeded thresholds set in the BQA Cow-Calf Assessment. For those handling outcomes, there was a substantial subset of operations that were not meeting thresholds, identifying a need to develop targeted educational and outreach resources to promote improvements in animal handling on cow-calf operations. The mean frequencies for the additional handling outcomes (Vocalization, Jump, Slip/Stumble, and Run) were all within BQA thresholds. Several factors were identified to be associated with each of the handling outcomes analyzed. The frequencies of Prod Use, Jump, Slip/Stumble, and Run were associated with multiple factors. Future research should focus both on exploring additional factors that could impact animal handling and exploring the relationships between the significant predictors. Challenges to be considered for future research in this area should include difficulties in recruitment and outreach.

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Conflict of interest

M. Clowser is employed by National Cattlemen's Beef Association, the organization that funded the project.

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