

## BOARD INVITED REVIEW

# Animal welfare in the U.S. slaughter industry—a focus on fed cattle

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## Abstract

Animal welfare within the U.S. slaughter industry continues to prevail as one of the top priorities for livestock producers, businesses, and consumers alike. There are federal regulations that enforce the humane transport, handling, and slaughter of cattle. The journey that cattle must make to the slaughter facility is comprised of many environmental and human factors that can positively or negatively affect animal welfare. Cattle may be exposed to multiple stressors, such as noise, unfamiliar animals and humans, temperature extremes, temporary food/water deprivation, variable transport distances and experiences, and new pen conditions. The animal caretakers involved in these processes attempt to minimize stress and discomfort for the animals, but research is needed to focus on the gaps in knowledge and to support the implementation of strategies known to enhance the human–animal interactions that occur from farm to slaughter. This literature review will provide a summary of fed cattle welfare topics, research, and industry tools that span across the beef animal's journey from the farm/feedlot through the slaughter process. In addition, areas that have had little research focus are identified to highlight the need for future work and development of industry tools. Some of these topics include examining trailer design, the use of trailer slats during weather extremes, the welfare aspects of cattle destined for salvage slaughter, multiple preslaughter factors and interactions, abnormal mobility and nonambulatory cattle, lairage environmental conditions, new stunning methods, and the impact of a well-trained, motivated, and stable workforce on cattle and people welfare. The authors conducted a survey at the 2019 North American Meat Institute Animal Care and Handling Conference, which comprised of stakeholders within the meat packing industry, packing plant employees, and food company employees, educators, and auditors. The survey responses identified training/education and communication as areas of need in animal welfare, whereas the majority of survey responses focused on the aspects of the human–animal interaction as the top challenges for the industry. By continuously identifying, measuring, monitoring, and managing animal welfare challenges within the beef cattle slaughter industry, prioritization and execution of programs and training that improve the welfare of cattle can be achieved as animals move through this final stage of the meat production system.

**Key words:** animal welfare, fed cattle, handling, humane, slaughter, transport

## Introduction

Animal welfare within the U.S. slaughter industry has been and still remains one of the top priorities for livestock producers,

businesses, and consumers alike. Although the federal regulations pertaining to humane slaughter have not changed for decades, the public focus on where their food comes from,

**Abbreviations**

BQA	Beef Quality Assurance
BQAT	Beef Quality Assurance Transportation
CFI	Center for Food Integrity
ELD	electronic logging devices
FAO	Food and Agriculture Organization
FSIS	Food Safety and Inspection Service
GMP	Good Management Practices
HACCP	Hazard Analysis Critical Control Point
NAMI	North American Meat Institute
NBQA	National Beef Quality Audit
NCBA	National Cattlemen's Beef Association
NOIE	Notice of Intended Enforcement
NOS	Notice of Suspension
PAACO	Professional Animal Auditor Certification Organization
ROS	Reinstatement of Suspension
RSA	Robust Systematic Approach
RVA	remote video auditing
SPUC	single-pulse ultra-high current

with a specific interest in animal care, has grown exponentially. Consumer trust and purchasing surveys have provided insight into how consumers are (or are not) making decisions on meat purchases at the grocery store (CFI, 2018; FMI, 2019). The most recent Center for Food Integrity (CFI) consumer research summary report indicated that only 25% of respondents believe that U.S. meat is derived from humanely treated animals (CFI, 2018). Yet in other consumer studies, it was determined that 3 out of 10 shoppers look for “better-for-..... claims relative to the animal and planet” when purchasing meat (FMI, 2019). This stark disconnect between preferences at the meat counter and consumer trust of the meat industry identifies the importance of understanding and adequately addressing the welfare needs of animals in the supply chain. In addition, farm animal welfare has come to be recognized not only as an investment risk but also as an investment opportunity, thus increasing the number of programs and dialog pertaining to the topic (Amos and Sullivan, 2018).

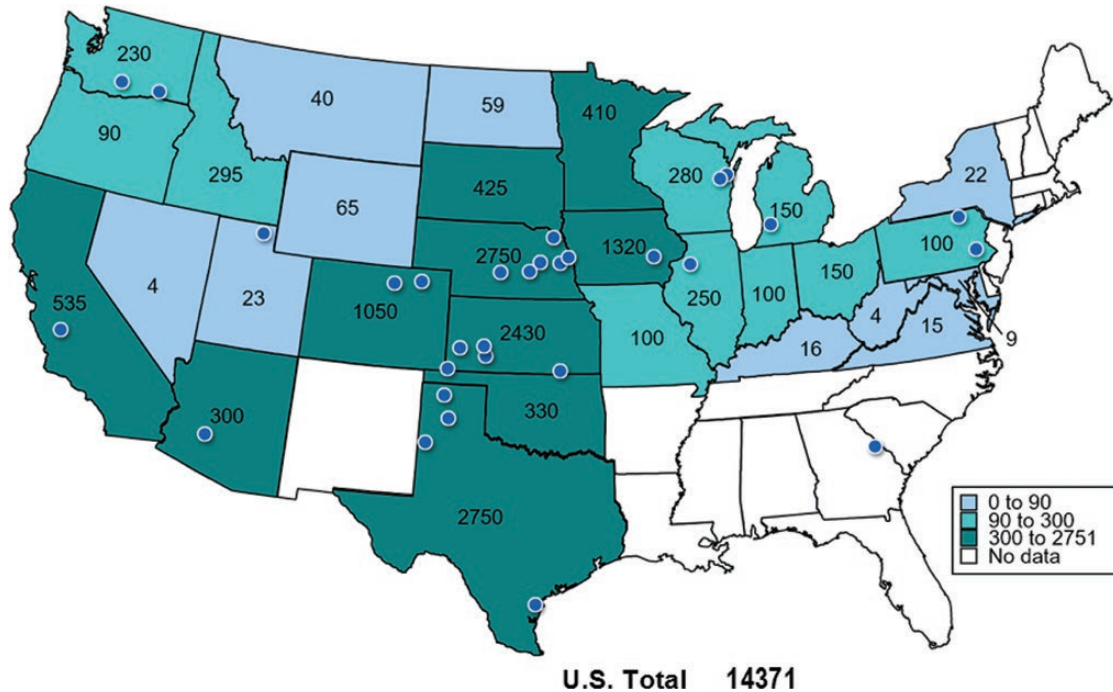
Slaughter companies, also known as packers or packing companies, must adhere to standards of animal welfare that satisfy governmental, societal, and company-specific expectations, all which continuously adapt to an ever-evolving view on animal welfare. Slaughter plants have the challenging and critical responsibility of ending the lives of animals to produce meat for human consumption while maintaining high standards of animal care. As Dr Temple Grandin once eloquently said, “I think using animals for food is an ethical thing to do, but we've got to do it right. We've got to give those animals a decent life and we've got to give them a painless death. We owe the animal respect.” By identifying the animal welfare challenges within the beef cattle slaughter industry, prioritization and execution of programs and training that continuously improve the welfare of cattle can be achieved as animals move through this final stage of the meat production system. The scope of this literature review will include fed cattle welfare topics from the phases of transport from the farm/feedlot to the slaughter facility and through the slaughter process. Fed cattle are defined in this literature review as cattle that are raised specifically for beef production; therefore, welfare topics focused on culled dairy cows will not be included. Often times, packing companies

are asked to have policies around how the animals they procure are raised (e.g., Beef Quality Assurance training requirements, policies for on-farm practices), but that component of animal welfare within the fed cattle industry will not be included in this review.

**Supply Chain 101**

Fed cattle are transported to slaughter facilities across the United States daily. Roughly 30 million head of cattle are slaughtered annually in the United States with approximately 80% of this total arriving at slaughter facilities as fed cattle from feedlots or sale barns (the remaining 20% comprises of cull cows and bulls; USDA NASS, 2018). In brief, when it is time for fed cattle to be marketed to slaughter, cattle are moved from their pens at their origin feedlot or point of purchase, loaded onto a trailer, transported to a slaughter facility, unloaded, and held in lairage prior to being humanely slaughtered and processed at the slaughter plant. The journey that cattle must make to the slaughter facility is comprised of many environmental and human factors that can affect animal welfare positively or negatively. Although the people involved in these processes (feedlot loading crew, truck drivers, animal handlers at the sale barn and slaughter plant, etc.) attempt to minimize stress and discomfort for the animals, cattle may be exposed to multiple stressors such as noise, unfamiliar animals and humans, temperature extremes, temporary food/water deprivation, and new pen conditions (Swanson and Morrow-Tesch, 2001; Broom, 2003; Ferguson and Warner, 2008; Schwartzkopf-Genswein et al., 2012; Cockram, 2017; Losada-Espinosa et al., 2018).

There is a wide range of transport distances that fed cattle undergo when they are hauled to a slaughter plant. The 2016 National Beef Quality Audit (NBQA) was the first of the National Cattlemen's Beef Association (NCBA) benchmarking audits to include transportation information of fed heifers and steers across 17 plants sampled, representing a significant portion of fed cattle slaughter volume (Eastwood et al., 2017). Transport times varied from 0.25 to 12 h (mean  $\pm$  SD; 2.7  $\pm$  2.4 h) and transport distances ranged from 12.9 to 1,400.1 km (mean  $\pm$  SD; 218.5  $\pm$  213.2 km; Eastwood et al., 2017). Figure 1 illustrates the potential distance traveled from the feedlot of origin to a slaughter plant by providing a visual representation of cattle on feed populations (from feedlots with 1,000 head or more) by state and the locations of slaughter plants sampled in both the fed steer and heifer and the market cow and bull NBQAs (30 plants representing a large majority of the U.S. fed beef slaughtered). Although there are many slaughter plants concentrated in the areas of highest cattle on feed population, it should be noted that not all cattle are shipped to the closest slaughter facility. The date and time of day when cattle are transported for slaughter (departure and arrival) are typically scheduled in advance by the location of origin and the packing plant. However, environmental circumstances may require adjustment of time and location for cattle when they are hauled in extreme situations. For example, times of extreme heat may alter transport times to cooler times of the day to avoid heat stress in cattle or slaughter facility emergencies may cause changes in the location where cattle are transported. There is only one federal regulation that governs the transportation of livestock in the United States and that is the *Twenty-Eight Hour Law (1994)*. Briefly, this law prohibits the travel of livestock for more than 28 consecutive hours without unloading for rest, water, and feed, and will be described in more detail in subsequent sections. As shown in Figure 1 and reported



**Figure 1.** Cattle on feed populations in the United States by the state in feedlots with a capacity of 1,000 or more head (1 = 1,000 head). States without cattle numbers reported account for 69,000 head of the total. Circles represent the locations of 30 USDA-inspected slaughter plants that slaughter fed steers and heifers across the United States (USDA NASS, 2019, adapted by National Cattlemen’s Beef Association with permission from Livestock Marketing Information Center for the use of the map). Some of the plants identified additionally slaughter cull cattle. These plants slaughter a large proportion of the fed cattle in the United States.

by the 2016 NBQA, the time needed to transport cattle to a slaughter plant is likely less than the maximum time permitted by the federal regulation.

Once cattle arrive at the packing plant, they will be unloaded from the trailer at their scheduled time of arrival and will enter into the facilities where they will be handled by non-familiar people, rest in unfamiliar pens with access to water, and then progress to slaughter. The [Humane Slaughter Act \(1978\)](#) enforces strict animal handling and slaughtering practices and is monitored by the USDA Food Safety and Inspection Service (FSIS) inspectors. The portion of the Act that pertains to animal handling requires that animals must be handled with a “minimum of excitement and discomfort” (CFR, 1979). There are also specific regulations for facility conditions, access to water and feed, handling of disabled animals, and stunning effectiveness. The FSIS inspectors’ role is to ensure that the slaughter plant complies with federal humane handling regulations and FSIS is required to take action in a packing facility if a violation of the federal requirements of the Act is observed. Egregious violations to humane handling and stunning requirements can result in the suspension of plant operations and noncompliance records for humane handling can be issued if a violation is less than egregious (i.e., not having water available in pens; CFR, 1979). In addition to monitoring humane handling and stunning, FSIS also conducts ante- and postmortem inspection of all animals presented for slaughter. During antemortem inspection in beef packing facilities, all cattle are observed at rest and in motion before moving to slaughter (CFR, 2016). Postmortem inspection is an inspection of the carcass, viscera, and head that occurs on the processing floor to verify carcasses are fit for human consumption, which is a requirement of the [Federal Meat Inspection Act \(1906\)](#). Relative to beef cattle welfare, government oversight provides the inspection framework that helps govern

every aspect of a beef packing plant, which includes strict animal handling and slaughtering practices. Although this level of government oversight makes the U.S. meat industry one of the most heavily regulated industries in the nation, these federal requirements are considered the minimum standards of animal welfare and additional animal welfare audits and training are voluntary steps taken by the industry to go above and beyond the federal requirements (NAMI, 2017). Slaughter plants often have internal animal welfare programs and audit tools modeled after the North American Meat Institute (NAMI) Animal Care and Handling Guidelines (NAMI, 2019a), which will be discussed in further sections. The combination of voluntary internal/external welfare tools with government oversight for federal requirements in handling and slaughter practices provides the verification framework that ensures all training and management efforts are effective and compliant.

### Journey to the Packing Plant— Transportation Factors Impacting Welfare

The Food and Agriculture Organization (FAO) states that transportation is the most stressful part of the supply chain for the livestock being transported (Chambers and Grandin, 2001). Indeed, during the transport process, cattle are exposed to multiple potential stressors including those occurring during loading, the transportation journey itself, and unloading. Schwartzkopf-Genswein et al. (2012) provide a review of literature focused on the impacts of transport on welfare in multiple livestock species. The authors focus specifically on transport factors, such as those factors associated with the transport process itself, and include a discussion of the impacts of loading density (Eldridge and Winfield, 1988; Eldridge et al., 1988;

Tarrant et al., 1988, 1992), transport duration and distance (Jones et al., 1990; Schwartzkopf-Genswein et al., 2006; Warren et al., 2010), trailer microclimate (Swanson and Morrow-Tesch, 2001; Mitchell and Kettlewell, 2008), animal factors (age, size, condition; González et al., 2012a, 2012b), bedding/slats (Warren et al., 2010; González et al., 2012c), and loading/unloading (Grandin, 2001; Booth-Mclean et al., 2007; Warren et al., 2010; González et al., 2012c) on beef cattle welfare. A selection of factors will be discussed further in this review; however, the reader is referred to the studies of Schwartzkopf-Genswein et al. (2012), Knowles (1999), and Tarrant (1990) for a thorough discussion of transport effects on cattle welfare.

## Regulations

As previously mentioned, the **Twenty-Eight Hour Law (1994)** is the only federal regulation that provides protections for livestock welfare during transport by limiting the time livestock can be transported without stopping for rest, food, and water. In the past, there have been criticisms of enforcement of the law (i.e., is it enforced?) in addition to questions regarding the scientific basis of the length of time allowed for transport (i.e., 28 h is a considerable amount of time). Currently in Canada, the equivalent regulation allows for 52 h of livestock transport before cattle must be unloaded for rest, feed, and water (CARC, 2001). In Europe, the ruling indicates that cattle destined for slaughter must be given a rest period of at least 1 h for water and feed if necessary after 14 h of travel, after which they may be transported for another 14 h (EC, 2005). As indicated earlier, industry benchmarking data reported average transport times of fed cattle destined to slaughter in the United States to be well below the 28 h limit (Eastwood et al., 2017).

Several years ago, there was heightened awareness about livestock transport times with the **Commercial Motor Vehicle Safety Enhancement Act (2012)** which when enacted required electronic logging devices (ELD) to be utilized in commercial transport. The new ELD regulations required commercial vehicle operators to utilize ELDs to comply with the Hours of Service requirements. Adherence to Hours of Service regulations was previously required but documented via paper logs. The use of ELDs limits flexibility for livestock haulers (i.e., it would not be possible to get an extra 30 min to get to a final destination or to continue driving to maintain airflow within the trailer once reaching the destination if the facility was not ready to unload cattle). Initially, there was not an exemption for livestock haulers and there was considerable industry concern that these ELD requirements could inadvertently and negatively impact cattle welfare. Industry stakeholders such as NCBA, Livestock Marketing Association, and American Farm Bureau petitioned for there to be an exemption for livestock haulers. Currently, the use of ELDs in livestock haulers is not enforced because Congress has defunded the Federal Motor Carrier Safety Administration (an agency of the U.S. Department of Transportation) enforcement of ELDs on livestock haulers through appropriations for the past 3 yr and similar language has been included for 2020 as well. Although livestock haulers are not currently required to utilize ELDs, this will likely be a focus in future years.

## Driver training

Several studies have identified that driver training, experience, and/or skill can have an impact on cattle welfare and subsequent meat quality (Eldridge et al., 1988; Warren et al., 2010; González et al., 2012c). In 2018, the NCBA Beef Quality Assurance (BQA) program launched a new cattle transporter

training program (Beef Quality Assurance Transportation; BQAT, 2018) to be utilized by the cattle industry to train transporters on good animal handling techniques during loading, transport, and upon arrival at the slaughter facilities. Prior to the BQAT program, the Master Cattle Transporter Guide had been in place since 2007 with few updates and limited online and in-person certification opportunities (MCTG, 2007). The new BQAT is administered via online modules or as an in-person training. In 2018, it was reported that approximately 1,600 certifications had been completed (Brown, 2018a). To date (January 2020), over 11,000 individuals have completed the training and received BQAT certification (C. DeCoite, J. Fulton, J. Pollard, January 2020, personal communication). The high rate of enrollment has been in part due to the announcements of large packing companies requiring drivers to show proof of BQAT certification in order to deliver cattle to their slaughter plants in the near future (Brown, 2018a; Rall, 2019).

## Fitness for transport

“Fitness for transport” is a critical consideration for cattle welfare. Although definitions of “fit for transport” exist within industry organizations (e.g., BQA, Farmers’ Assuring Responsible Management), the actual identification of whether an animal is fit for transport (by caretakers, transporters, and auditors, alike) is still subjective. Current definitions would benefit from further development. Additionally, fitness for transport is not regulated in the United States as it is in other countries. Although challenges with fitness for transport are usually focused around the condition of cull cows leaving dairies and arriving at slaughter plants, the consideration for fitness is still necessary for fed cattle, particularly in the case of animals destined for salvage slaughter. Nonperforming cattle in farms/feedlots, often referred to as “railers,” “chronics,” or “realizers,” are salvage slaughtered prior to optimal market size due to a lack of performance, health-related issues, or other complications relating to their inability to adapt to the feedlot management system. Previous reports have estimated that lame cattle account for 70% of sales of nonperforming cattle (Griffin et al., 1993), suggesting that this population of animals deserves increased attention with regard to fitness for transport. Although several studies have discussed the economic impact of realizers (Griffin et al., 1993; Davis-Unger et al., 2017), there is limited discussion of the welfare aspects of this population, particularly in relation to fitness for transport. The studies that do exist focus more on the welfare impacts of lameness and associated risk factors, such as becoming a realizer (Terrell et al., 2014, 2017).

The BQAT program includes a training module on fitness for transport, which includes considerations for both transport and the driver’s role in making fitness for transport determinations. The training mentions mobility, body condition, and health as factors to assess when making transport determinations. The NAMI Animal Care and Handling Guidelines and Audit Guide identify fitness for transport as one of the biggest welfare concerns associated with transport. The guidelines describe fitness as being able to “endure the normal stress of transport” and those animals that are unfit with reduced capacity to withstand transportation have a “high risk that transportation will lead to undue suffering” (i.e., are more likely to become nonambulatory, injured, fatigued, or died during the journey; NAMI, 2019a). Furthermore, the guidelines also define compromised animals as those that “have a reduced capacity to withstand transportation, but where transportation with



special provisions will not lead to undue suffering” (NAMI, 2019a). The NAMI Transportation Audit includes a criterion for “Condition of the Animal.” For this criterion, “unfit” animals are counted during audits at unloading, including those cattle that are injured, severely lame, heat stressed, and/or calving. To receive an “acceptable” score for this criterion, only 2% or less of the cattle sampled can be compromised upon unloading at the plant. Although the condition of fed cattle arriving at the slaughter facility is likely better than other classes of cattle (e.g., culled dairy cows), it is still an essential component to monitor.

### The trailer

Loading density is the space given to an animal on a trailer during transport and can have an impact on cattle welfare, either by providing too much or too little space during transport (Eldridge et al., 1988; Eldridge & Winfield, 1988; Tarrant et al., 1988, 1992). The number of animals loaded on a trailer to be transported to the plant is often dictated by cost and federal and state transportation regulations on truck weights, while trying to balance cattle welfare concerns (Whiting, 2000; Schwartzkopf-Genswein and Grandin, 2014). Previous versions of the NAMI Animal Care and Handling Guidelines (last included in the 2017 revision; NAMI, 2017) contained a chart on appropriate space allowances by animal type, originally cited from the Federation of Animal Science Societies Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010). The NAMI guidelines no longer include the tabular information regarding stocking density, as the information can be readily found in species-specific industry animal care program standards and guidelines. For instance, the BQAT *Transportation Handbook* includes a loading density chart with recommended cattle numbers based on trailer size and cattle weight (BQAT, 2018). Although guidelines exist for certain cattle transportation parameters, such as loading densities, many of the recommendations are not based on scientific studies (Schwartzkopf-Genswein et al., 2012) and highlight the need for research in this area.

Two areas that have received little attention, but are noteworthy, are 1) the use of slats on trailers during transportation in extreme weather conditions and 2) trailer design. The pork industry has recommendations and auditing criteria for appropriate bedding and trailer slat coverage (FASS, 2010; NPB, 2017), but the equivalent information does not exist for cattle. Fed cattle may not be the population of bovines most at risk for becoming compromised due to transport in weather extremes (i.e., this may be more critical for culled or young animals), but research in this area could be informative for best transportation practices. Additionally, there has been significant discussion regarding the interaction between trailer design, increased cattle size, and subsequent bruising of carcasses; however, there is little research in this space. The impacts of trailer design on meat quality aspects will be discussed in later sections.

## Management of Cattle Welfare at the Packing Plant

### Plant arrival

As cattle arrive at the slaughter plant, they are unloaded into holding pens. Although all efforts are made to ensure that cattle do not spend additional time waiting in trailers to unload, sometimes that does occur. The range of these wait times has not

been documented in the United States. The NAMI transportation audit tool has a criterion for acceptable range of time prior to unload at the plant, requiring that this time be less than 60 min for the trailers sampled. In extreme hot weather, this amount of time may actually be too long, but this has not been explored. Additionally, the NAMI transportation audit tool includes many provisions for facility conditions and cattle handling related to unloading. Usually unloading is relatively efficient at fed cattle plants, as the animals exit the trailer without much assistance needed.

### Facility condition and design

Facility condition and design are important in minimizing cattle welfare risks at the slaughter facility. Poorly conditioned facilities can cause injury via tripping, falling, and/or bumping into sharp edges and corners. Research has demonstrated that poorly conditioned facilities can contribute to increased bruising prevalence in cattle (Weeks et al., 2002; Huertas et al., 2010). One of the basic tenets of teaching appropriate animal handling and management at slaughter plants is ensuring that there is proper flooring in animal handling areas, beginning on the trailer, and extending all the way through the restrainer or knock box at the facility (NAMI, 2019a). Additionally, U.S. federal regulations require that facilities “shall be maintained in good repair” and “be free from sharp or protruding objects,” so as not to cause injury or pain to animals (CFR, 1979). When facilities are not in good repair, FSIS will disallow the use of those areas until fixed. Often, internal quality assurance personnel will also monitor the condition of animal handling facilities during their daily and weekly audits.

Despite the fact that the importance of well-maintained facilities is generally accepted, motivating companies and employees alike to prioritize the maintenance of facilities can sometimes be a challenge. Most times, needed maintenance improvements in slaughter plants are minimal and relatively inexpensive (e.g., fixing a gate latch, repairing a broken pen, adding a back-up gate to the single-file chute), but simply take time to fix. Most plants likely have spent significant funds and time in the maintenance of livestock handling areas, but many of the slaughter facilities in the United States were built in the 1960s and 1970s and are in need of significant updates simply due to the age of the facilities. The capital investment needed to completely renovate cattle handling areas within a large commercial slaughter facility is considerable and thus without a tangible return on investment, it is a challenge to commit to the expenditure. Welfare scientists and economists need to look for effective ways to quantify the economics of animal welfare, for example, showing how improved maintenance can reduce animal injury, increase plant efficiency, and ultimately save money. It is essential to have a scheduled maintenance plan for livestock handling areas that is supported by upper management and consistently implemented.

### Lairage conditions

Lairage is the time that cattle spend resting in holding pens at the plant prior to slaughter. It also functions to provide a time for antemortem inspection by FSIS inspectors and to maintain groups of animals in order to run the plant at an efficient rate (Warriss et al., 1992). The time dedicated to lairage is highly dependent on the plant and industry benchmarking data on lairage time in the United States does not exist. Sometimes, lairage is short when turnover in processing is swift; other times, it is relatively longer, that is, when animals arrive in the

evening to be slaughtered the next day (not a practice utilized by all packing plants). There is relatively little research conducted on this part of the preslaughter management process in fed cattle in the United States. In general, fed cattle do well during lairage (i.e., no deterioration in their condition), which perhaps is why limited attention is paid to this part of the process.

Weeks (2008) identified stocking density, ventilation, air quality, and noise as important considerations for maintenance of cattle welfare during lairage. In the United States, stocking rates are highly variable between plants and are determined by the space available, number of animals needed to ensure the plant runs consistently, and maintaining groups (or lots) of cattle together (i.e., prevent different groups of cattle from getting mixed at the slaughter plant). In the United States, governmental regulations require that cattle in holding pens have access to water at all times and that cattle held overnight have adequate space to lie down (CFR, 1979). Therefore, as long as the stocking rate does not impact an animal's ability to gain access to water, there are no specific governmental guidelines, except for overnight conditions. Within the NAMI guidelines, there are some "rough guidelines" with suggestions for space allowance in lairage conditions of cattle, but this is not an audited component. There is a question in the audit tool that is considered as a "secondary item" (i.e., not scored) and asks if the holding pens "appear to be overcrowded" (NAMI, 2019a).

Stocking density does not only impact the space available for rest and water access, but it can also impact the microclimate within the pens (i.e., the temperature and humidity at animal level; Weeks, 2008). In large U.S. commercial fed cattle slaughter plants, the majority of the lairage pens are outside, exposed to the elements, and many plants do not have shade. In outdoor facilities, heat abatement is commonly accomplished with sprinkler systems utilized throughout the day; in indoor facilities, fans are often utilized. There is a lack of research available in understanding the multifactorial impacts of lairage environmental conditions and how those may affect both welfare and meat quality in fed cattle. There is likely an interaction between time of lairage, space provided, and environmental conditions, an area worthy of further investigation.

## Cattle handling

In order to remain compliant with federal regulations and address the ethical obligations of optimizing cattle welfare, cattle handling at slaughter facilities must follow the same principles of humane livestock handling (also called "low stress handling") as researched and implemented in other segments of the cattle industry (Grandin, 2018a). Humane cattle handling principles are based on the understanding of the cattle flight zone, point of balance, and the natural instincts and behaviors of cattle. For a thorough review of these principles, the reader is directed to Grandin (2018a) and Grandin and Deesing (2008). Once employees are trained on these principles, oversight and monitoring of handling occur by the use of scoring systems by auditors (internal or external to the packing company). In 1991, the American Meat Institute (currently known as NAMI) and Dr Temple Grandin published the first voluntary animal welfare guidelines for the meat packing industry (*Recommended Animal Handling Guidelines for Meat Packers*), which was followed by a second document in 1997 that detailed measurable and objective criteria to evaluate livestock welfare in packing facilities (*Good Management Practices [GMPs] for Animal Handling and Stunning*; NAMI, 2019a). In 2004, NAMI's Animal Welfare Committee determined that these two documents should be merged into a single document to create an official animal

welfare audit tool comprised of guidelines, objective criteria, and reasonable "targets" for good animal handling and stunning practices (NAMI, 2019a). The NAMI audit tool, released in 2005, is widely used by the meat packing industry undergoing a review every 2 yr. Today the handling guide and audit tool are called the *Recommended Animal Handling Guidelines & Audit Guide: A Systematic Approach to Animal Welfare*.

Within the current NAMI audit tool, the objective animal handling criteria that are scored include electric prod (or goad) use, falls, vocalization, and willful acts of abuse (or egregious acts) during human-animal interactions (Grandin, 2018b; NAMI, 2019a). These criteria are considered the core criteria that must be evaluated within audits and each was established with industry targets from survey data collected in the U.S. packing plants since 1997 (NAMI, 2019a). Collectively, the core criteria and industry targets help packing plants determine how their handling practices change over time relative to the industry average and help drive continuous improvement. The objective core criteria and industry targets for cattle handling are defined in Table 1. Grandin (2012) reports that audit data collected in 2010 revealed great improvements in cattle handling in U.S. and Canadian beef plants when compared with the 1996 audit scores. In summary, the 2010 audit data of 32 beef plants showed that 97% of plants had 3% or less of cattle vocalizing, 94% of plants had no animals falling, and 81% of plants used electric prods on 5% or less of the cattle (Grandin, 2012). It is recommended by the NAMI audit guidelines that packing plants should have these criteria audited weekly via internal self-audits and annually by third-party organizations (external independent audits). For internal audits, it is suggested that audit days and shifts be varied so that the factors of employee experience, behaviors, and fatigue are accounted for and other variables that impact audit outcomes (plant personnel changes, livestock breed/age/gender, livestock's previous experience with handling or human contact, weather conditions, and auditor influence) do not affect the audit's ability to capture an accurate "snapshot" in time of cattle handling practices (NAMI, 2019a). With advances in remote video auditing (RVA) technologies, there are new tools for facilities to conduct audits while not impacting animal movement and employee behavior. Ultimately, auditors (internal or external) play a critical role in properly evaluating humane handling, but completing audits, observing trends, and providing employees with on-going feedback should be considered as part of the commitment to an animal welfare and handling program.

## Training

Professionalizing the role of animal handlers, caretakers, and auditors is a goal the meat packing industry has continuously strived for (Edwards-Callaway, 2016) and such an approach has been encouraged by animal welfare experts globally (Fraser, 2014; Daigle, 2016). The efforts to promote and elevate the role of animal caretakers are not only needed to sustain a strong culture of animal care across the livestock industry, but also to maintain a stable workforce at commercial operations where workers can grow their professional development, value to the industry, and level of job satisfaction (Hagevoort et al., 2013; Coleman and Hemsworth, 2014; Daigle and Ridge, 2018). Many commercial packing plants address the proper treatment of animals through their standard operating procedures and monitoring programs (Edwards-Callaway, 2016), but a critical component of achieving humane handling and stunning practices requires investment in effective training programs and data gathering capabilities, which collectively ensure standards and expectations are met.

**Table 1.** Core criteria for scoring humane handling in cattle from the North American Meat Institute's (NAMI) animal welfare audit tool: *Recommended Animal Handling Guidelines & Audit Guide: A Systematic Approach to Animal Welfare* (NAMI, 2019a)

Core criteria	Definition	Industry target
Electric prod use	Touching livestock with an electric prod whether the prod is energized or not.	Percent of cattle prodded: <ul style="list-style-type: none"> <li>• Excellent—5% or less</li> <li>• Acceptable—25% or less</li> <li>• Failure—more than 25%</li> </ul>
Falling	A fall occurs when an animal loses an upright position suddenly in which a part of the body other than the limbs touches the ground.	Percent of cattle observed: <ul style="list-style-type: none"> <li>• Excellent—no falling</li> <li>• Acceptable—fewer than 1%</li> <li>• Failure—more than 1%</li> </ul>
Vocalization	An animal should be scored as “vocalizing” if the vocalization (moo or bellow) is determined to be provoked by handling or equipment.	Percent of cattle that vocalize: <ul style="list-style-type: none"> <li>• Excellent—1% or less</li> <li>• Acceptable—3% or less</li> <li>• Failure—more than 3%</li> </ul>
Willful acts of abuse/egregious acts	<ul style="list-style-type: none"> <li>• Dragging a conscious animal, nonambulatory or otherwise;</li> <li>• Intentionally applying prods to sensitive parts of the animal, such as the mouth, eyes, ears, nose, anus, vulva, testicles, or belly;</li> <li>• Deliberate slamming of gates on animals;</li> <li>• Malicious driving of ambulatory animals on top of one another</li> <li>• Purposefully driving animals off high ledges, platforms, or off a truck without a ramp;</li> <li>• Hitting or beating an animal;</li> <li>• Animals frozen to the floor or sides of the trailer.</li> </ul>	Any willful act of abuse observed, no matter where or why they occur, constitutes an automatic failure on the transportation and plant audits.

The goal of effective training programs is not only to provide education and hands-on experience to managers, supervisors, and employees to ensure they are informed of their roles and responsibilities in ensuring animal welfare, but to also educate workers on how to prevent and protect themselves from job and ergonomic hazards (NAMI, 2016). For training programs to be effective, it is recommended that training programs should: 1) be designed and implemented by qualified individuals, 2) be inclusive of all employees at a plant, and 3) be presented in the appropriate language, format, and education level of the trainees (NAMI, 2016). The mindset of continuous improvement also applies in the approaches taken to train employees and maintain a culture of animal care, so that the meat packing industry must continue to be informed on research advances, share best practices, and embrace training programs (NAMI, 2017). At the 2019 NAMI Animal Care and Handling Conference in Kansas City, MO, the packing industry demonstrated their engagement in these areas by giving presentations and sharing information on best practices, including but not limited to: strategies to minimize stress when handling and stunning cattle, enhancing the effectiveness of training programs, setting a strong company culture with animal welfare as a priority, regulatory updates and methods to demonstrate compliance, and research updates on cattle welfare, including stunning, sensibility, and euthanasia (NAMI, 2019b, 2019c).

Data gathering in the area of employee management and training (i.e., new hire requirements, training strategies, continuing education) can be useful to determine where the packer segment currently trends and how it can continue to empower its workforce. Results from NAMI's 2013 packer and processor member survey indicated a strong commitment to both animal welfare and voluntary efforts that go above and beyond regulations and federal requirements (NAMI, 2017). Survey results indicated that many plants require new hires to have a combination of skills including experience with live animals (27.3% of responding plants) and education about live animal handling (72.3% of responding plants). In addition, the survey

revealed that background checks and personality profiling were completed for new hires in 63.6% and 45.5% of responding beef plants. Given the lack of skills and animal experience that is commonly seen in many new hires, the need for effective training and an appropriate delivery mechanism of educational resources (i.e., account for language barriers, multimodal learning styles, level of education achieved) is crucial not only for animal welfare but also for worker safety and plant efficiency. The 2013 NAMI survey indicated that 100% of responding beef plants require animal handling training prior to working in areas where live animals are handled, and 93.8% of responding beef plants use videos to train employees (with 42.9% using training videos created by NAMI). Training efforts that extend beyond the new hire process, such as interactions with industry experts and participation in industry conferences/meetings, can be beneficial to employees by helping them continuously gain new skill sets and provide professional development opportunities for long-term careers within their packer organization. The 2013 NAMI survey indicated that 43.8% of responding beef plants use third-party experts to troubleshoot animal welfare issues and 58.8% of responding beef plants regularly send key personnel to the annual NAMI Animal Care and Handling Conference (NAMI, 2017). Effective training programs coupled with variable levels of oversight have also demonstrated success in helping a diverse workforce develop the necessary skill set to appropriately and safely work with animals in beef packing facilities.

### Mobility

Over the past several years, there has been increased industry monitoring of the mobility of fed cattle due to events in 2013 where observations of cattle that were nonambulatory, slow and difficult to move, and, in some cases, sloughing their hoof walls occurred in packing facilities (Cima, 2013; Vance, 2013). These anecdotal reports resulted in industry-wide discussions among stakeholders and animal welfare experts, which led to the realization that there was insufficient scientifically based evidence to determine the cause of the observed mobility

challenges. Therefore, numerous research studies were conducted to gain more insight into this welfare condition and identify factors associated with impaired mobility specifically at the packing plant. For a thorough review on the current research on fed cattle mobility, the reader is directed to the study of [Edwards-Callaway et al. \(2017\)](#). In addition to research, industry tools and monitoring programs were simultaneously developed among industry stakeholders to begin measuring and benchmarking mobility trends for fed cattle arriving in packing plants. One example of a tool that was developed at this time was a locomotion scoring system specific for fed cattle with a packing plant application in mind. This tool was created as a collaboration between NAMI's Animal Welfare Committee and industry experts and is known today as the NAMI Mobility Scoring System ([NAMI, 2016](#)). Since 2014, the NAMI Mobility Scoring System has been used as an industry-wide tool to monitor fed cattle mobility and a training video was developed to enhance the adoption of this scoring system in commercial operations ([NAMI, 2016](#)). The scoring system is based on a 4-point scale and provides a tool for trained observers to view, evaluate, and score the movement of cattle at feedlots or the packing facility. In general, a score of 1 indicates normal conditions, while a score of 4 indicates significant challenges to movement. Details of the scoring categories are outlined below in [Table 2](#).

To date, the NAMI mobility scoring system has been effective in measuring fed cattle mobility issues at packing plants and has also been adopted as part of internal mobility monitoring programs in large packing companies ([Edwards-Callaway et al., 2017](#)). An example of an industry-wide mobility monitoring program is the Full Value Beef Cattle Mobility Assessment Program launched by Elanco Animal Health in August of 2013. In this program, third-party evaluators are trained to use the NAMI Mobility Scoring System to score individual cattle during unloading, antemortem inspection, or lairage at packing plants. To date, Elanco's Cattle Mobility Assessment Program has collected data at 15 different packing plants and on more than 12 million head of cattle. Current trends on the mobility data captured are presented in [Figure 2](#) and seasonal trends have been identified with abnormal mobility scores (2, 3, or 4) increasing during the summer months ([Edwards-Callaway et al., 2017](#)). This ongoing monitoring program has provided the beef and packing industries with important insight into factors associated with abnormal mobility and strategies to help improve cattle welfare and locomotion (e.g., [Calvo-Lorenzo, 2019](#)). Overall, industry-wide efforts to measure and monitor abnormal cattle mobility continue to be an important welfare topic for fed cattle in production. These industry efforts in conjunction with research

studies on cattle welfare provide opportunities to collect welfare monitoring data that can inform the entire industry and drive continuous improvement in identifying and managing mobility issues.

### Nonambulatory cattle

Although the intention and goal of the beef industry are for every animal shipped to slaughter to enter the supply chain through the system, sometimes there are losses that occur throughout the transport and preslaughter management process; these cattle are commonly called nonambulatory cattle or "downers." Nonambulatory disabled cattle are defined by the USDA as cattle "that cannot rise from a recumbent position or cannot walk, including, but not limited to, those with broken appendages, severed tendons or ligaments, nerve paralysis, fractured vertebral column, or metabolic conditions" ([CFR, 2016](#)). These cattle are not permitted to enter the food supply chain and must be humanely euthanized and carcasses condemned and disposed of ([CFR, 2009](#)). At USDA-inspected slaughter facilities, all animals are presented to FSIS personnel for antemortem inspection ([CFR, 2016](#)). The annual percentage of fed cattle that are condemned prior to slaughter is shown in [Figure 3](#). The information shown does not identify the cause of antemortem condemnation but presents the condemnation rate by animal type. The rate of antemortem condemnation in fed cattle (heifers and steers) is low compared to the condemnation rate in all other animal types grouped together, which includes culled beef and dairy cows, bulls, and stags.

Appropriate handling and euthanasia of nonambulatory cattle are critical with significant repercussions for animal and human safety if procedures are not executed properly. If fed cattle are injured (rather than being generally compromised as seen in culled cows), they can become dangerous to handle and difficult to euthanize as they may be aggressive and unsafe to approach. Some companies have implemented the use of xylazine, a sedative, to sedate an injured animal prior to euthanizing it to minimize risk to the animal handlers and ensure effective euthanasia ([Thomson, 2019](#)). The use of xylazine is only permitted with an established Veterinary-Client-Patient-Relationship. Euthanizing an animal that is in pain or fearful is challenging and packing plants must continuously update and revise protocols to ensure appropriate restraint of these animals for euthanasia.

### Stunning and insensibility

Stunning is arguably one of the most critical control points in the slaughter process as it begins the meat production process and is essential to ensuring a humane end of life for the animals. Although there are several approved methods appropriate for stunning cattle ([CFR, 1979](#); [AVMA, 2013](#)), in the United States, the majority of commercial slaughter facilities utilize a penetrating captive bolt gun either pneumatically powered or a handheld powder-loaded device, to stun the animal prior to processing. Federal regulations require that animals be "rendered immediately unconscious" prior to further processing regardless of stunning method ([CFR, 1979](#)). These regulations for stunning leave no room for error as the expectation is that stunner operators perform their job correctly every time. Due to the high regulatory scrutiny of stunning practices, in addition to its importance for ensuring animal welfare, stunning efficiency is a critical component of internal animal welfare programs. At a minimum, plants will have a training program for stunner operators. Additionally, they should have a preventative maintenance program for the stunning equipment.

**Table 2.** The North American Meat Institute (NAMI) Mobility Scoring System for scoring mobility in cattle ([NAMI, 2016](#))

Mobility score	Definition
1	Normal, walks easily, no apparent lameness, no change in gait
2	Exhibits minor stiffness, shortness of stride, slight limp, keeps up with normal cattle in the group
3	Exhibits obvious stiffness, difficulty taking steps, obvious limp, obvious discomfort, lags behind normal cattle walking as a group
4	Extremely reluctant to move even when encouraged by a handler; statue-like



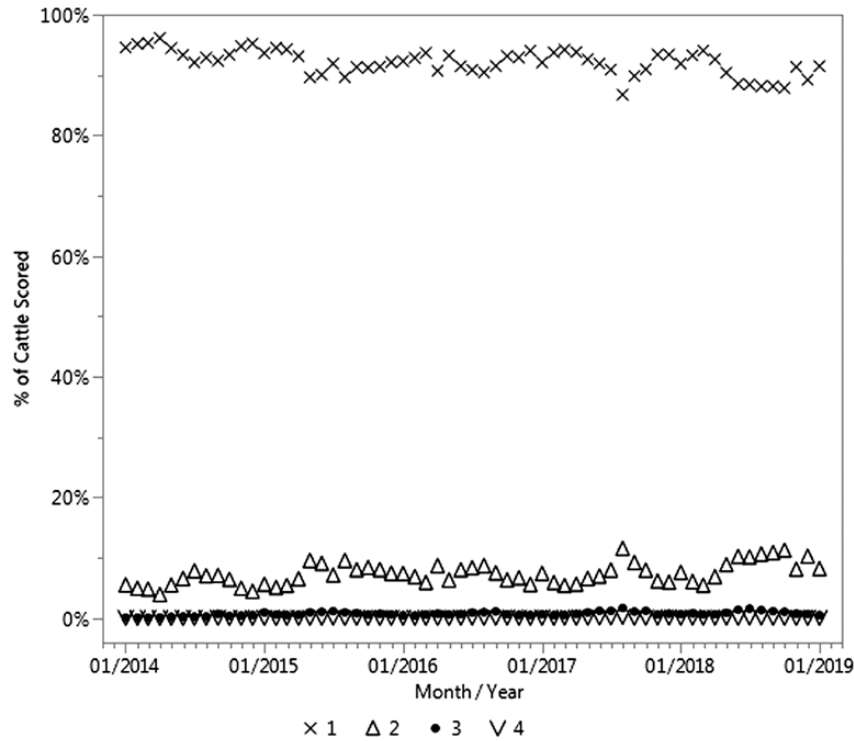


Figure 2. Percentage of fed cattle mobility scores graphed by year (2014–2019) and mobility category. The mobility score categories are based on the North American Meat Institute (NAMI) Mobility Scoring System: 1 = normal, walks easily with no apparent lameness or change in gait; 2 = exhibits minor stiffness, shortness of stride, or a slight limp but keeps up with normal cattle in the group; 3 = exhibits obvious stiffness, difficulty taking steps, an obvious limp or obvious discomfort and lags behind normal cattle walking as a group; 4 = extremely reluctant to move even when encouraged by a handler, statue-like (NAMI, 2016). The data represent information from approximately 12 million fed cattle from up to 15 commercial packing plants in the United States and Canada (Courtesy of and with permission from Elanco Animal Health, Greenfield, Indiana, 2019).

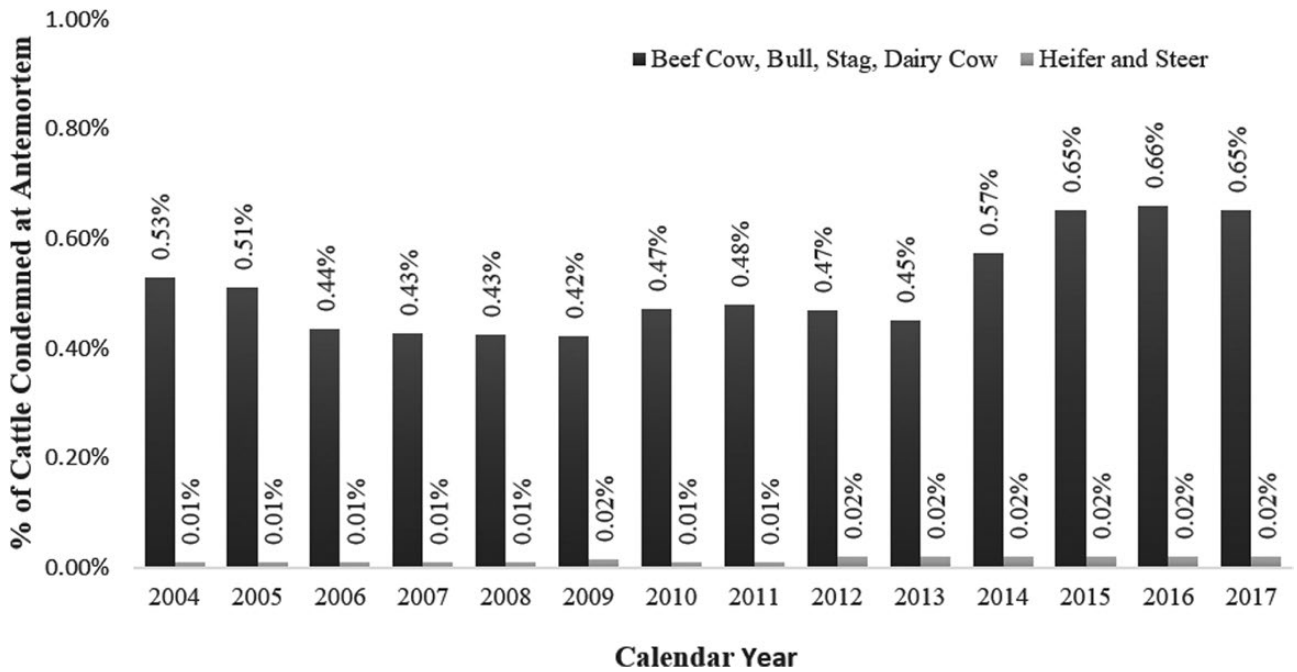


Figure 3. Percentage of cattle condemned antemortem at USDA-inspected plants by the calendar year from 2004 to 2017 (USDA FSIS, 2019). Cattle are represented as two groups in the graph: 1) beef cows, bulls, stags, and dairy cows and 2) heifers and steers.

The NAMI Animal Care and Handling Audit includes a core criterion for effective stunning. To pass a third-party audit, and often an internal audit if the thresholds have been similarly

set, plants must achieve a 96% efficiency rate (i.e., 96 out of 100 animals must be rendered insensible with the first stunning attempt). The acceptable rate was 95% for many years until it

was increased in the 2017 revision to continually improve in this area. An additional step taken to measure effective stunning is by auditing insensibility, which is usually done once the animal has been shackled and hoisted onto the rail. Results from NAMI's 2013 packer and processor member survey found that 87.5% of the responding beef plants complete daily sensibility audits to ensure that stunning systems work effectively in rendering animals insensible to pain (NAMI, 2017). Table 3 outlines the stunning and insensibility criteria from the NAMI audit providing definitions and thresholds.

Despite the fact that there is significant attention around stunning and insensibility in beef packing plants, stunning error is the most frequent cause of governmental enforcement actions (e.g., Notice of Intended Enforcement [NOIE]; Notice of Suspension [NOS]; Notice of Reinstatement of Suspension [ROS]). In brief, FSIS has the authority to suspend plant operations for varying amounts of time as a consequence of humane handling violations (CFR, 1979). Aside from the negative impacts on animal welfare, suspension of operations is a large risk for slaughter plants because it has significant consequences including costs incurred from decreased efficiency, customer scrutiny and potential business loss, and other animal welfare risks (i.e., trucks waiting to unload due to suspended operations). The improvement of humane handling practices has been incorporated into one of the goals of the FSIS Strategic Plan 2017–2021, measured by percentage of slaughter establishments that are compliant with all livestock restraint and/or stunning requirements (i.e., establishments that have not received an NOIE or NOS within the past year; USDA FSIS, 2016). Information regarding plants experiencing a NOS or NOIE is tracked by FSIS. Table 4 provides enforcement action data for the past 3 yr. It

should be noted that the number of total enforcement actions has decreased over the past several years. Additionally, the number of NOS/ROS has decreased in all plant sizes particularly between 2018 and 2019. Improvements in these numbers could be due to internal animal welfare and stunning improvement initiatives and programs. The majority of these enforcement actions are related to stunning (Galindo, 2019), an area of heightened focus. Additionally, in 2004, FSIS introduced the concept of a Robust Systematic Approach (RSA) for Humane Handling for adoption by slaughter plants (USDA, 2004). An RSA is essentially a HACCP-like (Hazard Analysis Critical Control Point) plan focused on minimizing animal handling and stunning risk. By having a written and implemented plan, improvements could be made in humane handling at slaughter. The FSIS encourages packing plants to have an RSA, as one benefit for having an RSA is reduced severity in enforcement action in the event noncompliance occurs and the plant can show they have a program in place. In 2019, FSIS reported that 60% of the USDA-inspected slaughter plants have implemented an RSA (Bowman-Blackwell, 2019). Other plants may have animal handling programs, but to be recognized as robust plans, the programs must include written procedures, up to date records, and be available for FSIS review.

Captive bolt stunning research in cattle has focused on characteristics (e.g., bolt velocity, stun accuracy) of penetrating (Vimini et al., 1983; Daly et al., 1987; Gregory et al., 2007; Gouveia et al., 2009; Gregory and Shaw, 2000; Atkinson et al., 2013; Oliveira et al., 2017) and non-penetrating (Finnie, 1995; Gibson et al., 2009) captive bolt stunning and comparisons between captive bolt stunning methods (Daly et al., 1988; Anil et al., 2006; Zulkifli et al., 2014; Gibson et al., 2019). Wagner et al. (2019) and Martin et al. (2018) explored the use of a longer bolt utilized in a pneumatically

**Table 3.** Core criteria for scoring humane stunning and insensibility in cattle from the North American Meat Institute's (NAMI) animal welfare audit tool: *Recommended Animal Handling Guidelines & Audit Guide: A Systematic Approach to Animal Welfare* (NAMI, 2019a)

Core criteria	Definition	Industry target <sup>1</sup>
Effective stunning	Plants are evaluated on the effects of a single application of appropriate stunning methods for cattle (i.e., captive bolt, firearm, or electric stunning).	Percent of animals observed: <ul style="list-style-type: none"> <li>• Excellent—100% instantly rendered insensible with one shot</li> <li>• Acceptable—96% or more instantly rendered insensible with one shot</li> <li>• Failure—less than 96% instantly rendered insensible with one shot</li> </ul>
Bleed rail insensibility	Plants are evaluated on the presence of the sensibility signs listed below: <ul style="list-style-type: none"> <li>• Insensible animals have ALL of the following signs ABSENT: <ul style="list-style-type: none"> <li>◦ Menace reflex occurs when a hand is waved in front of the eye</li> <li>◦ Eyelash reflex in response to touch</li> <li>◦ Corneal reflex</li> <li>◦ Rhythmic breathing where the ribs move in/out at least twice</li> </ul> </li> <li>• Animals transitioning back to sensibility have ONE OR MORE of the following signs PRESENT (animal is not fully insensible): <ul style="list-style-type: none"> <li>◦ Eyelash reflex in response to touch</li> <li>◦ Rhythmic breathing where the ribs move in/out at least twice</li> <li>◦ Corneal reflex</li> </ul> </li> <li>• Sensible animals have ANY of the following signs PRESENT: <ul style="list-style-type: none"> <li>◦ No loss of posture/animal standing</li> <li>◦ Righting reflex on the rail</li> <li>◦ Vocalization</li> <li>◦ Spontaneous, unprovoked blinking</li> <li>◦ Menace reflex occurs when a hand is waved in front of the eye</li> <li>◦ Eye pursuit of a moving object</li> </ul> </li> </ul>	Percent of animals that show 1 or more signs of sensibility <sup>1</sup> : <ul style="list-style-type: none"> <li>• Excellent—1 per 1,000 animals or less</li> <li>• Acceptable—1 per 500 animals or less</li> </ul>

<sup>1</sup>For insensibility, the audit criterion is that 100% of animals must be insensible. The targets provided are to be used for internal audits to evaluate the performance over time by averaging scores.

**Table 4.** The number of enforcement actions, including Notice/Reinstatement of Suspension (NOS/ROS) and Notice of Intended Enforcement (NOIE), implemented by USDA Food Safety Inspection Service personnel in plants by plant size (very small, small, large) and year (Bowman-Blackwell, 2019).

Year <sup>1</sup>	Type of enforcement action <sup>2</sup>	Total number of enforcement actions	Number of enforcement actions (% of total enforcement actions)		
			Plant size		
			Very small	Small	Large
2017	NOS/ROS	69	46 (67%)	13 (19%)	10 (14%)
	NOIE	20	8 (40%)	7 (35%)	5 (25%)
2018	NOS/ROS	80	53 (66%)	21 (26%)	6 (8%)
	NOIE	20	12 (60%)	7 (36%)	1 (5%)
2019	NOS/ROS	49	34 (70%)	14 (29%)	1 (1%)
	NOIE	21	10 (48%)	9 (43%)	2 (9%)

<sup>1</sup>Represents data collected from January through September for each year.

<sup>2</sup>NOS, Notice of Suspension; ROS, Reinstatement of Suspension; NOIE, Notice of Intended Enforcement.

powered penetrating captive bolt gun by assessing the extent of brain damage and postmortem kicking. Results indicated that a longer bolt did increase the amount of brain damage but did not reduce postmortem kicking. Additionally, the standard bolt size used still caused considerable brain damage and rendered all animals insensible during the study. In 2018, Jarvis Products Corporation (Middletown, CT) launched a new pneumatically powered penetrating captive bolt gun (Model USSS-21). The new model has some features to increase the velocity of the bolt and reduce the operating pressure required. Research studies are underway to assess brain damage, stunning efficiency, and stunning accuracy using the new Jarvis model.

More recently, microwave stunning has been explored as an alternative method of humane stunning in cattle, specifically as an option for religious slaughter (Rault et al., 2014; McLean et al., 2017; Small et al., 2019). Some religious slaughter methods permit a reversible stun and microwave stunning has demonstrated potential as a nonpermanent stunning method. Although this method will need increased validation, initial research on cattle cadaver heads (McLean et al., 2017), anesthetized sheep (Small et al., 2013) and cattle (Rault et al., 2014), and unanesthetized cattle (Small et al., 2019) suggest that a microwave energy application system has promise as a potential method of humane stunning in cattle. Single-pulse ultra-high current (SPUC) stunning has also been tested in cattle demonstrating stunning effectiveness and absence of post-stun grand mal seizures, associated with conventional electric stunning, which is beneficial for both worker safety and meat quality (Robins et al., 2014). Future research in alternative stunning methods is warranted.

### Religious slaughter

Some religions (e.g., Jewish and Muslim faiths) have specific requirements for the slaughter of animals, the major difference from conventional slaughter being the absence of stunning prior to exsanguination. Religious (or ritual) slaughter is recognized within the *Humane Slaughter Act* (1978) as a humane method of slaughter and slaughter of this nature is exempt from stunning animals prior to exsanguination. All other federal requirements for humane handling within the slaughter facilities remain the same. Although religious slaughter is considered a humane method of slaughter per regulatory definitions, there are some animal welfare concerns with the process related to the pain resulting from the neck incision, distress during exsanguination, and the extended duration of time to loss of consciousness

(Grandin and Regenstein, 1994; Gregory, 2005; Gibson et al., 2009; Gregory et al., 2009, 2010; Velarde et al., 2014; Zulkifli et al., 2014). Dependent upon the particular religious organization and certification body, reversible stunning may be permitted (e.g., non-penetrating captive bolt stunning; Abdullah et al., 2019). This is one reason why some of the new technologies (i.e., microwave stunning) previously discussed are being explored as alternative stunning methods with the potential to be utilized in religious slaughter to improve animal welfare during the process. Proper preslaughter restraint, an effective neck incision, adequate tools, and training of the individual performing the exsanguination are all critical components of religious slaughter necessary to ensure optimum welfare (Abdullah et al., 2019).

The NAMI guidelines do provide specific provisions for auditing religious slaughter (NAMI, 2019a). The audit criteria listed in Tables 1 and 3 are the same when auditing religious slaughter with a few exceptions. During religious slaughter, vocalization must be 5% or less to be acceptable; this is a higher threshold than in conventional slaughter practices due to differences in the process, primarily restraint. Additionally, as stunning is not required, stunning is not audited during religious slaughter but insensibility still remains an audit criterion; animals must be insensible prior to beginning carcass processing (i.e., skinning) and violation of this results in automatic audit failure.

### Audit types and tools

In the United States, retailers have worked with animal agriculture industries over the past several years to develop minimal standards of care that serve as guidelines for livestock caretakers and as the basis for animal welfare verification programs and oversight (Mench, 2003). Today, there are different audit types and tools that the beef packing industry uses to voluntarily evaluate, benchmark, and monitor onsite practices. These exist to ensure that animal caretakers and handlers are meeting consumer expectations for animal welfare and to continuously improve animal welfare and productivity. A single snapshot of animal care and handling practices is taken each time auditors conduct internal (first-party) or external (second- or third-party) audits. First-party auditors, or internal auditors, are employed by the livestock operation or packing facility, whereas second-party auditors are employed by a stakeholder group or allied industry. Both these auditor types may not be considered as fully independent by an outsider; however, they are the auditor types that help provide direction or implement the changes needed in

practices and an operation's culture to meet the organization's animal welfare standards and expectations. Third-party auditors are independently contracted and have no association with the operation, packing facility, or stakeholder. Thus, a third-party auditor may bring a level of confidence to outsiders given the nature of their unbiased position and independence from the customer-supplier relationship, but this should be balanced with the recognition that these auditors only provide awareness of their audit observations and are not involved in driving change at the operational level. Depending on the animal welfare program of a packer organization and welfare audit tool selected, third party-audits may result in certification, registration, an award, license approval, a citation, a fine, or a penalty issued by the third-party organization or an interested party. Multiple professional organizations exist to offer third-party animal welfare auditing services (Weimer et al., 2018; USDA AWIC, 2019).

Certified animal welfare auditors (inclusive of first-, second-, and third-party) are trained through independent certification programs, such as the Professional Animal Auditor Certification Organization (PAACO), that provides the "seal of approval" for both animal welfare auditors and animal welfare audit tools (Weimer et al., 2018). Certified auditors are required to complete extensive training on their auditing methods, knowledge of specific audit tools and welfare standards, and complete comprehensive exams and ongoing education relative to animal welfare (PAACO, 2019). To maintain greater accuracy, repeatability, and less ambiguity across auditors and audit results, audit assessment tools used within the packing industry commonly use simple and objective numeric criteria, rather than vague and subjective criteria, to assess animal welfare practices, as described in previous sections. In addition, audit criteria may fall under three general categories of animal welfare measurements which include: animal-based measures (measurements that can be collected by directly looking at the animal), resource-based measures (observations from the animal's environment that impact the animal), and protocol-based measures (measurements taken from written protocols; Proudfoot, 2018).

Animal welfare audits in packing facilities can be conducted live (physically present) at the site of observation, or remotely using video surveillance technology that enables trained auditors to observe practices distantly. RVA systems are increasingly being used in the meat packing industry to enable continuous monitoring of live animal welfare conditions and to provide plant operators with real-time feedback information about normal plant operations in their facilities (Pellegriani, 2011; Berger, 2017). In general, an RVA system consists of installing camera systems throughout live animal areas so that trained auditors can analyze the footage and provide feedback to plant management on a daily, weekly, or monthly basis, as a way to ensure frequent oversight and to correct or reinforce welfare principles in a prompt manner. It is important to note that active cameras alone may not impact behaviors by people, because employees may perform better when their supervisor is observing and active cameras do not reveal to employees when their managers may be observing. However, it is video surveillance coupled with active auditing and timely feedback that can better ensure welfare standards are met when this method of remote oversight is used.

## Other Considerations

### Labor

The U.S. meat and poultry slaughtering and processing industry is made up of more than 500,000 workers, with approximately

70,000 workings in plants where animals are slaughtered (NAMI, 2019d; USDOL BLS, 2019a). Animals destined for slaughter will typically remain in packing plants for a short duration of time, depending on the facility and harvesting schedule. Although these animals, such as beef cattle, will only interact with plant employees for a short duration of time, the significance of caring for these animals with principles of animal welfare highly depends on the workforce and culture created at each packing facility. Therefore, achieving optimal animal welfare in such plants lies in establishing a work environment where optimal worker welfare is a priority. When achieved, many benefits can be seen beyond cultivating the ethical importance of enhanced animal welfare, including improvements in worker morale, worker safety, plant efficiencies, and meat quality (NAMI, 2017).

The U.S. Department of Labor reports annual occupational employment statistics for slaughterers and meat packers, and the 2018 mean hourly and annual wages for the animal slaughtering and processing industry was \$13.76 and \$28,620, respectively (USDOL BLS, 2019a). Since 1963, the meat packing industry has not reportedly offered wages that are attractive to local residents, which may be partially due to the industry's migration from urban centers to rural locations with lower costs of living in the United States, resulting in packer jobs filled with migrant labor (Drabenstott et al., 1999). Hourly positions in the meat industry typically provide "on the job training" and do not often require formal education or previous experience (NAMI, 2015), yet this industry is highly regulated in how livestock are handled and slaughtered. Due to the high demands of federal requirements for animal welfare and increased consumer scrutiny for good animal care during slaughter (FMI, 2019), finding high-quality labor and retaining workers long-term have been difficult for the packing industry.

Traditional strategies to attract and retain workers, such as raising wages, have been found to be minimally effective and creative approaches to recruit and retain employees at packing plants are becoming more common (McCracken, 2018). In an effort to improve labor availability and encourage employees to grow their careers within a packer organization, the U.S. meat industry has offered varying benefits to employees that can range from providing insurance to earning additional paid vacation or winning free cars (MeatingPlace, 2019). In a 2013 survey completed by packer and processor members of NAMI, key findings about the effective benefits offered to attract and retain employees included: 100% provided health insurance coverage; 42% offered wellness programs; 83% offered pension, 401(k), or other investment plans; and 33% provided English as a second language class (NAMI, 2015). In extreme situations, such as emergencies or catastrophes, packers have demonstrated their commitment to their employees by ensuring pay to full-time, active employees while operations are temporarily down (e.g., Tyson, 2019) and provide opportunities to serve their communities after weather disasters (USCCF, 2013; Brown, 2018b; Cargill, 2019; Souza, 2019). New partnerships between the packer industry and their communities, such as a community college training program to create a trained local workforce, may be a creative approach resulting in benefits for both parties by improving the prospects of a stable workforce, reducing turnover rates, and potentially offering higher wages (Drabenstott et al., 1999).

Workforce stability is an important component of driving continuous improvement in animal welfare practices and expectations. Current societal dynamics, however, make this effort of retaining workers difficult and the packing industry is reportedly experiencing record absenteeism and



turnover rates (McCracken, 2018). Examples of major factors that currently impact the available labor supply and worker retention rates include increased reliance on migrant workers, hostile immigration policies and raids, alleged workplace discrimination and intimidation, and growing competition from other industries like oil, construction, and landscaping (Jamison, 2005; McCracken, 2018; Rosenberg and Cooke, 2019). In processing plants, it is common to find an employee workforce with an excess of 50% immigrant workers, many times with Latinos making up the majority of these diverse employee populations, which express language, cultural, and religious preferences that may differ among the multiethnic workforce (Jamison, 2005). Worker safety in the workplace can also be correlated with employee absenteeism, productivity, morale, and costs from injury and illness, and is, therefore, another important factor to consider due to the use of sharp tools and repetitive motions required in these labor-intensive job roles (NAMI, 2016). The packer industry's commitments to promote safe workplaces can be reflected in its improved rates of occupational injuries and illnesses over the last 20 yr (NAMI, 2016), in which it has achieved an all-time industry low in its current incidence rates for nonfatal occupational injuries and illnesses, including the more serious injuries known as "days away, restricted or job transfer" rates (NAMI, 2019e; USDOL BLS, 2019b). Nonetheless, worker and workplace safety not only remains a critical issue important to the industry, but also one that likely influences the recruitment, retention rates, and overall stability of the packer workforce.

The complex challenges that influence the workforce at packing plants are profound and diverse solutions to overcome these hurdles will be vital to sustain the animal protein industry and maintain a strong culture of animal care relative to livestock welfare. Furthermore, these challenges are coupled with significant consumer pressure demanding exceptional animal welfare at slaughter facilities. Research has demonstrated that positive human-animal interactions driven by improved worker attitudes and behaviors toward animals result in enhanced animal welfare and productivity in commercial livestock operations (Hemsworth et al., 2002; Coleman et al., 2003; Ridge et al., 2019) and potentially improved retention rates and job satisfaction (Coleman et al., 1998, 2000; Coleman and Hemsworth, 2014). Furthermore, investments made in livestock workers are investments linked to improved animal welfare and agricultural sustainability, which can promote the development of a long-term highly skilled workforce (Daigle and Ridge, 2018). Examples of investments that can make significant improvements in worker recruiting and retention success at packing plants include providing comfortable work environments (air conditioning, cafeterias, break rooms, clean bathrooms), offering free medical services and free childcare, donating to the community, creating a cultural attachment to the local area, and providing effective training and onboarding of workers and managers (McCracken, 2018). As the packer industry continues to demonstrate its commitment and efforts to optimizing animal welfare, improvements and investments in the welfare of its workforce should continue to be a critical focus as there can be mutually beneficial outcomes in maintaining a stable workforce and enhancing the welfare of both people and animals.

### Meat quality and animal welfare

Due to a substantial body of meat quality research across livestock species, it is known that factors like fear, stress, discomfort, and the physiological changes associated with a stress response

can negatively affect meat quality (Warriss, 1990; Hambrecht et al., 2005; Ferguson and Warner, 2008; Edwards et al., 2010a, 2010b; Cockram, 2017). As discussed previously, cattle may be exposed to multiple stressors during the marketing process to slaughter. The changes in an animal's physiology associated with a stress response can have detrimental effects on meat quality and potentially result in economic losses. Financial loss can range from complete monetary losses (i.e., if an animal dies in transport or must be euthanized and diverted from the food chain) to variable losses (i.e., from meat quality defects such as dark cutters and/or bruising; Warriss, 1990). The impact of many of these preslaughter stressors on meat quality in livestock species have been documented in several reviews (Swanson and Morrow-Tesch, 2001; Broom, 2003; Ferguson and Warner, 2008; Schwartzkopf-Genswein et al., 2012; Cockram, 2017; Losada-Espinosa et al., 2018).

Many of the studies conducted on the impact of preslaughter management on subsequent meat quality attributes have been conducted outside of North America. Table 5 summarizes the research conducted on variables related to transport and in-plant management on meat quality in fed cattle. There are other studies indicating the impacts of preslaughter management on meat quality, but those studies focus on different animal types (i.e., calves or cull cows rather than fed cattle); therefore, they were not included in this summary. It should be noted that out of the studies summarized, only five were conducted in North America and of those, two were conducted in the United States. Many of the studies previously conducted focus on 1 or 2 preslaughter management practices and do not look at how multiple factors interact in large cattle sample populations. In Cockram's (2017) recent book chapter focusing on understanding the effects of handling, transportation, lairage, and slaughter on cattle welfare and beef quality, he identifies that future research needs to include large-scale epidemiological studies examining multiple factors and interactions. There exists little research on some other important in-plant variables, such as animal handler experience, time waiting in trailers to unload at the plant, and use of cooling systems at the plant, all of which are factors that may impact both welfare and quality outcomes. The handling, transport, and slaughter processes are complex and cattle welfare and quality outcomes are likely impacted by many of them.

### Industry Perspectives—Beef Packing Animal Welfare Survey

Cattle are exposed to multiple events and factors that may affect their state of welfare as they progress from the farm/feedlot and through slaughter. In order to make continuous improvements in welfare that drive progress across the beef industry, it is critical that all individuals involved in handling, transporting, and caring for fed cattle have the knowledge, training/education, and feedback they need to understand why they do what they do and how new research advancements/tools can be applied to enhance the welfare of cattle. Furthermore, it is also important to obtain the perspectives and experiences of those who directly and indirectly work within the beef supply chain, so that programs, practices, and training/education are prioritized and executed to effectively improve the welfare of both cattle and their caretakers. The authors surveyed attendees at the annual NAMI Animal Care and Handling Conference, which is attended by many stakeholders within the meat packing industry, packing plant employees, people in corporate roles at food companies, educators, and auditors. The Institutional Review Board at

**Table 5.** Summary of research studies assessing the impacts of transport and preslaughter management practices on meat quality in fed cattle<sup>1</sup>

Transport/preslaughter management variables	Research conducted
Compartment density	Eldridge and Winfield (1988) Mach et al. (2008) Mendonça et al. (2016) Mendonça et al. (2019) Tarrant et al. (1988, 1992)
Driver experience	Huertas et al. (2010) Warren et al. (2010)
Facility condition	Huertas et al. (2010) Mendonça et al. (2019)
Feed/water withholding	Amtmann et al. (2006) Jarvis et al. (1996) Jones et al. (1990)
Handling	Alende et al. (2014) Costa et al. (2006) Frimpong et al. (2014) Maria et al. (2004) Marshall (1977) Mendonça et al. (2019) Minka and Ayo (2007) Miranda-de la Lama et al. (2014) Warriss (1990); Warriss et al. (1992)
Lairage time	Brown et al. (1990) Chulayo et al. (2016) del Campo et al. (2010) Gallo and Lizondo (2000) Gallo et al. (2003) Linares et al. (2006) Shorthose et al. (1972) Tadich et al. (2005)
Pen density (plant)	Alende et al. (2014) Mach et al. (2008) Chulayo et al. (2016)
Stunning	Huertas et al. (2010)
Trailer condition	Lee et al. (2017)
Trailer type	Mendonça et al. (2019)
Transport duration	Amtmann et al. (2006) Brown et al. (1990) Chulayo et al. (2016) Fischer (1981) Gallo and Lizondo (2000) Gallo et al. (2003) Huertas et al. (2010) Jarvis et al. (1996) Jones and Tong (1989) Linares et al. (2006) Maria et al. (2004) Mayes et al. (1979) Mendonça et al. (2016) Mendonça et al. (2019) Shorthose (1965) Tadich et al. (2005) Wythes et al. (1980, 1981)
Transport route	Huertas et al. (2010) Minka and Ayo (2007)

<sup>1</sup>Shaded references represent studies conducted in North America; bolded references represent studies conducted in the United States.

Colorado State University approved protocols and procedures related to survey administration and data collection (Protocol ID: 19-9349H). In general, the survey asked conference attendees

to anonymously state what they felt were the top animal welfare issues and needs in the beef packing industry. Attendees at the conference also have experience with other livestock and poultry species, but the authors limited the survey questions to those intimately engaged in the beef slaughter industry. Each respondent was asked the following question: “What do you think are the top 3 animal welfare issues in the beef packing industry?” All answers were reviewed and allocated into larger categories for comparison, as some responses were very broad and others very specific. The number of times a certain category was mentioned was tallied and then divided by the total number of possible responses (three animal welfare issues listed × total number of respondents) by job role within the industry to be expressed as a percentage (role = n, total no. of possible responses: Managers = 22, 66; Auditors = 5, 15; Corporate = 8, 24; Educator = 5, 15). Figure 4 shows the resulting percentages for the top three challenges mentioned by respondents’ roles and is shown in the order of highest mention. Cattle handling with specific mention of downer animals and training needs were listed as top priorities in all groups. Stunning was also mentioned across multiple groups.

When asked about future improvements needed within the beef packing industry (survey question = “What do you think the beef packing industry needs to do to improve animal welfare?”), training and education, communication, facility maintenance, and research were mentioned across almost all of the different job role types (Figure 5). Interestingly, the majority of survey responses were focused on some aspect of the human–animal interaction that occurs while the animals are at the packing plant and moving through the slaughter process. Training and communication were two key factors identified as areas of need within the beef packing industry. There is an opportunity for more focus on providing appropriate training to plant employees, likely both in quantity and in quality, although this level of granularity was not provided in the survey responses. As discussed in previous sections, the efforts to professionalize, promote, and elevate the role of animal caretakers are needed to sustain a strong culture of animal care across the beef industry. But that cannot occur without resource and time investment in effective training programs and monitoring capabilities that provide employees with what they need to continually meet welfare standards and expectations. With published research demonstrating that positive human–animal interactions enhance animal welfare and productivity, and the authors’ survey descriptively illustrating that animal caretakers and supervisors are asking for more focus on training and communication relative to animal welfare, an emphasis on the areas of training/employee development and its interconnection with the animal welfare topics identified and discussed throughout this review is warranted for future research.

## Conclusion

Animal welfare within the U.S. beef slaughter industry remains a top priority not only for farmers, transporters, and packers but also for businesses and consumers alike. Cattle caretakers have the critical responsibility of maintaining high standards of animal care as cattle make their journey from farm/feedlot to slaughter, and caretakers must do so by adhering to the standards of animal welfare that satisfy governmental, societal, and company-specific expectations. Plenty of research exists that has substantiated the standards of animal welfare and federal regulations, in addition to the development of new tools and technologies that enhance how individuals can identify,

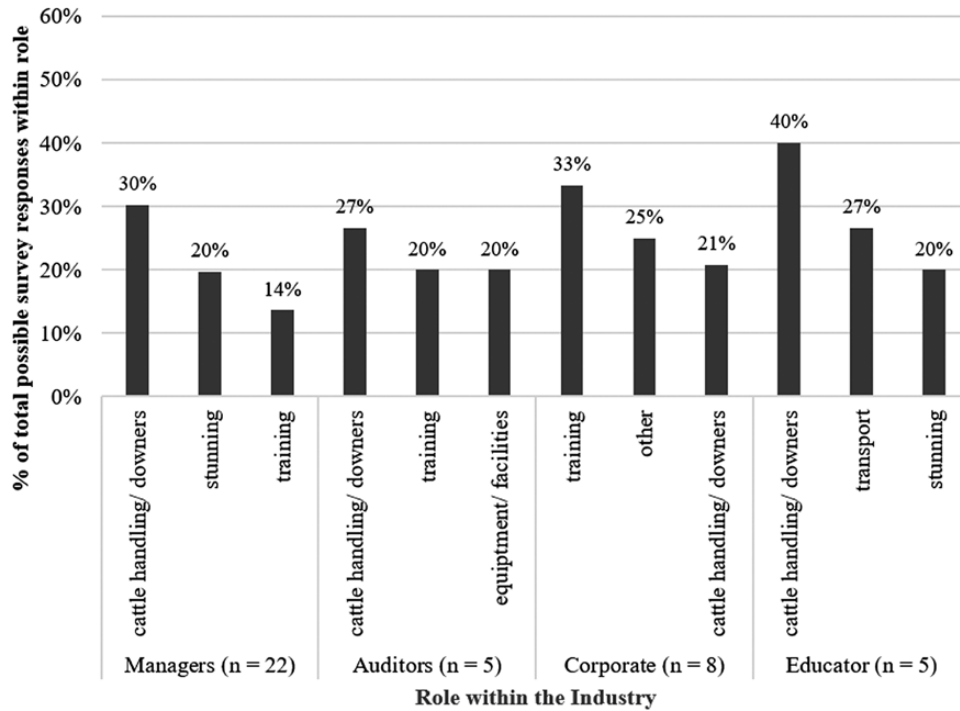


Figure 4. Responses from North American Meat Institute (NAMI) Animal Care and Handling Conference attendees to the question “What do you think are the top 3 animal welfare issues in the beef packing industry?”, expressed by respondent role within the beef packing industry. The question was asked on a paper survey and respondents anonymously wrote their answers, i.e., there were no choices given for selection. Each respondent provided three answers. All answers were reviewed and allocated into larger categories for comparison. Cattle handling/downers included topics related to the humane handling of animals and the management of downers or cattle at risk of becoming downers. Stunning included both methods of stunning and efficiency of stunning. Training included training of all personnel. Equipment/facilities included topics related to the proper use of equipment and designs of facilities. The number of times a certain category was mentioned was tallied and then divided by the total number of possible responses (three animal welfare issues listed × total number of respondents) by role within the industry to be expressed as a percentage (role = n, total no. of potential responses: Managers = 22, 66; Auditors = 5, 15; Corporate = 8, 24; Educator = 5, 15). Some respondents listed multiple issues within one category.

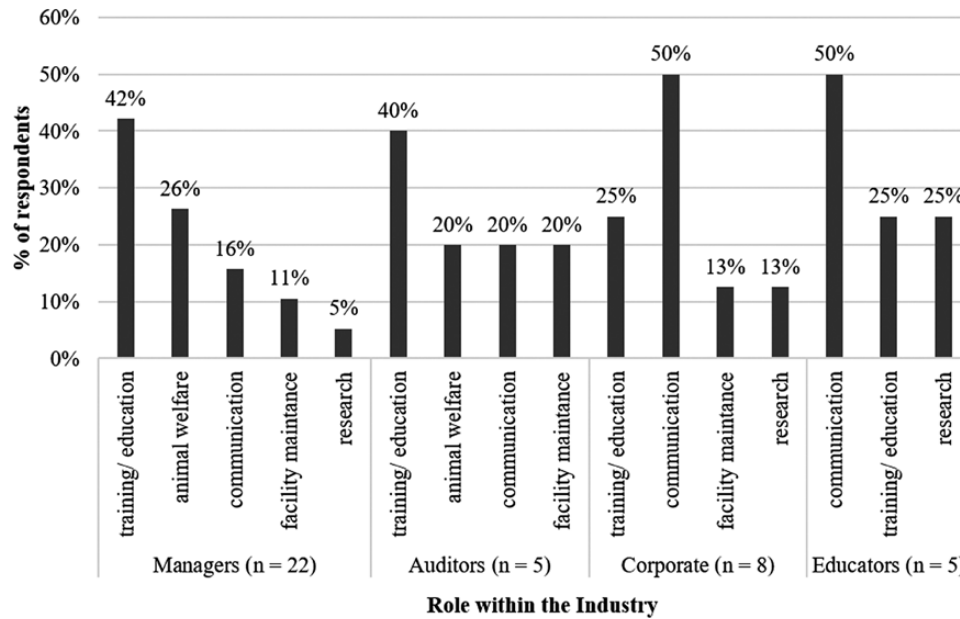


Figure 5. Responses from North American Meat Institute (NAMI) Animal Care and Handling Conference attendees to the question “What do you think the beef packing industry needs to do to improve animal welfare?”, expressed by respondent role within the beef packing industry. The question was asked on a paper survey. All anonymous responses were reviewed and allocated into larger categories (training/education, animal welfare, communication, facility maintenance, research) for comparison. Training/education included education for all roles within the industry (e.g., regulatory inspectors, auditors, managers, workers). Animal welfare included topics related to the welfare status and condition of animals within the supply chain. Communication included topics related to communicating between different members of the supply chain, communicating goals, outreach to consumers, and having access to welfare information and programs. Facility management included plant maintenance and improvements. Research included research needs across the supply chain.

monitor, and improve animal welfare conditions. Furthermore, industry and research audit data show that great improvements have been seen in handling and stunning practices across the U.S. beef supply chain. Research is still needed, however, to focus on the gaps in knowledge and the implementation barriers of effective strategies known to enhance the human-animal interactions that occur from farm to slaughter. Overall, the ethical responsibility of ending the lives of animals to produce meat for human consumption must be balanced with science, caretaker development and management, and societal values that ensure animals are humanely treated as they enter the meat production system.

### Conflict of interest statement

The authors declare that this literature review was conducted in the absence of any commercial or financial relationships that could be construed as a potential or actual conflict of interest.

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