Assessment of culled dairy cows on farms, and at livestock auction markets in Ontario

by

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ABSTRACT

ASSESSMENT OF CULLED DAIRY COWS ON FARMS, AND AT LIVESTOCK AUCTION MARKETS IN ONTARIO

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This thesis investigated the cull cow sector of the Canadian dairy industry. There is little research investigating the condition of cows sold at auction markets, comparisons of auction market cows to industry standards and federal transport legislation, or what influences a producer's decision to send a cull cow to auction. A total of 4,460 culled dairy cows were assessed at three Ontario auction markets, according to proAction® industry standards. The main issues identified were low body condition and abnormal gait. These conditions were associated with a significantly lower selling price. Subsequently, 47 dairy producers were provided with culled cow evaluation forms to encourage them to conduct a systematic assessment of each cow leaving their farm. Use of the form increased the time producers spent assessing cows, increased their confidence in related decision-making, and motivated them to use the form for developing their own standard operating procedure for shipping cattle.

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STATEMENT OF WORK DONE

Throughout my master's program, I completed, along with the help of many hands, a literature review surrounding culling and cattle transport within the dairy industry, and two research projects aimed at addressing major gaps in the literature. I was the one to examine the literature and complete the literature review. My committee provided feedback and edits. My advisors, Derek Haley and Todd Duffield, were the ones to propose the aim and objectives for the first study, outlined in chapter 2, along with the methodology in order to complete the study. It was myself, along with four volunteer research assistants, who travelled to the auction markets and collected the data. The data analysis was done by myself along with the assistance of William Sears. I then completed a research paper with the intention of submitting this paper to the Journal of Dairy Science for publication. My advisors, along with Ann Godkin, David Kelton, and Jeffrey Rau each read and provided feedback on the paper prior to its submission. It was my responsibility for submitting the paper to the journal and completing any revisions provided by the journal's reviewers. Ann Godkin was the one to propose the aim of the second study, outlined in chapter 3. Ann created the evaluation form to be distributed to producers. Derek and myself developed the pre- and post-study surveys to be distributed to the veterinary and producer participants. Todd, David, and Jeffrey peer reviewed all documents. Ann and myself compiled the packages sent out to participants. Ann collected the packages once they were finished and sent them to me. I was responsible for inputting the data into spreadsheets. Again, with the assistance of William Sears, we analyzed the data. I was responsible for completing a research paper with the intention of submitting the final paper to the journal "Frontier's in Veterinary Science" for publication.

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CHAPTER ONE

LITERATURE REVIEW

In production agriculture, culling of livestock can be generally defined as the removal of an animal or animals from the herd (Fetrow et al., 2008). Culling is a routine practice that inevitably occurs to each member of the herd. The decision to cull can be quite complex and is influenced by several factors such as economics, herd performance, and the individual cow's welfare. In 2017 the National Farmed Animal Health and Welfare Council (NFAHW) developed a report regarding the management of cull dairy cows in Canada. The council recognized that cull animals require special management measures and developed a consensus statement for guidance in future policy, actions, and research efforts regarding culled livestock. One conclusion was the need for information, analysis and awareness of the transportation of culled dairy cows, especially those with compromised health (NFAHWC, 2017). Dairy producers and industry experts are also attempting to determine a common approach to culling that is applicable to all herds, provides the best economic benefits, and ensures the welfare of the cows are not compromised.

There is a large amount of scientific and grey literature pertaining to culled dairy published over the past few decades. The literature ranges in topics from defining culling-related nomenclature to determining the optimal culling rate for maximizing profit, and identifying herd-level and individual risk factors for increased risk of culling. At first glance, there is overlap in the literature that identifies risk factors and economic impact of culling. However, there is disagreement among authors in defining what it means to cull an animal from the herd.

This review examines literature pertaining to the practice of culling and transporting dairy cattle. The first section will examine literature that defines culling nomenclature, herd-level culling rates, the economic and welfare impacts of culling, and common risk factors. The subsequent section will review literature and Canadian regulations pertaining to transportation and the impact of transportation on dairy cattle welfare. The last section examines literature that describes what factors influence a producer's decision to cull, and instances of how decisions surrounding culling impact cow welfare. The aim of this paper is to review the literature regarding culling practices in the dairy industry in order to identify knowledge gaps and propose research projects.

CULLING DAIRY COWS FROM THE HERD

Culling nomenclature

Culling. When reviewing the literature pertaining to culled cows it is important to have a working definition of the term "cull". Throughout the literature, authors defined what it means to be culled differently. Some describe culling as the removal of a cow from the herd (Dohoo and Martin 1984; Oltenacu et al., 1984; Hadley et al., 2006) but do not state for what reasons or to what destination. Some describe the specific events that need to occur for a cow removal to be considered a cull (Langford and School, 2012; either euthanized or sold for slaughter). Many articles use culling terminology, but do not provide a definition: Milian-Suazo et al., 1988; Kennedy and Scott, 1993; Bascom and Young, 1998; Grohn et al., 1996; Esslemont and Kossaibati, 1997; Grohn et al., 1997; Rajala-Schultz and Grohn, 1999; Booth et al., 2004; Chiumia et al., 2012. This would suggest that the term "cull" is considered to be common

knowledge amongst the dairy industry. This presents an issue when comparing articles and findings, because different authors may have a different understanding of the term.

In 2006, a working group in the U.S. was formed to review culling-related nomenclature in the dairy industry with the aim of standardizing culling terminology (Fetrow et al., 2008). The committee defined culling as the departure of cows from the herd due to sale, salvage, slaughter, or death. It stated that to "cull" meant for a cow to leave the herd regardless of the destination (Fetrow et al., 2008). They reported that the final destination of the cow can likely be classified into three groups: dairy sale, where the cow is sold to another dairy; slaughter-salvage, where the cow is sent to slaughter and may or may not enter the food chain; and death, where the cow dies or is euthanized on farm (Fetrow et al., 2008).

Voluntary and involuntary culling. Categorizing the reasons for culling is the most controversial topic regarding culling terminology (Fetrow et al., 2008). In many cases, culling has been categorized as either being voluntary or involuntary (Oltenacu et al., 1984; Rogers et al., 1988; Grohn et al., 1997; Rajala-Schultz and Grohn, 1999; Fetrow et al., 2008; Chiumia et al., 2011; Langford and Scott, 2012). Cows that are culled by choice, or voluntarily, are typically considered to be functioning normally, but have low milk production compared to their herd-mates and could be replaced by a cow with higher milk production potential (Grohn et al., 1997). Alternatively, cows that are culled involuntarily are often culled due to fertility or production problems, or due to a health condition, when the producer would have otherwise wanted to keep the cow (Grohn et al., 1997; Rajala-Schultz and Grohn, 1999; Fetrow et al., 2008).

These categories do not stand true in all instances. Oltenacu et al (1984) indicated that cows may leave the herd voluntarily due to low production, poor genetic merit, or to be sold to another dairy, or leave involuntarily due to health problems. Both Langford and Scott (2012), and Chiumia et al. (2012) described voluntary culling as a choice by the producer as a way to benefit overall herd production, whereas involuntary culling was a cull that was made before a farmer would otherwise choose to remove the cow due to infertility, poor health, injury, or death. Milian-Suazo et al (1989) defined culling as a cow being voluntarily or involuntarily removed from the herd due to sale, slaughter, or death, but did not describe which cows fall into which categories. In other articles, these two categories have also been labeled as "forced" which is similar to involuntary culling, and "economic" which is similar to voluntary culling (Oltenacu et al., 1984; Fetrow, et al., 2008).

Regardless of how voluntary and involuntary culling is defined, the terms have long been scrutinized (Radke and Lloyd, 2000; Dohoo and Dijkhuizen, 1993), and even recommended to be removed from culling terminology all together (Fetrow et al., 2008). The paper by Fetrow et al. (2008) was written with the goal of standardizing culling terminology, however, there continue to be discrepancies when using these terms. Future research, and knowledge translation and transfer (KTT) which provides a standardized definition of the term would be of benefit to the industry. Furthermore, any literature using these terms should provide a definition to ensure clarity.

Culling rate. Another commonly used term is culling rate, which is used to quantify the percentage of the lactating herd that is culled over a period of time (Rogers et al., 1988; Bascom and Young, 1998; Smith et al., 2000; Hadley et al., 2006; De Vries et al., 2010; Orpin and

Esslemont, 2010; Chiumia et a., 2012; NFAHWC, 2017). This can be useful for the producer as it can help determine economic performance, and allow comparisons between dairies (Fetrow et al., 2008; Orpin and Esslemont, 2010). Like the terms mentioned above, the definition of culling rate varies throughout the literature. The term 'rate' indicates a specific event over a defined period of time; however, some authors are not consistent with this definition. Hadley et al. 2006 described the culling rate as "the percentage of cows removed from the herd" (pg. 2286), but did not indicate over what specific time period, or what denominator. Fetrow et al. (2008) indicated that culling is a specific event, or incident, and to measure the occurrence of these incidents is done by measuring the frequency of the incidences over a specific time period. Therefore, they argued that culling *incidence* rate is the most ideal way to measure the percentage of the herd that is culled, and is defined as the "number culled over a specific time period divided by the population at risk for being culled over the same period" (pg. 1897).

Although, culling rate is the most common term used, many articles use other terms including: "percent left herd" (Gangwer et al., 1993), "proportion removed from herd" (Smith et al., 2000), "replacement rate" (Allaire 1981), and "yearly turnover" (AgSource Cooperative Service 2005). Oltenacu et al. (1984) uses the term "turn-over rate" to describe the frequency of annual culls. Knowing this, readers should be aware that the way the calculations are completed may differ in the literature and should therefore be cautious when comparing results.

Rogers et al. (1988) completed a study that aimed to determine the optimal annual culling rate on American dairies that would maximize economic performance and revenue. The team adapted a model by Van Arendonk (developed for use in the Netherlands), to calculate monthly costs and revenues for dairy herds with Holstein cows in the U.S. in 1986. The model considered

the costs of feed, veterinary services, replacement heifers, involuntary culling, units of semen, variation in milk yield, milk prices, conception probabilities, genetic improvement, body weight depending on age, and energy requirements (Rogers et al., 1988). Their results suggested the optimal annual culling rate should be 25.1%. They recognized that this number was lower than the national U.S. average of 31% at the time, but argued that lowering culling rates provided more opportunity for potential revenue, and offset the costs of replacement heifers. The culling rate presented by Rogers et al. (1988) has been used in several articles since as the optimal culling rate when comparing their own findings (Bascom and Young, 1998; Smith et al., 2000; Hadley et al., 2006).

Several studies have been conducted which determine culling rate for their sample population. In a study completed by Hadley et al. (2006) data were collected from 20,132 Dairy Herd Improvement (DHI) dairy farms (7,087,699 individual lactating dairy cows) in the Northeast and Upper Midwest region of the U.S. from 1993 to 1999. Culling rate was calculated as the number of cows sold, plus those that died, over the total average number of milking and dry cows in the herd (Hadley et al., 2006). Their results indicated that the average culling rate was 35.1% per year across the 7-year period. They also reported that culling rate increased with average herd milk production and herd size (Hadley et al., 2006). In a similar study conducted by De Vries et al. (2010) data were collected from 727 herds with more than 200 lactating cows (2,345,015 DHI lactation records) over 36 eastern states from 2001 to 2006. Annual culling rate was calculated as the number of cows culled from the herd divided by the number of cow-days at risk multiplied by a calendar year (De Vries et al., 2010). Results indicated an annual cull rate of 32%, which is similar to the results presented by Hadley et al. (De Vries et al., 2010).

When examining publications from the United Kingdom (UK), culling rates are consistently lower than those reported for herds in the USA. In a study by Orpin and Esslemont (2010), a web-based health planning tool was developed to aid veterinarians and farmers to analyze culling rates and economic analysis of the costs related to culls. Data were collected from 843 dairy herds (133,910 milking cows) in the UK. The mean culling rate was 22.7%. In another study completed in the UK by Chiumia et al. (2013) data were collected on lactating cows and their reported reasons for culling. Their results indicated a culling rate of 33.7% per ear over the 7-year period, higher than reported by Orpin and Esslemont (2010).

Peer-reviewed literature describing culling rates for Canadian dairies are difficult to find. In 2017, a policy report "The management of cull dairy cows in Canada" was completed by the NFAHWC council. The report indicated that 40% of dairy cows were culled annually from dairy herds in Canada. The calculation for the culling rate was not provided.

All articles examined, except for the study by Orpin and Esslemont (2010), found culling rates to be higher than the optimum culling rate of 25.1%, reported by Rogers et al. (1988). It should be noted, however, that the number reported by Rogers was calculated using net revenues and costs that were appropriate for the time that the article was published. All the articles examined in this review were published after the year 2000. The estimated prices used in Rogers article may be different compared to current costs and revenues. A similar study using similar dynamic programing to estimate an optimal culling rate for the current economic climate and for Canadian conditions, would be beneficial to determine the optimal culling rate for current dairy producers.

Risk factors for culling

A predominant area of research has been to identify risk factors associated with an increased risk of culling in dairy herds (Milian-Suoazo et al., 1989; Bascom and Young, 1998; Rajala-Shultz and Grohn, 1999a). This research is valuable as replacement costs can be high and an unexpected expense for the producer (De Vries, et al., 2010; Langford and Scott, 2012). Identifying risk factors can aid producers to focus on key areas of herd health to keep options open for retention or replacement.

Undoubtedly, the most frequently recorded reasons for culling pertain to health or production disorders that impact the cow's ability to perform sufficiently compared to her herd-mates. Several studies have shown that reproductive issues, udder problems, and low milk production are associated with an increased risk of culling (Dohoo and Martin, 1984; Milan-Suazo et al., 1988; Bascom and Young, 1998; Esslemont and Kossaibati, 1997; Rajala-Schultz and Grohn, 1999a; Smith et al., 2000).

Bascom and Young (1998) summarized the reasons why producers cull cows and determined whether producers cull cows for multiple reasons. Twenty dairy producers in the north-western United States were provided with culling logs and recorded their perceived primary, secondary, and tertiary reason for culling each cow. The most frequently recorded primary reason for culling was reproductive issues, accounting for 20% of all culls during the study period. This result is in agreement with other studies which report that reproductive problems, such as remaining open, or having several services, as one of the most common reasons for culling and results in an increased risk of being removed from the herd (Rajala-Shultz and Grohn, 1999b; De Vries et al., 2010; Orpin and Esslemont, 2010). The second most

frequently recorded primary reason was mastitis, with 15% of all culls due to mastitis (Bascom and Young, 1998). Again, this is in agreement with others as being another frequently reported reason for culling (Oltenacu et al., 1983; Beaudeau et al., 1993; Chiumia et al., 2013). The third most commonly recorded primary reason for culling was low milk production, accounting for 14% of all culls. Similar results have been found in other studies (Dohoo and Martin, 1984; Milian-Suoazo et al., 1989; Smith et al., 2000). Bascom and Young (1998) also provided the opportunity for producers to record a secondary reason for culling. Low production and udder conformation each made up 8% of these secondary reasons. Overall, the results of this study agree with the concept that conditions which interfere with the cow's ability to reproduce and/or produce milk will likely reduce the likelihood of survival within the herd.

Multiple studies have looked at how disease presence influences the risk of culling among dairy herds (Cobo-Abreu et al., 1975; Dohoo and Martin, 1984; Oltenacu et al., 1984; Beaudeau et al., 1993; Rajala-Shultz and Grohn, 1999; Grohn et al., 1997). Beaudeau et al. (1993) conducted a literature review of the relationship between health disorders and culling in dairy herds. Over 50 studies were reviewed; the relationship of the factor to culling, and relative risk or odds ratios were reported. Grohn et al. (1997) and Rajala-Shultz and Grohn (1999) completed studies that looked at the relationship between culling and many of the same health disorders reviewed by Beaudeau et al. (1993). The findings of the review will be reported, and findings from other studies will be compared with to the review.

Firstly, Beaudeau et al. (1993) assessed studies that examined the effects of specific reproductive disorders on the risk of culling, but reported that the results were often not conclusive. For metritis, Beaudeau et al. (1993) found that some authors (Cobo-Areu et al., 1979;

Oltenacu et al., 1990) reported a positive association between metritis and culling, meaning the presence of metritis increased the risk of culling, whereas others (Dohoo and Martin, 1984; Erb et al., 1985) found no association. Studies included in the review that suggest a positive association between metritis and culling are in agreement with Rajala-Shultz and Grohn (1999a) who also reported the same positive association. Oltenacu et al. (1990) reported a positive association between the presence of ovarian cysts and culling, whereas Cobo-Abreu et al. (1979) and Dohoo and Martin (1984) reported no association between the two. Grohn et al. (1997) and Rajala-Shultz and Grohn (1999a), reported a positive association between ovarian cysts and culling in their studies, published after Beaudeau et al. (1993). The relationship between having a retained placenta and the risk of culling was also inconclusive when comparing results across multiple studies. Within the review, Cobo-Arbeu et al. (1979) reported a positive association between having a retained placenta and culling, while Dohoo and Martin (1984) and Erb at al. (1985) reported no association between the two. Grohn et al. (1997) found a positive association between retained placenta and culling. When reviewing studies of dystocia as a risk factor, it was consistently reported that dystocia was associated with an increased risk in culling (Beaudeau et al., 1993). However, the effect of dystocia on the increased risk of culling was seen in the next lactation and not the current one (Beaudeau et al., 1993). The findings in the review by Beaudeau et al. (1993) are in agreement with the results reported by Rajala-Schultz and Grohn (1999a). Beaudeau et al., 1993 indicated that differences in the results reported by the multiple studies may be explained by variability in the definition of the disorder, the assessment and diagnosis of the risk factors, variation in the time of diagnosis, and variation in the stage of lactation included in the study period. Differences may also be due to the prevalence of the risk factor throughout

the herds in the study. It can be concluded that reproductive disorders can both directly and indirectly impact the risk of culling. The disorder itself may be the primary reason for culling, or may result in poor breeding performance and decreased fertility, overall, and therefore indirectly contribute to the increased risk of culling (Beaudeau et al., 1993).

In the following section of the review, Beaudeau et al. (1993) assessed articles that addressed milk production disorders and their relation to culling. With regards to mastitis, the literature consistently reported mastitis as a risk factor for culling (Cobo-Abreu et al., 1979; Dohoo and Martin, 1984; Oltenacu et al., 1990) regardless of the impact of other variables such as breed, study period or sample type (Beaudeau et al., 1993). These results are in agreement with multiple other studies, published after this review (Grohn et al., 1997; Smith et al., 2000; Hadley et al., 2006). High somatic cell count was also reported to be positively associated with culling by Dohoo and Martin, 1984 (Beaudeau et al., 1993), and these results are in agreement with other studies by Hadley et al. (2006) and Chiumia et al. (2013). Teat problems, such as teat injuries, were also positively associated with culling (Dohoo and Martin, 1984). Both Dohoo and Martin (1984) and Oltenacu et al. (1990) reported a negative association between ketosis and culling, which may be due to its association with milk yield (Beaudeau et al., 1993). However, these findings are in disagreement with Rajala-Schultz and Grohn (1999) who reported a positive association between ketosis and culling. Differences in the association between ketosis and culling could be related to challenges with identifying the disease, since ketosis in these earlier studies would rely on identifying clinical signs (clinical ketosis) and would not include subclinical ketosis. A study that examined objective measures of hyperketonemia showed an increased risk of early lactation culling in cows with ketosis (Roberts et al., 2012).

Lastly, Beaudeau et al. (1993) also reported on locomotor disorders and their effect on culling, however, because of the wide variability in definitions used to describe "foot problems" there was considerable discrepancy in the findings among articles that assessed this variable. Other factors that may have affected results include time of diagnosis and the ability to diagnose. A positive association between lameness and culling was reported by Dohoo and Martin (1984), and Milan-Suazo et al., 1988 (Beaudeau et al., 1993). Additionally, Collick et al., (1989) indicated that lameness may indirectly increase the risk of culling by resulting in poor breeding performance (Beaudeau et al., 1993). These results are in agreement with other studies that have reported a positive association between lameness and culling (Esslemont and Kossaibati, 1997; Rajala-Shultz and Grohn, 1999b; Smith et al., 2000).

There have also been studies conducted which exclusively look at the effects of lameness on culling. Lameness has been widely recognized as a detrimental condition that negatively impacts herd productivity, health, and welfare (Esslemont and Kossaibati, 1996; Rajala-Shultz et al., 1999). Lameness is a major concern for producers and researchers for these welfare and productivity reasons, but also because of its impact on culling (Barkema et al., 1994; Booth et al., 2004).

A study conducted by Barkema et al. (1994) examined the effect of lameness on reproduction, milk production and culling of dairy cows. The authors used a retrospective cohort study design and recorded instances of lameness on 13 dairy farms in the Netherlands from 1988 to 1991. Of all lame cows that were culled in the study period, results indicated that 26.4% of cows were culled because of lameness (Barkema et al., 1994). Additionally, results indicated that

lame cows had a long interval between calving to first service and from first service to conception, which subsequently affected their breeding performance (Barkema et al., 1994).

A similar study conducted by Booth et al. (2004), assessed the effects of lameness on culling. Data were collected on 2520 Holstein cows housed in two free-stall barns from 1997 to 1998. Results indicated that cows diagnosed as lame were as likely or more likely to be culled compared to non-lame cows (Booth et al., 2004). It was reported that culling due to lameness depended on stage of lactation and that overall, cows in mid to late lactation had a greater likelihood of being culled due to lameness (Booth et al., 2004). The findings from these two studies and the review by Beaudeau et al. indicate that lameness, similarly to reproductive issues, can be directly related to an increased risk for culling, or indirectly related to increase the risk for culling by reducing reproductive performance.

In addition to the conditions mentioned above, other risk factors for culling have also been reported. Grohn et al. (1997) reported both hypocalcaemia and displaced abomasum as having a positive association with culling. Cobo-Abreu et al. (1979) reported that presence of pneumonia was also positively associated with culling. Higher parity has also been commonly reported as being positively associated with culling (Grohn et a., 1997; Hadley et al., 2006; De Vries et al., 2010). Kossaibati and Esslemont (1997) reported that 41% of culls occurred before cows reached their fourth parity, and De Vries et al. (2010) reported that 83% of culls occurred prior to the fourth parity. Lastly, death has been reported by several studies (Bascom and Young, 1998; Esslemont and Kossaibati, 1997; Smith et al., 2000) as a predominant reason for removal from the herd. Bascom and Young (1998) reported that death accounted for 13% of the primary reasons for culling. Esslemont and Kossaibati (1997) reported that 6.85% of the total number of

cullings were due to death across 50 dairy herds in the UK. Smith et al. (2000) reported the percentage of culls due to death ranging from 14.8% in high-producing herds to 19.8% in low-producing herds. Whether or not the death of a cow on the farm should be included in the culling rate or the mortality rate of the herd is still debated.

The research presented above has provided the industry with an extensive list of factors that are likely to increase the risk of culling. Previous research has shown that large portions of culls are in some way due to disease. Producers and veterinarians can use this information to address areas in herd management to improve the health of their cattle and increase survival rates. A concern arises when cows are culled due to disease or injury and then required to be transported off farm. Research to date has explored causes of culling, but stopped there. Inevitably, some cows will develop a health condition that is past the point of reasonable treatment and will need to be culled from the herd. As mentioned by Fetrow et al. (2008) and the NFAHW council (2017), cull cows are often transported to a sales barn or abattoir. There is very little research that assesses the impact of disease or injury on a cow's ability to withstand the stress of transport to a sales barn. It is reasonable to believe that if a cow is lame or is experiencing malaise, the handling, co-mingling, duration, and weather conditions associated with transport could worsen the cow's condition. However, how these factors impact the cow's welfare have not yet been explored. Further research is needed to determine how transportation impacts the health and well-being of cows that are removed from herds due to health-related conditions. Additionally, there is a lack of research that addresses what influences a producer's decision to transport a culled cow, instead of choosing other options such as euthanasia or immediate slaughter. Research is needed to determine whether producers are choosing to

transport cows that should not have been transported, due to pre-existing disease or injury, and if they are doing so, why these instances are occurring.

Economic impact of culling

A dairy farm is an economic enterprise that is founded on cows producing milk. Culling a cow from the herd can have a large financial impact for the herd overall, especially if the cow is culled before the producer would choose to do so based on the perceived economic benefit (Langford and Scott, 2012). Additionally, because costs associated with culling can widely vary (replacement costs or selling price), producers will often modify their culling decisions, depending on the associated costs that would result (Langford and Scott, 2012). Research has been done to investigate the economic impact of culling (Rogers et al., 1988; Orpin and Esslemont, 2010; Langford and Scott, 2012) on overall farm revenue. This research can aid producers in determining the anticipated costs of culling, and how culling rate can impact a producer's revenue.

A large cost associated with culling is the purchase or rearing of replacement heifers. If the number of culled cows exceeds the number of replacement heifers, a heifer may need to be purchased to enter the herd (Langford and Scott, 2012). Rogers et al. (1988) modelled the optimal culling rate for a U.S. dairy herd to maximize revenue. The programming considered the cost of the replacement heifers to be 1100 USD. Although the cost of a replacement heifer can be high, it may be necessary if the costs of keeping a cow in the herd become too great. Reoccurring health problems prior to culling can also result in accumulated veterinary or treatment expenses (Langford and Scott, 2012). An additional cost to consider is the sale price of the cow. Producers

may send their cattle directly to slaughter or to an auction market where their cow will be bid on, and purchased by abattoir representatives, after which the cow is transported and slaughtered. Estimating the sale price of the cow is difficult. In Ontario, a commodity organization (Beef Farmers of Ontario) collates and reports slaughter cow sale prices weekly, monthly, and annually. These prices may follow annual trends, but are also subject to many factors, including supply of cows, consumer demand of certain meat products, trade pressures, perceived hanging weight of the carcass, or the quality of the meat provided.

Studies differ in recommendations for optimal culling to maximize revenue. Rogers et al. (1988) indicated that in order to maximize revenue, culling rate should not exceed 25% of the herd, annually. Their recommendations for culling are not reported to be influenced by the parity of the cow or the level of milk production in the herd. Langford and Scott (2012) report that a cow should be culled after the 6^{th} or 7^{th} parity to reduce the likelihood of extra veterinary costs associated with older cows. Future research examining these different methods (culling based on a standard proportion or based on age and production level), and how each impacts economic profitability could provide a useful reference for producers. Additionally, further research which takes into consideration the Canadian economic climate, and supply management would be useful for Canadian dairies, as the literature assessed in this review, are primary research articles conducted in the USA and UK.

Welfare implications of culling

Although culling is largely influenced by economics and revenue, it is important to consider how culling may impact the welfare of the cow being removed. According to the World Organization for Animal Health (OIE), an animal's welfare is dependent on the animal's ability

to cope with its environment (OIE, 2008). Fraser et al. (1997) indicated there are three overlapping areas of concern to determine an animal's welfare: animals should be free from negative affective states such as fear, pain, or distress; they should live in a natural setting that allows the expression of natural behaviours; and should have proper biological functioning in terms of overall health, growth, and vigor.

When deciding to cull, producers should first assess the overall condition of the cow and use their assessment to aid in determining how the method of culling could impact the cow's welfare (Langford and Scott, 2012). If a cow is experiencing some form of health disorder or injury, their welfare may already be compromised, and activities around culling may exacerbate poor welfare by causing exhaustion, malaise, or pain. As mentioned previously, health disorders largely influence culling, either directly or indirectly (Martin et al., 1982; Milan-Suazo et al., 1989; Grohn et al., 1997). Beaudeau et al. (1993) reported that 50% of culls from dairy facilities were related to health disorders regardless of the production system. When considering the health status of a cow, a producer could alter their decision regarding timing of culling and the final destination of the cow, to protect their welfare. The producer may cull cows sooner to prevent further decline in cow health status. If the cow's health has already deteriorated to a point where the cow is not fit for transport, the producer may attempt to treat the condition until the cow has fully or partially recovered and is able to be transported.

Additionally, if a cow is experiencing health problems, it is important to consider the stage and severity of the disorder when considering culling. If a health disorder is reoccurring it may be in the best interest of the cow to cull her, to prevent prolonged suffering. Similarly, if a health disorder occurs in which treatment is not feasible (due to no effective treatment being

available, or lack of resources), a producer may consider culling to be the best option to prevent prolonged suffering. However, to maintain a specific herd size or volume of milk shipped, a producer may decide to keep a cow in the herd for an extended period, when that cow would have otherwise been culled because of the health reason (Langford and Scott, 2012). If a cow remains in the herd to maintain herd size with a health disorder that is not receiving adequate treatment, this will prolong the pain or malaise experienced, or the disorder may progress and negatively impact the cow's welfare.

As mentioned in previous sections, there are several possible destinations for a cow after leaving the farm including: sold into dairy production, sold for slaughter, or death on the farm (Fetrow et al., 2008). The length of travel to reach this destination is an important consideration when considering the cow's welfare. If a cow is transported off the farm and sent to an auction market, then transported again to be slaughtered, the cow's welfare is of concern from the time of culling, until their final destination, which could vary from days to weeks. The longer the time between culling and the final destination, the more risk there is for the cow's welfare to be impacted. A producer may consider the distance of travel along with the health status of the cow, when determining which course of action is best for protecting their welfare.

Overall, the impact on welfare can depend on the cause of the culling, the length of time between the onset of a health disorder and culling, and the length of travel as a result of culling (Langford and Scott, 2012). It is important to consider how all of these factors may impact the welfare of the cow being culled. To date, research has been done to assess culling decisions that provide the best options for maximizing revenue (Rogers et al., 1988) and ensuring good welfare (Langford and Scott, 2012). There is a lack of research, however, that looks at how different

culling decisions impact the welfare of the cow. Further, in September 2017, the Dairy Farmers of Canada proAction® Animal Care module was implemented in Canada. As part of this module, a producer is required to have a standard operating procedure for shipping cattle that ensures the cow is fit for transit and her welfare will not be compromised. Research is needed to assess what constitutes a cow that is "fit for transport" while taking into consideration the factors discussed above, and if the conclusions are in agreement with federal transport regulations. Additionally, further research is needed that looks more closely and specifically at how culling decisions and actions can affect welfare, and what recommendations should be made.

TRANSPORTATION OF CATTLE

Since the majority of culled cows are transported off farm, either to another dairy or sold for slaughter (Fetrow et al., 2008), it is important to review the literature pertaining to transportation of livestock, as this is an important step in the culling process. Within Canada, there are legislative documents that include regulations and guidelines for the transportation of livestock. This information is available to all producers, veterinarians, transport personnel, and sales yard managers.

Canadian Transport Regulations

At the national level, the transportation of cattle is safeguarded by both government legislation and industry-imposed expectations. The process of transportation can be considered to start with assembling the livestock for transportation, to the unloading of the livestock from the transport vesicle (CFIA, 2017). The two main documents that describe transportation regulations and guidelines for transporting cattle are: part XII of the Health of Animals Regulations (CFIA, 2017), and section V of the Codes of Practice for the Care and Handling of Dairy Cattle

(NFACC, 2009). The Health of Animals Regulations are federal legislation enforced by the Canadian Food Inspection Agency. The legislation first came into effect in 1990 and was last amended in 2017. The Codes of Practice are industry- and government- developed guidelines whose development is overseen by the National Farm Animal Care Council. The revised dairy code document was released in 2009. Amendments are planned within 5 years, but are yet to be scheduled. While the Health of Animals Regulations is mandatory legislation, compliance with the Codes of Practice guidelines is voluntary.

The Health of Animals Regulations are broken down into 23 subsections, each of which contain legislation based on that specific subsection. Sections describe appropriate stocking density, ventilation, lighting, insulation, food and water, loading equipment and other aspects to ensure the safe transport of livestock. The regulation applies to all animals transported within Canada, or those leaving or entering Canada, and is to be adhered to by any individual involved with the transport of livestock. The regulation states that transportation is a highly stressful event for livestock, and can result in deterioration of an animal's condition and as such, the stated purpose of the legislation is to improve animal welfare and care through the implementation of these requirements (CFIA, 2017). According to the regulation a non-ambulatory animal cannot be loaded or transported. A non-ambulatory animal is defined as an animal that "due to infirmity, illness, injury, fatigue, or for any other cause cannot be transported without undue suffering". The latest amendment aimed to align the requirements with industry practices, current scientific literature, international standards, and consumer expectations (CFIA, 2017).

The Code of Practice for the Care and Handling of Dairy Cattle was developed through consultation of a scientific committee, and uses currently available scientific literature. The

transportation section of the Codes of Practice has two subsections. Within each subsection there are requirements and recommended best practices. Requirements refer to the minimum industry imposed expectations, whereas recommended best practices provide suggestions for continued improvement of care (NFACC, 2009). The first subsection provides guidelines for pre-transport decision-making and determining fitness for transport. The requirements state that every animal must be assessed prior to transport, and non-ambulatory animals should not be transported. The second subsection provides guidelines for loading and receiving, and states that the use of electric prods should be reserved for extreme situations, aggressive animals should be segregated, and that the procedures for loading and unloading should comply with the Health of Animals Regulations.

Ontario transport regulations

At the provincial level, the Livestock Community Sales Act (LCSA) is the predominant regulatory document for the transportation of livestock in Ontario, and is enforced by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). The LCSA came into effect in 1969 and was last amended in 2009. The act applies to community sales, and those sales that sell livestock by pubic auction (i.e., a public auction market or sales yard). The act prevents the sale of diseased livestock, licenses the sale of consigned livestock, provides methods of disease control, and methods for humane handling of livestock, and ensures financial stability for the community sale. R.S.O. 1990, c. L.22 provides the regulations under the LCS Act and provides for the classification of community sales, conditions for licensing of sales, sanitary requirements of the sales facility, requirements for handling diseased livestock, conditions for offering an animal for sale and the detainment of non-ambulatory animals found on a vehicle. Under the

LCSA, OMAFRA appoints animal care officers, veterinarians, and lay inspectors to ensure that the facilities, livestock, and handling methods meet standards consistent with current LCSA legislation. Lay inspectors are responsible for inspecting every animal prior to the sale and for segregating any non-ambulatory animals for later inspection by the appointed veterinarian. The LCSA provides legislation for all livestock except poultry. The legislation describes the necessary records, the powers and expectations of the appointed inspectors, and the regulations for adhering to the intentions of the act.

Lastly, there is the Food Safety and Quality Act (FSQA) in Ontario. The FSQA came into effect in 2001 and was last amended in 2018. The purpose of the act is to provide guidance for the quality and safety of agricultural commodities and food, and to manage food safety risks. There are seven regulations under the FSQA, with the Ontario regulation 105/09 "Disposal of Deadstock" being relevant to animal transport. The FSQA indicates that anyone responsible for the care of a fallen animal must promptly euthanize, or arrange for the fallen animal to be euthanized. The FSQA also prohibits the movement of a fallen animal before it is euthanized. A fallen animal is described as an animal that has been disabled by disease, emaciation, or any other condition that will be likely to cause death.

Relationship between transportation and stress

Throughout government and industry documentation it is stated that transportation is a stressful time for cattle and can result in deterioration of their condition, and subsequently negatively impact their welfare (NFACC, 2009; OMAFRA, 2009; CFIA 2017). Considering this, there is a need for documentation to ensure minimum standards of care, and protect the welfare of the livestock being transported. These documents are often developed through consultation of

scientific literature, but do also take into account industry and societal expectations (NFACC, 2009; CFIA, 2017) that may have been developed without scientific reference. Additionally, legislation does not require any form of referencing, so it is difficult to determine from what resource these regulatory statements and policy guidelines were developed. To have a comprehensive understanding of how transportation impacts the welfare of livestock, it is important to investigate peer-reviewed literature on this topic.

There has been a substantial amount of research conducted addressing how transportation influences the stress response in livestock (Blecha et al., 1984; Murata et al., 1987; Arthington et al., 2003; Yagi et al., 2004; Buckham Sporer et al., 2007; Gupta et al., 2007). A predominant area of focus has been calves (Blecha et al., 1984; Arthington et al., 2003), and the effects of transportation on physiological responses of stress (Murata et al., 1987; Arthington et al., 2003; Gupta et al., 2007). There are few studies that address transportation stress in adult dairy cattle (Yagi et al., 2004), and how transportation effects welfare as a whole (Simova et al., 2016), hence the title of this section.

The literature unanimously indicates that transportation results in an increased stress response in cattle. Blecha et al. (1984) evaluated the effects of transportation on immune response in feeder calves, and found changes in white blood cell counts (neutrophilia and eosinopenia), after transport. Arthington et al. (2003) found a loss in body weight, and an increase in an acute-phase protein (a product that results due to the proinflammatory response) in newly weaned transported beef calves. Buckham Sporer et al. (2007) reported that nine hours of transport with a 45-minute rest period, resulted in young bulls expressing a classic physiological stress response, of an increase in plasma cortisol, neutrophilia, and altered expression of four

neutrophil genes (Fas, 1-selectin, MMP-9, and BPI) that are essential in regulation of inflammation. Gupta et al. (2007) investigated the effects of a 12-hour transport on bulls and found that from the time of being held in a chute prior to loading, until unloading, cortisol concentrations were increased. The study also found that transportation resulted in neutrophilia, eosinophilia and lymphopenia, which are indicative of a physiological stress response, as well as disrupted homeostasis with increased packed cell volume, red blood cell and haemoglobin levels (Gupta et al., 2007). Lastly, Murata et al. (1987) assessed how transportation affected cellular immune function in calves and found that calves transported for four hours experienced leukocytosis due to neutrophilia, a decrease in T-lymphocytes, reduced activity of neutrophils, and an increase in plasma cortisol levels, after unloading. The study indicated that these results were in agreement with results found when experimentally administering adrenocorticotrophic hormone (ACTH) to cattle, and therefore concluded that transport resulted in a stress response and decreased cellular immune function (Murata et al., 1987).

In a study by Yagi et al. (2004), blood and milk samples were collected from nine Holstein-Friesian cows at eight points in time including just after loading, during transport, and after unloading, to determine if the physiological stress of transport effected somatic cell count (SCC). Results of the study showed that there was an increase in the plasma cortisol levels during transportation, with a peak reading at two hours into transport, and a slight decrease in milk production until one day after unloading (Yagi et al., 2004). Leukocytosis also persisted until two hours after unloading (Yagi et al., 2004). Overall, there was an increase in SCC throughout transportation with maximum values seen before and immediately after unloading (Yagi et al., 2004). Increase in plasma cortisol, leukocytosis, and increased SCC are all

indicative of physical stress, indicating that transportation resulted in increased stress for the dairy cows in this study (Yagi et al., 2004).

In a review by Simova et al. (2016), the authors argued that the majority of factors that may cause reduced welfare for cattle during transport occur during the pre-transport phase. Therefore, special attention should be paid to this part of the transport process in order to minimize adverse effects to the cattle (Simova et al., 2016). Subsequently, the authors provided information about a number of factors that can occur during the pre-transport phase that have the potential to negatively affect welfare (Simova et al., 2016). Proper route planning, ensuring that a route takes into consideration road and weather conditions, distance from farm to the slaughter facility, and number of stops the transport vesicle will need to make (since drovers often pick up cattle from multiple farms) were the first factor (Simova et al., 2016) Next, it was reported that the cattle must be fit for transport, meaning in good health, prior to loading, taking into consideration that younger animals are at a higher risk for physiological stress (Simova et al., 2016). Thirdly they indicated that animals should be grouped according to breed, size, and temperament, allowing for appropriate stocking density to ensure animals have enough space to allow for their preferred posture (Simova et al., 2016). It was also indicated that mixing different breeds and sexes should be avoided, whenever possible. The authors stressed the necessity for humane handling during rearing and loading as it is considered to be the most important factor with the potential to influence welfare at time of loading. The authors suggested using quiet handling techniques and to make use of flight zones instead of physical contact, to avoid electric prods or whips. Facilities should use properly designed facilities that have good grip flooring and are curved and avoid injury due to sharp points. Additionally, facilities should have stockpersons

undergo regular training on handling, have a good knowledge of animal behaviour and welfare and have a calm demeanor (Simova et al., 2016).

Overall, it has been well documented that transport can be a stressful event for cattle (Blecha et al., 1984; Murata et al., 1987; Yagi et al., 2004; Gupta et al., 2007), and has the potential to negatively impact welfare due a variety of factors (Simova et al., 2016). However, transport is an inevitable event for many cattle because of the potential revenue from the sale of the animal, or necessity to transport for medical care. A good approach may be to conduct research that provides information about best practices for transport, which minimizes adverse effects resulting in stress, distress, fear, and malaise/injury. Similar to the review by Simova et al. (2016) and work done by Grandin (1990; 1997; 1998; 1999) that provide suggestions for proper pre-transport management techniques, handling techniques for reduced stress during loading and transport, and proper facility design, research that studies all aspects of transport would be beneficial for determining the best course of action. Further research on non-human transport related factors, such as weather conditions and travel duration are needed. This research could help to determine the circumstances when transport should be postponed or prohibited (i.e., severe weather, ambient temperatures above or below a certain cut-off), or if rest stops are needed more often in these circumstances. Another area that should be investigated is the impact of long distance transport on the welfare of animals. Canada is a large country where farms in remote areas may be very far away from the nearest processing facility; certainly much greater distances than in most European countries. Additionally, the number of abattoirs in Canada is on the decline, meaning longer trips for animals. There is little research on how this affects the welfare of dairy cows that have to withstand longer travel distance. Research is needed on how

transport influences affects adult culled dairy cattle specifically, as this specific sub-population of cattle may require unique accommodations during transport that need not be considered for transport of other animals. For example, culled cows may be lactating, are at the end of the productive lifespan, and may be older than market weight steers, are more likely to be experiencing disease that has lead them to be culled, or may be in a negative energy balance after finishing their last lactation. It is unknown how these factors influence their ability to withstand the stress of transport, and would be beneficial in helping producers to make the best decision when culling.

CULLING DECISIONS OF PRODUCERS

What influences a producer's decision to cull a cow from the herd is complex and affected by many factors. These factors have been discussed in depth above, but will be repeated for the purpose of this section. Overall, past literature has indicated that often a producer may choose to cull for one of two reasons: because of a perceived financial benefit of culling the cow and having a replacement come into the herd, or because the option to keep the cow in the herd is no longer feasible in the opinion of the producer (Fetrow et al., 2008; Langford and Scott, 2012). Regarding the first option, a producer may choose to replace a cow with another that has higher milk production or better genetic potential (Fetrow et al., 2008). This provides the opportunity for improving the overall performance of the herd, subsequently increasing revenue (Rogers et a., 1988). Regarding the second reason, there are a variety of factors which may make keeping the cow in the herd too much of a strain for the producer. As discussed previously, if a cow has fertility or udder problems, that negatively impact her ability to reproduce or produce milk, her role in the herd is compromised (Bascom and Young, 1998). Subsequently, the cow may be

costing the producer money instead of making a profit. Additionally, it has been well documented that various health conditions such as lameness (Barkema et al., 1994; Boot et al., 2004), milk fever (Dohoo and Martin, 1984), ketosis (Grohn et al., 1997), dystocia (Beaudeau et al., 1993), pneumonia (Cobo-Abreu et al., 1979), or metritis (Rajala-Schultz and Grohn, 1999a), can increase a cow's likelihood of being culled. A producer may decide to cull due to health conditions because of the veterinary costs, likelihood of reoccurring diseases, or a combination of factors that make the condition too difficult to manage. Additionally, the decision to cull may a combination of any of these reasons; a producer may be struggling with the fertility of a cow, and have a replacement heifer, and as a result, choose to cull.

The decision to cull can also be dependent on the producer's personal views on optimal culling rates. Some producers view low culling rates as a good indicator of success of the herd and subsequently try to keep their culling as low as possible. However, others may see each cull as the potential for continual improvement of the herd, and therefore their rates may be much higher. Although previous research has been done to determine an 'optimal' culling rate (Rogers et al., 1988), culling rates can vary widely depending on the farm, and are not necessarily indicative of good or bad practice. Additionally, one should consider how supply management in Canada could impact a producer's optimal culling rate, in order to meet their quota. Smith et al. (2000) looked at the effects of herd size, overall milk production, and region to determine why cows are culled in the United States. Findings indicated that low-producing herds had lower culling rates, and smaller herds had more cows culled due to fertility issues and mastitis than medium and larger herds (Smith et al., 2000). This study helps to show the multifactorial nature of culling decisions, and how culling rates can vary widely depending on many factors.

The usefulness in using a culling rate to determine good management practice is debatable. There may be no optimal culling rate for all dairy herds. Instead, one could look at individual culling instances to determine good management practices. A concern arises when producers seemingly make the decision to cull and transport an unfit cow, and subsequently the welfare of the cow is at risk. There have been instances in Ontario when a cow is transported to auction markets, despite not meeting the transport or food safety requirements laid out by Canadian legislation. Ontario is unique compared to other provinces in having government-appointed lay inspectors present at each auction sale who inspect all animals prior to sale and segregate animals for further inspection by a veterinarian. If the veterinarian determines that any animal at auction is non-ambulatory, or is suffering beyond sufficient treatment, the veterinarian may euthanize the animal. When euthanasia is conducted, an incident report will be written, and a warning letter sent to the producer. The producer may be subjected to a government inspection soon after, to ensure no other animals are in a similar state on the farm (LCSA, 2009).

Although reports of the outcomes of court cases are publicly available, there is no documentation of the frequency of incidents, which can also include cases that are not brought to court. It is also not known how frequently cattle enter auction markets in a physical condition that is below industry standards. Since it is not known how often unfit culled cows are transported to auction, it is difficult to determine the magnitude of the problem and what action should be taken to address these issues. Research is needed to determine the frequency of non-ambulatory culled cows arriving at auction markets, and the delivery of cull cows that are in poor physical condition, as determined by industry expectations. Research is also needed to explore

methods to encourage producers to assess their cattle prior to loading, and ensure that they only transport cows that are considered fit to withstand transport.

CONCLUSION

This is a review of the current legislation, reference guides, and scientific literature regarding culling and the transportation of dairy cattle between farm and off-farm disposal sites. Culling may be defined as the removal of a cow from the herd and the end of productive life. Culling has been described as being a voluntary or involuntary choice of the producer, whose decisions can largely influence culling rates and the profit of the herd. There are many risk factors for culling, with the most common being fertility, milk production, or udder problems, which can be either directly or indirectly influenced by injury or disease. If injury or disease is present, a cow may be considered non-ambulatory, and this has the potential to put the cow's welfare at risk during transit due to exhaustion, pain or malaise. Similarly, there is an abundance of literature discussing the welfare implications of transportation, and multiple Canadian legislations that intend to protect the welfare of animals that are transported. A producer's decision to cull, and subsequently transport a cow from the herd is multifactorial, and can be influenced by perceived profit, health status of the cow, and its perceived benefit to the herd.

Currently, there are multiple gaps in the literature pertaining to culling and transportation of cows. A more thorough understanding of the entire cull and transportation process would greatly benefit the industry. Firstly, although a cohesive definition for the term 'cull' has been made, its implementation into the literature has not been successful. Future efforts to implement knowledge translation and transfer of this definition are needed to ensure all those involved in the topic of culling fully understand its definition. Additionally, research is needed to determine

under what circumstances a cow may be considered to be unsuitable for transport, for standardization of animal transport standards. This can help producers to confidently determine when a cow should, or should not, be transported. Research is also needed to determine how compromised cow health status impacts on the ability to withstand the stress of transport. Research in determining how different transport conditions, such as journey length or weather would also be beneficial in determining if transportation should proceed or be halted under specific transport conditions. In addition to this, research is needed that will explore methods for encouraging producers to cull and transport on healthy cows that are fit for transport and suitable for slaughter, to prevent the transport of unfit cattle and protect their welfare. Similarly, an area of research that has not yet been explored is the frequency of dairy cows that are culled and transported off of farm in conditions that are considered to be below industry animal care expectations. The lack of investigation in this field prevents the industry from having a comprehensive understanding of how large of a problem, the transport of unfit cull cows may, or may not be.

Research objectives

The work described in this thesis was designed to address two of the major gaps in the literature. First, a study was designed to determine the general condition of cull dairy cows entering and sold at auction markets in Ontario over a defined time period. The condition of these cows was assessed using industry animal care standards. The second research project was a study that assessed a producer's decisions to cull based on understanding of current animal health industry standards. This study provided producers with a tool to allow them to assess cow conditions and compare to industry standards to determine the suitability of a cow they intended

to cull for transport. Together these research projects provided a more comprehensive understanding of the condition of cull cows at farm, and sold at auction markets, in Ontario.

CHAPTER TWO

ASSOCIATIONS BETWEEN THE GENERAL CONDITION OF CULLED DAIRY COWS AND SELLING PRICE AT ONTARIO AUCTION MARKETS

INTRODUCTION

The process surrounding the decision to cull, or to remove a cow from the herd, is quite complex in terms of overall farm production but also cow welfare (Langford and Scott, 2012). Culling is a routine practice with the annual culling rate, or the rate at which cows leave the herd, being above 30% of the herd in the U.S. (Hadley et al., 2006; De Vries et al., 2010; NFAHWC, 2017). Most commonly in North America, culled cows are sent to slaughter; they are transported to an auction market, bought by abattoir representatives, and then further transported to the abattoir to enter the food chain (Fetrow et al., 2008). The most common risk factors for culling are reproductive problems, low milk production, or udder problems (Milian-Suazo et al., 1989; Beaudeau et al., 1993; Bascom and Young, 1998; Chiumia et al., 2011). The presence of injury or other diseases, however, can both directly and indirectly increase the risk of culling for dairy cows, as cows may be culled specifically because of that condition, or because its presence negatively impacts the cow's performance (Dohoo and Martin 1984; Grohn et al., 1997; Rajala-Shultz and Grohn, 1999a; Rajala-Schultz and Grohn 1999b). In fact, Beaudeau et al. (1993) found that at least half of all culling decisions are associated with health problems. This finding can be further supported by studies which have found an association between lameness and reproductive problems, mastitis, and reduced milk production (Barkema et al., 1994; Booth et al., 2004), as well as reproduction and production problems (Martin et al., 1982; Dohoo and Martin

1984; Rajala-Schultz and Grohn 1999b). However, the complex reasons for culling are typically not observed in farm records as dairy producers commonly record only one primary reason for culling, and therefore the full influence of all culling factors are not captured (Bascom and Young, 1998).

As stated in both the Codes of Practice for the Care and Handling of Dairy Cattle (National Farm Animal Care Council, 2009) and the Health of Animals Regulations Part XII (Canadian Food Inspection Agency, 2016), producers should transport only healthy animals. It follows that animals that are unable to cope with the stress of transport due to disease, injury, or any other factors, which may impact their welfare, should not be transported. As mentioned above, a cow may be culled and subsequently transported to an auction market with an injury or disease that impacts their performance (Milian-Suazo et al., 1989; Bascom and Young, 1998; Chiumia et al., 2011), but that disease or injury could also put their welfare at risk during transport (Langford and Scott, 2012). Additionally, the disease or injury may be exacerbated by transport, however, currently there are no data available to determine to what extent. To the best of our knowledge, there are no published reports on the general condition of cows transported to, and sold at Ontario auction markets. Therefore, it is difficult to quantify if, and how frequently, compromised animals are transported. Furthermore, there has been no research published on the potential effect of culled cow condition on market price.

The objective of this study was to assess the general physical condition of culled dairy cows sold at Ontario auction markets and to determine if there was a relationship between their condition and the sale price. Assessment of each culled cow was made in accordance with the Dairy Farmers of Canada proAction Animal Care guidelines (2017); a Canadian audit that uses

animal-based measures for scoring the health and welfare of farmed dairy cattle. ProAction is the first animal care audit to be nationally implemented within Canada. We hypothesized that culled cows sold at auction in suboptimal condition, as determined by using proAction Animal Care animal-based evaluation methods (2017), would sell for less compared to cows that were in good condition.

MATERIALS AND METHODS

Data collection

Culled dairy cows, sold at auction, were visually observed and evaluated during weekly sales at licensed Ontario livestock auction markets. The livestock auction markets (n=3) were visited from May to August 2017, inclusive. This study was designed as a cross sectional observational study. Observers had no influence on the care and handling of the cattle being sold.

Through the use of Beef Farmers of Ontario weekly auction market reports we determined there were 28 licensed auction markets in Ontario, which were selling over 2,000 culled cows a week. Based on ring announcements at sales, it was determined that Ontario receives cattle from other provinces outside of Ontario. Additionally, Ontario is also the only province with mandatory government inspection at livestock auction markets, carried out by government-appointed veterinarians. Therefore, Ontario was an ideal province for conducting this research. The three auction markets visited in this study were a convenience sample selected based on logistical considerations, in particular, selling cull cows on different days of the week (to allow for weekly visits), and their geographical location (to allow for daily commuting from the home of the primary observer).

Other non-auction locations throughout Ontario may also be used for the sale and collection of culled cows, but are not licensed or recorded in the provincial auction market reports used for reference in this study, and therefore are not represented in this project.

A sample size was difficult to estimate given the limited information published in this area. A preliminary unpublished pilot study conducted at the University of Guelph, which observed just under 1000 cows at an Ontario auction, conducted approximately four years ago, yielded an average price of $0.49 per kg and a standard deviation of 0.08. In that study, the smallest difference between cows with abnormalities and normal cows was $0.01 per kilogram. Using these data it was estimated that approximately 1400 cows would need to be sampled at an auction in order to find a difference in price of at least $0.01 per kilogram with a power of 80% and with 95% confidence. Given that the pilot was conducted at only one auction a target sample size of 1400 cows per auction was planned. This would have provided a total target sample size of 4200 cows for the study. Based on this, observers aimed to collect data on 100 cows, per sale, however, there were some auctions when reaching the minimum target sample was not possible because of the small number of cows offered for sale on that day at that location. By referencing weekly auction market reports, 4 weeks prior to the start date of data collection, we determined that the number of culled cows sold through the three auction markets represented approximately 40% of all culled cows sold at auction in Ontario during that time frame. Therefore, it is likely that this sample may be considered representative of Ontario culled cows sold at auction markets.

Observers arrived at the livestock auction market approximately 15 minutes prior to the scheduled start of the cull cow/slaughter cow portion of the sales. The date and time of the

previous weeks' auction sale were reported on the auction market websites, which were used to determine the start time of the culled cow sales. Two observers stationed themselves within the stands intended for public viewing of the cattle, sitting no further than 10 meters from the auction ring. Observers also sat in-line with the door through which animals entered the ring, to ensure a consistent viewing perspective of every animal across the different study sites.

Prior to sale, cattle were kept in group pens at the auction facilities. They may or may not have had access to food (dry hay) and water, depending on factors beyond our control (e.g., date of arrival at the facility, pen space available for holding). At the start of the sale, employees moved the cows to the sales ring where the cow was bid on. No information regarding the cow's origin, medical history, or transport duration was available for the research team to use. For every culled dairy cow that entered the auction ring, the primary observer scored and recorded each cow's general physical condition by visually determining the hock injury score, body condition score (BCS), gait score, and the presence or absence of a tail (see Table 1 for exact methods used). The secondary observers recorded the breed, body weight (BW) shown on the auction ring scale, and the cow's sale price (CAD/pound BW) announced by the auctioneer. Data were then later converted to metric units ($/kilogram). Government-appointed veterinarians, present at every sale, had the authority to condemn and/or prohibit the sale of any cow they felt could not be transported without undue suffering, due to disease, injury, fatigue, or any other factor. Therefore, the cows observed in this study did not include the cows that were prohibited from sale. The exact number of cows condemned per sale was unknown to the researchers.

All variables used to score the general physical condition of the cows were adapted from proAction Animal Care program (2017), which uses a prescribed scoring system (Table 2.1).

Observers had an average of 20 seconds of viewing time per cow, and were seated up to 10 meters away from auction ring. Due to the difficulty of accurately distinguishing between 4 or 5 different categories, given the circumstances, each measure was categorized as either acceptable or unacceptable (Table 2.1). The use of these terms reflects terminology used in the proAction Animal Care standards manual (acceptable, needs corrective action, and monitor) and is based on whether the measures meet, or fail to meet, proAction standards. The primary observer was trained by a Holstein Canada Animal Care representative, and re-evaluated scoring resources every three weeks in order to retain intraobserver reliability. Secondary observers were brought to the auction market for one training session prior to the start of the data collection period. Observations were only made on dairy cows and heifers brought into the auction ring. Many breeds of dairy cows, were evaluated, including Holstein, Jersey, Brown Swiss, Ayrshire and crosses. Beef cows, steers, bulls, and calves were excluded from this study. The observers were not blind to the hypotheses during data collection. Standardized data collection sheets were consistently used at every sale to record observations. Data were directly entered into an Excel spreadsheet (Microsoft Excel © 2016). The excel spreadsheet was then imported into Statistical Analysis Software (SAS 9.4; SAS Institute Inc., Cary, NC, USA) for statistical analysis.

Statistical analysis

The frequencies of acceptable and unacceptable hock injury scores, BCS, gait scores, and tail scores were tabulated using the SAS procedure PROC FREQ (SAS 9.4 Institute Inc., Cary, NC, USA) with data sorted by location. To model the dependent variable, price, a general linear model was used with the procedure PROC MIXED (SAS 9.4 Institute Inc., Cary, NC, USA). The fixed effects, or explanatory variables, included in the model were: hock injury score, BCS, gait

score, tail score, BW, location, week, and breed. Except for location, 2-way interactions between all explanatory variables were tested as well as a quadratic term for BW. Location was treated as a blocking variable, a source of variation to be accounted for; but interactions with location were not thought to be meaningful due to the auction market's confidentiality wanting to be maintained. Data were then converted from $/pound to $/kilogram. Because there were over 4400 observations made throughout the study, variables not significant at $P < 0.001$ were removed from the model.

The assumptions of the ANOVA were assessed via residual analyses. In order to assess for normality, the assumptions of the ANOVA were assessed via residual analyses using PROC UNIVARIATE (SAS 9.4 Institute Inc., Cary, NC, USA): Kolmogorov-Smirnov, Shapiro-Wilks, Cramér-von Mises, and Anderson-Darling. No tests were successful in normalizing the data. In addition, the residuals were plotted against the explanatory variables used in the model. Outliers were also removed from the data in order to attempt to normalize; however this did not create normality and were left in the data set. Therefore, no residual analysis was used. The least square means were used to calculate the estimated price for each variable, and were plotted against each variable to determine how different scores of the variables impacted the estimated sale price for the cow.

RESULTS

General description of sample numbers and averages

A total of 4460 culled dairy cows were observed during 64 auction sales at three Ontario auction markets throughout the study period. Complete data were recorded for 95% of the cows

assessed (n = 4235/4460). Culled cows sold were predominantly Holstein (92.5%) along with Jersey (3.8%), Ayrshire (3%), and Brown Swiss breeds (<1%). Observations were made for 1401 culled cows at location 1 (31.4% of the sample), 1290 culled cows at location 2 (27.7%) and 1769 culled cows at location 3 (38%). For the price difference analysis, any culled cows assessed that did not have complete data were removed from the analysis (n = 225). However, in order to determine the frequency of each variable measured for the general physical condition, all available data were used. Overall, data were recorded for 4439 cows for a hock injury score, 4457 cows for a BCS, 4271 cows for a gait score, and 4459 cows for a tail score.

The average sale price ($/kg BW) for culled cows was $1.94/kg, however, the sale price varied by location. At location 1, culled cows sold for an average of $1.94/kg ranging from $0.24 to $3.24/kg. At location 2, culled cows sold for an average of $1.90/kg ranging from $0.53 to $3.31/kg. At location 3, the average price/kg was $2.00 ranging from $0.22 to $0.81. The average BW of the culled cows sampled was 640 kg. BW also varied depending on location. Location 1 sold cows with an average BW of 642 kg, ranging from 322 kg to 1027 kg. Location 2 sold cows with an average BW of 620 kg, ranging from 218 kg to 993 kg. At location 3 cows were sold with an average BW of 654 kg, ranging from 302 kg to 1102 kg.

General condition of culled cows in Ontario

The frequency of each measure scored as either acceptable or unacceptable (Table 2.1), according to proAction Animal Care standards (2017), was calculated and plotted in Figure 2.1. For the 4439 cows that had data recorded on hock injury score, 27.2% were scored as having an unacceptable hock injury score, meaning an injury was present on at least one leg with swelling

greater than 1 cm and/or a lesion (n = 1209/4439). For the 4457 cows that had data recorded on BCS, 40.5% of culled cows scored had an unacceptable BCS of 2 or less, which is considered too thin (n = 1804/4457). For the 4271 cows that had data recorded on gait score, 72.7% of culled cows were scored as having an unacceptable gait, indicating that they had some abnormality in their stride which ranged from a severe limp, to inability to track-up (n = 3090/4271). Lastly, for the 4459 cows that had data recorded on tail score, 12.5% of culled cows had tails that were docked at or above the switch (n = 550/4459).

Relationship to price/kilogram

The final statistical model comparing the association between the general condition measures of the cows and price is presented in Table 2.2. Results showed that there was a $0.20 difference in the price paid/kg for culled cows had a BCS≤2, compared to those that had a BCS>2 ($P < 0.001$; 95% CI: 0.18-0.21). There was a $0.05 difference in price paid/kg for culled cows that had an abnormal gait, compared to those that had a normal gait ($P < 0.001$; 95% CI: 0.035-0.066).

There was a significant interaction between BCS and gait on price paid/kg, which is presented in Figure 2.2. If the cow had a normal gait, there was a $0.24 difference in price paid/kg depending on whether the cow had a BCS>2 or a BCS≤2 ($P < 0.001$; 95% CI: 0.20-0.26). Similarly, if the cow had an abnormal gait there was a $0.15 difference in the price paid/kg depending on whether the cow had a BCS>2 or a BCS≤2 ($P < 0.001$; 95% CI: 0.014-0.18). If BCS>2, there was a $0.09 difference in price paid/kg for cull cows with a normal gait compared to an abnormal gait ($P < 0.001$; 95% CI: 0.068-0.101).

There was no difference in the sale price ($0.009/kg) found for culled cows that had unacceptable hock injuries compared to those that had no hock injuries ($P = 0.23$; 95% CI: 0.022-0.053). There was also no difference in the sale price ($0.007/kg) for culled cows with docked tail compared to those with a full tail ($P = 0.4451$; 95% CI: 0.024-0.0011).

DISCUSSION

In Ontario, approximately 120,000 culled cows (beef and dairy) are marketed through licensed auction markets a year (Mike Draper, OMAFRA, Woodstock, ON, personal communications). Although, the most common risk factors for culling are issues regarding the cow's milk production or fertility (Beaudeau et al., 1993; Bascom and Young, 1998; Chiumia et al., 2011) disease and injury can also contribute to a producer's decision to cull. A cow may be culled specifically because of that injury or disease, or because it results in a reduced performance by the cow (Dohoo and Martin 1984; Grohn et al., 1997; Rajala-Schultz and Grohn 1999a; Rajala-Schultz and Grohn 1999b). If a cow is culled and transported to an auction market, with a present disease or injury, it may not be able to withstand the stress of transport, and its welfare thus may subsequently be reduced (Canadian Food Inspection Agency, 2016).

Despite the growing interest in animal welfare, specifically surrounding livestock transport, this is the first study to document the general condition of culled dairy cows sold at licensed auction markets in Ontario. Due to the lack of previous research on this topic, it is unknown how frequently culled dairy cows are sent to auction markets in unacceptable condition, as determined by recent industry guidelines for animal care. Having a benchmark of

this frequency would provide insight for the industry, identify key areas of focus for improving livestock transport conditions throughout Canada, as well as protect animal welfare.

General condition of culled cows in Ontario

The first objective of this study was to determine the general physical condition of culled cows sold at Ontario auction markets, and the frequency of culled cows with apparent physical problems sold at auction markets. The general physical condition of the culled cow was assessed in accordance with Dairy Farmers of Canada proAction Animal Care standards (2017). Since it's implementation, these standards are the new national standard in assessing animal care and welfare. The general condition of a number of the culled cows sold at auction sampled in this study did not meet proAction's industry standards. Because these standards were only implemented in September, 2017, after the data collection period had been completed, it may be of value to repeat this study in future to assess whether the industry has made progress.

Regarding hock injury scores, 27% of culled cows observed had a hock injury present on at least one leg with medium to major swelling and/or a lesion present. The frequency of unacceptable hock scores was lower at the auction market than what has previously been reported on farm. A recent study (Zaffino Heyerhoff et al., 2014), which is the largest of its kind in Canada, found that 47% of 2713 cows, measured across 90 free-stall farms, had at least one hock injury present, when using the same scoring criteria as the present study. Similarly, Nash et al. (2016), found that 52% of the 3868 cows measured, across 100 ties-tall farms in Quebec and Ontario, had a hock injury present, when using the same scoring criteria as the present study. Hock injuries have been widely accepted as a welfare concern for dairy cattle by the scientific

community and by expert opinion (Whay et al., 2003). The results found in this study may indicate that progress is being made in identifying and preventing hock injuries in dairy cattle, as it is a highly prevalent injury within the industry and has become an area of focus in the proAction Animal Care standards. Alternatively, methodological differences in the current study compared to the studies cited (study population, study period, reduced time to assess injuries, and viewing animals from a greater distance), may have yielded a more conservative prevalence of injuries at the auction markets.

The results of the BCS of culled cows sampled in this study illustrated that 40% of culled cows had a BCS≤2, which is considered too thin according to proAction Animal Care Standards (2017). Roche et al. (2009) reported that cows that calve with lower body condition were likely to have lower milk production, reduced fertility with a longer postpartum anestrus interval, and were more likely to be categorized as being at risk for reduced welfare. These results suggest that low BCS is related to common risk factors for culling such as milk production and fertility problems, potentially explaining the high prevalence of low BC (Bascom and Young, 1998). Additionally, in a study completed by Norring et al. (2014), with data collected on 70 milking cows regarding feeding behaviour and gait scoring, results indicated that cows had reduced feed intake and allocated time to feeding at or before visible change in gait. It is likely if feed intake decreases, that body condition will also decrease to compensate, potentially resulting in low BCS. Hence, as the many reasons leading to culling may contribute to dairy cows losing weight, it was not unexpected that a high proportion of culled cows sold at auction markets had low BCS. Further research is needed to examine the possible relations between animal welfare and

low BCS, specifically how culled dairy cows with low BCS respond to transport and being sold at auction.

In this sample of culled cows, 72% had some abnormality in their stride, which ranged from an inability to track-up to a severe limp. Previous research conducted in Ontario, Canada, which assessed 40 free-stall barns, found that the average prevalence of on-farm lameness was 20 to 30% of the milking herd, and was as high as 69% (Solano et al., 2015). Therefore, when comparing previous findings of abnormal gait on dairies to the findings in this study, our results are not unexpected. Additionally, previous research has indicated that lameness can impact the risk of culling. Booth et al. (2004) reported that lameness increased a cow's risk for being culled, depending on days in milk at diagnosis. Barkema et al. (1994) found that lameness can have a negative effect on reproductive performance, one of the most common risk factors for culling dairy cows. The results from these previous studies may help to explain why over two thirds of the cows sampled in the current study had an abnormal gait. Future research is needed to assess how abnormal gait and lameness may impact the welfare of culled cows during transport and how the conditions of transport influences lameness severity.

Finally, 12% of culled cows sampled had their tails docked at or above the switch. The practice of tail docking in dairy herds remains prevalent in North America despite substantial research that shows there is no benefit to the practice (Matthews et al., 1995; Tucker et al., 2001). The 2014 National Animal Health Monitoring System reported 49.5% of dairy cow operations in the United States had at least one or more cows with a docked tail. With the implementation of proAction Animal Care standards in September 2017 in Canada, performing tail docking on dairy farms is now prohibited unless deemed medically necessary by a

veterinarian. In preparation for adhering to these new standards, farmers may feel pressured to cull cows that already have docked tails to improve their chance of scoring well in their initial proAction Animal Care assessment.

Relationship to price/kilogram

The second objective of this study was to examine whether there was an association between the general physical condition of culled cows sold at auction and sale price. We found that culled cows with BCS≤2 sold for less compared to cows with BCS>2. Considering that the average BW for culled cows with BCS≤2 sampled in this study was 584 kg, and applying the difference in price to this lower average BW, the overall loss was approximately $117/thin cow. Although buyers may look for leaner animals, as their meat will typically be used for food products such as lean/extra-lean ground beef or hamburger, this difference in price may largely be influenced by extremely thin cows (BCS 1), as the buyers may be hesitant to buy a cow that looks emaciated.

Culled cows that had an abnormal gait sold for less. This difference in price approximated to a loss of $32/cow. As mentioned previously, abnormal gait, specifically lameness, is related to multiple diseases commonly seen in the dairy industry, and therefore may be perceived negatively by the buyers, because lame cows could be at risk of having other less obvious problems. Further, purchased culled cows are transported after the sale to abattoir, and buyers may be concerned about the risk of potential losses from transporting a lame cow who has a greater likelihood of becoming recumbent during transport, leading to euthanasia or condemnation. More research is needed following culled cows through the entire food system

from farm, through auction, to abattoir to assess fitness for transport and how it may be affected by different transit conditions.

There was also a relationship between BCS, gait and price (Figure 2.2). Culled cows with a BCS>2 and a normal gait, sold for more compared to culled cows with a BCS≤2 and a normal gait. Similarly, culled cows with an abnormal gait and a BCS>2 sold for more compared to culled cows that had an abnormal gait and a BCS≤2. These results indicate that a difference in BCS has a more profound effect on price compared to a difference in gait score. If a cow was considered too thin, differences in the sale price, depending on gait score were minor. However, if a cow was well conditioned (BCS>2) the differences in the sale price due to differences in gait score were larger. According to the Codes of Practice for the Care and Handling of Dairy Cattle (National Farm Animal Care Council, 2009), neither too thin, or lame cows are fit for transport, and should be treated on farm. However, in this case, the concern for abnormal gait seems to be more prominent in well-conditioned cows, compared to thin cows. Future research to assess how lameness and BCS impact buyer's decisions is needed to further encourage producers to refrain from shipping thin or lame cattle.

There was no difference in the sale price between culled cows that had acceptable versus unacceptable hock injury scores (see Table 2.1), or for culled cows with a full tail compared to those that had a docked tail. These results suggest that there is no financial penalty for producers sending culled dairy cows to auction with hock injuries or docked tails. Reasons for the lack of association between these aspects of the cow's condition and the sale price are unknown, however, it may be that these measures are not something that concerns buyers when assessing the value of the cow. Cows with hock injuries are not necessarily lame, thus there may be less

risk to the buyer. Additionally, there is little research to indicate how hock injuries are associated with other health conditions. As such, this may contribute to a general lack of concern regarding hock lesions by cull cow purchasers. Similarly, a full tail or a docked tail has minimal effect on the overall health or condition of the cow when being viewed at auction, therefore is unlikely to impact the buyer's decisions. Docked tails are also not assessed at abattoirs, and there is no consequence to buying a cow with a docked tail for slaughter.

This study is limited by the fact that results can only be interpreted for the specific time frame and locations used during the study period. The three locations visited in this study sell a large proportion of culled cows sold in Ontario, and therefore, is likely representative of culled dairy cows sold in Ontario. Prices at which these cows are sold can vary at different times due to many factors, such as consumer demand, the US dollar relative to the Canadian dollar, and economic market. Because of the influence of these factors, we cannot make inferences about seasonal trends at auction markets and therefore the data may not be predictive of what one could expect to see next year, or a decade from now.

CONCLUSION

Culling is an important aspect of the dairy industry, and culled cows are constantly being bought and sold throughout Canada. This study provides the first benchmark of the condition of culled dairy cows sold at Ontario auction markets. Results showed that in many cases culled cows in less than optimal condition are transported to auction markets in Ontario and sold. Despite there being regulations in Canada that describe when an animal can and cannot be transported, results from this study show that culled cows are sold at auction markets in

conditions which do not meet industry standards and Ontario transport regulations. The main issues identified with culled cows in this study were low body condition score (too thin) and abnormal gait. Both translated into a lower sale price for the animal compared to those that were in good condition, which reduces potential profits for the dairy producer. Further research is required to determine ways to prevent the transport and sale of cows in poor general condition to protect their welfare and also to improve revenue for the producer. Future research is needed to assess fitness for transport for culled dairy cows and whether this may be impacted or limited by their general physical condition

Table 2.1 Variables used to determine the general condition of culled cows evaluated during sales at three auction markets, in Ontario, Canada, modified from, and in accordance with Canadian proAction® Animal Care standards (2017).

Variable	Acceptable score	Unacceptable score
Hock Injury Score[1]	No or minor (<1 cm) swelling, no hair loss, or balding area on hock	Medium (1-2.5 cm) to major (>2.5 cm) swelling, and/or broken skin (lesion) or scab on bald area
Body condition Score[2]	BCS > 2	BCS ≤ 2
Gait Score	No limp present when observed for at least four strides	Limp is obvious (cow is favoring one or more limbs), walks with an uneven, irregular jerky or awkward step, unable to track-up
Tail Score	Full tail present	Tail removed above or at the switch

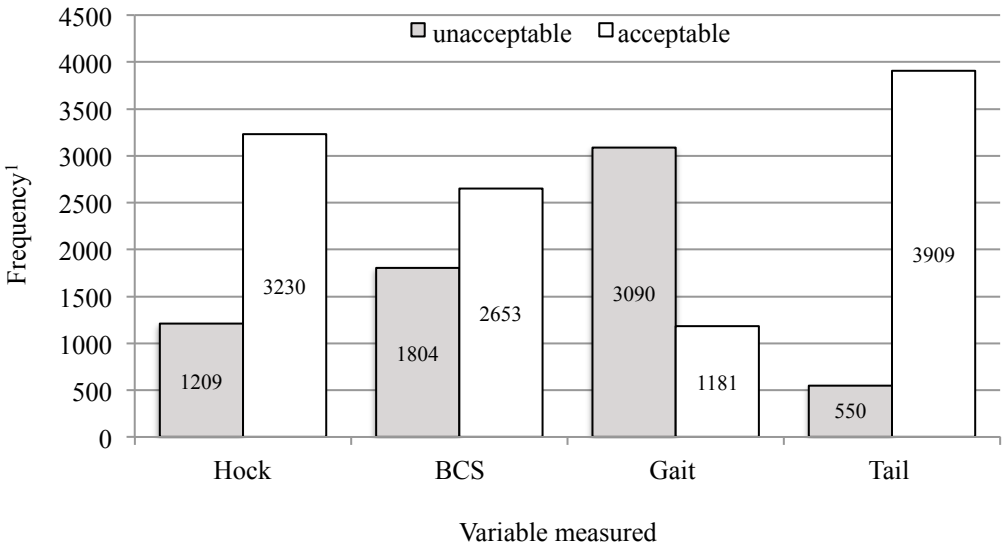
[1]Definitions for 4-point hock injury score provided by the 2017 Dairy Farmers of Canada, proAction® Animal Care program

[2]Definitions for 5-point body condition score provided by Codes of Practice for the Care and Handling of Dairy Cattle (NFACC, 2009)

Table 2.2 Final statistical model of the LSMEANS for factors associated with $/kg for culled dairy cows sold at three Ontario auction markets, over 16 weeks.

Variable	Estimated price ($/kg)[3]	SE[2]	95% CI[1] LCL	95% CI[1] UCL	*P*-value
No sale	0.00	0.00	--	--	--
Intercept	1.48	0.093	1.28	1.65	
BCS					
BCS>2	2.01	0.011	1.98	2.03	<0.001
BCS≤2	1.81	0.013	1.79	1.83	<0.001
Gait					
Normal gait	1.94	0.012	1.92	1.96	<0.001
Abnormal gait	1.89	0.011	1.87	1.92	<0.001
Hock					
No injury	1.92	0.017	1.87	1.94	<0.001
Injury	1.90	0.017	1.87	1.94	<0.001
Tail					
Full tail	1.92	0.016	1.87	1.94	<0.001
Docked tail	1.90	0.018	1.87	1.94	<0.001
Location					
Location 1	1.90	0.017	1.87	1.94	<0.001
Location 2	1.87	0.018	1.85	1.92	<0.001
Location 3	1.94	0.017	1.90	1.96	<0.001
Breed					
Holstein	1.94	0.0044	1.94	1.96	<0.001
Jersey	1.70	0.17	1.65	1.74	<0.001
Brown Swiss	2.05	0.035	1.94	2.16	<0.001
Other	1.94	0.021	1.90	1.98	<0.001
Body weight	0.090	0.012	0.066	0.11	<0.001
Week	0.066	0.0029	0.062	0.073	<0.001

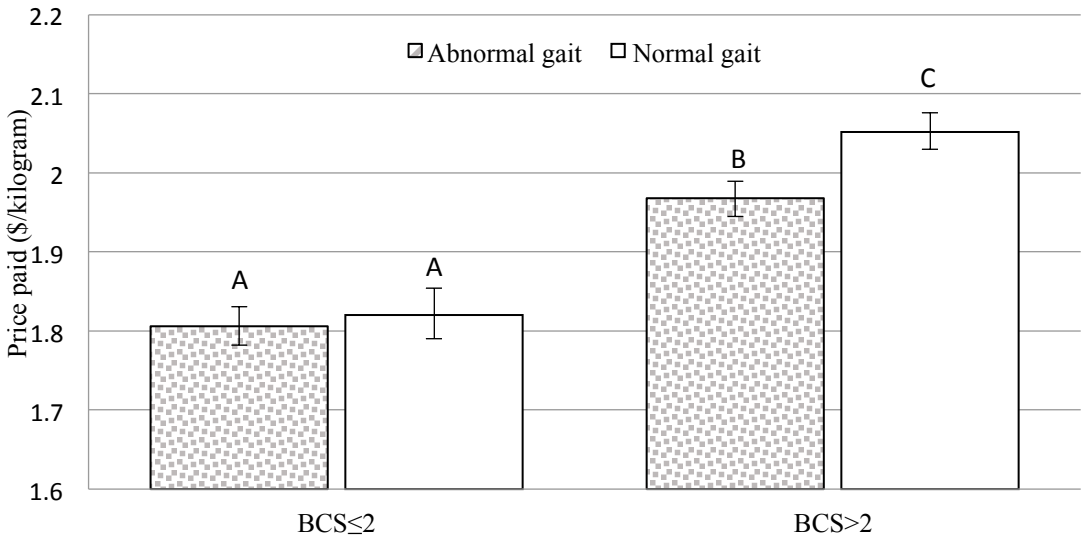
[1]Confidence interval for LSMEANS, lower (LCL) and upper (UCL) confidence limits
[2]Standard Error
[3]Estimated price/kilogram($/kg BW)



[1]Full data (all variables) were available for 4439 cows for hock scoring, 4457 cows for BCS, 4271 cows for gait scoring, and 4459 cows for tail scoring

Figure 2.1 The frequency of acceptable and unacceptable scores given to culled dairy cows sold at three auction markets in Ontario, Canada, based on the 2017 Canadian proAction Animal Care guidelines for animal-based measures.

Acceptable hock = no injury present, or a hock with swelling less than 1 cm, and balding only, no broken skin or scab; unacceptable hock = hock injury present with swelling greater than 1 cm and/or broken skin/scab; acceptable BCS = BCS>2; unacceptable BCS = BCS ≤ 2; acceptable gait = no abnormalities observed in four consecutive strides; unacceptable gait = presence of limp or inability to track up viewed during four strides and; acceptable tail = full tail; unacceptable tail = a tail docked at or above the switch.



* Different letters above the bar indicates there is a significant difference in estimated price paid per kilogram ($P < 0.001$)

Figure 2.2 Estimated price paid ± standard error bars, in dollars/kilogram, for culled dairy cows sold at three Ontario auction markets, when the least squares means was plotted against price to determine how score impacted estimated sale price, and interaction between BCS and gait score variables was considered.

CHAPTER THREE

EVALUATION OF A CULL COW EVALUATION FORM DESIGNED TO AID DAIRY PRODUCERS TO SYSTEMATICALLY ASSESS COWS PRIOR TO CULLING

INTRODUCTION

In Canada, about 40% of dairy cows are culled, or removed from the herd, annually (NFAHWC, 2017). Most commonly, culled cows are transported to auction markets, bought by abattoir representatives and enter the food chain (Fetrow et al., 2008). The most common reasons for culling include reduced milk production, reproductive problems, and udder problems (Milian-Suazo et al., 1989; Beaudeau et al., 1993; Bascom and Young, 1996; Chiumia et al., 2011). Multiple studies have found that the presence of disease or injury increases a cow's risk of being culled (Martin et al., 1982; Dohoo and Martin 1984; Milian-Suazo et al., 1989; Beaudeau et al., 1993; Grohn et al., 1997; Rajala-Schultz and Grohn 1999). Although cows may ultimately be culled for production-related reasons, the presence of an underlying disease or injury can put culled cows at risk of not being fit for transport according to the Health of Animals Regulations (CFIA, 2017). If a cows that are not fit for transport are likely to have a reduced ability to cope with the stress of transport (NFACC, 2009).

In Canada, the Health of Animals Regulations (Humane transportation) requires that cattle meet certain health and welfare standards prior to being transported, to ensure their welfare (CFIA, 2017). It is also a Requirement of the Canadian Codes of Practice for the Care and Handling of Dairy Cattle (NFACC, 2009) that every animal be assessed before transport and that

only healthy and fit cattle, that are able to withstand the stress of the expected trip, are transported. In the province of Ontario, the Livestock Community Sales Act (LCSA) requires that every licensed auction market have government-appointed lay inspectors, who inspect all animals that arrive at the auction market, and a veterinarian who inspects all of the animals that are considered compromised or non-ambulatory and have been segregated (LCSA, 1990). A non-ambulatory animal is defined as an animal that has a reduced capacity to cope with the stress of transport due to poor health, injury, distress, fatigue, infirmity or their age (CFIA, 2017). Further, the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2015), which is a provincial document used by appointed inspectors, outlines next steps to be taken with livestock at auction and abattoir, depending on the specific health conditions of the animal.

Currently, the Codes of Practice provide tools to assist in evaluating cows prior to transport, such as a decision tree and standard operating procedures (SOPs; NFACC, 2009) to ensure that only cows fit for transport are loaded. Additionally, due to the recent implementation of Dairy Farmers of Canada's proAction Animal Care initiative, as of September 2017, all dairy producers are required to have a documented SOP for transporting cattle. These tools may not be sufficient to ensure producers are evaluating all of their cows prior to transport. Despite these regulations, veterinary inspection and specific tools for farmers, dairy cattle still occasionally arrive at auction markets in a non-ambulatory state (Mike Draper, OMAFRA, Woodstock, ON, personal communication). Additionally, recent research has shown that there are instances of culled cows that have low body condition or are lame and are sold at auction markets, which is inconsistent with proAction Animal Care guidelines (Moorman et al. *Accepted*). As such, there is a need to train producers to effectively assess their cattle prior to loading to prevent the shipment

of cows that are not suitable for transport. Further, the National Farm Animal Health and Welfare Council (2017) indicated in their recent lay publication, "Management of Cull Dairy Cows" that greater involvement of veterinarians in their producer's decision-making on suitability for transport would be beneficial for ensuring more timely culling, and subsequently prevent the exacerbation of health disorders (NFAHWC, 2017).

In this present study, dairy producers were recruited by their veterinarians and taught how to use an evaluation form to assess their cattle prior to loading, in order to reduce the instances of shipping cattle, unfit for transport. Recently, authors from Utrecht University, summarized models throughout the literature that focus on creating behavioural change (Lam et al., 2017). The RESET model, that includes the use of Rules, Education, Social pressure, Economics and Tools, in multifaceted approach, can be effective at motivating behaviour change (Lam et al., 2017). For this study, we used an evaluation form to encourage producers to refrain from transporting unfit culled cows, with the aim of reducing the number of non-ambulatory and compromised culled cows arriving at auction markets.

The aim of this study was to evaluate the effectiveness of Ontario dairy producers' use of a cull cow evaluation form to systematically evaluate the cows to be culled from their herd. The objectives of this pilot research project were to educate dairy producers about the Health of Animals Transport Regulations and suitability of cattle for slaughter; to have producers use the evaluation form to prevent the transport of unfit cows and subsequently change their behaviour; to assess the utility of the evaluation form for improving the decision-making process; and to increase the involvement of veterinarians in their client's decision-making regarding transportation of culled cows. We hypothesized that the form would effectively increase the

knowledge of dairy producers and veterinarians on Canadian transport regulations, and that its use would result in the participants systematically assessing their cattle, and adopting the evaluation form into their every-day practice after the completion of this study.

MATERIALS AND METHODS

All methods for this study were reviewed and approved by the University of Guelph Research Ethics Board (REB#: REB17-03-010).

The research team, who had a combined knowledge of bovine veterinary medicine, dairy extension, and dairy cattle welfare, developed a cull cow evaluation form (Figure 3.1). The questions asked on the form were developed through the experience of the research team and consideration of the Health of Animals Regulations (Humane Transportation Regulations). The form was peer reviewed by the advisory committee prior to being used.

Recruitment

Sixteen bovine veterinarians, practicing in Ontario, were recruited to participate in this study in early December of 2016. Veterinarians who attended any of the 2nd Annual Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Veterinary Update seminars, were made aware of the forthcoming project and invited to contact one of the primary investigators for more information. Those who did were invited to participate in a conference call, hosted by the advisory committee, in early January 2017. Veterinarians received $100 for participating on the call, during which they were provided with further information about the study, its objectives, an overview of the study, and upcoming important dates throughout the study period.

Veterinarians then recruited up to 10 of their dairy clients to voluntarily participate in the study. The veterinarians were paid $25 for every farm they enrolled, up to a maximum of 10 farms. Some veterinarians from the same practice worked together to recruit 10 dairy producers rather than recruiting 10 per individual veterinarian. Three practices had three veterinarians working as a team and recruited 5 farms total, as opposed to 10. All other veterinarians worked individually.

Data collection

Once all producers were enrolled (Appendix 3.1), veterinarians were sent their own veterinarian package, and producer packages, corresponding number of producers they had recruited, to distribute to their enrolled dairy clients. The veterinarian packages contained: a 2-page cross-sectional pre-study survey, a guide sheet on how to score body condition (BCS) and lameness (consistent with the Guide to the Uniform Disposition of Compromised Livestock; Appendices 3.1 & 3.2), and 10 no-carbon required (NCR) cull cow evaluation forms (Figure 1). The producer packages included: a 3-page cross-sectional pre-study survey, guide sheets to scoring BCS and lameness (identical to those provided to the veterinarians; Appendices 3.1 & 3.2), and 10 NCR cow evaluation forms.

The pre-study surveys were developed by the research team to gather knowledge and opinions regarding the current practices and attitudes of both veterinarians and producers regarding their culling decisions. The use of NCR evaluation forms allowed the producer to retain 1 copy of each evaluation for their records, while returning the other copy to the research team for data analysis.

Producers were taught by their veterinarians to use the cull cow evaluation form. Producers were asked to complete one evaluation form each time a cow was culled from the milking herd from January 1st to June 30th 2017 inclusive. The form was to be used for cows greater than one parity. After the study period was complete, the post-study survey was sent out to be completed. The post-study survey intended to gather feedback on the usefulness of the evaluation form, to any potential areas for improvement, and to assess differences in veterinarian and producer's practices and attitudes as a result of being trained.

Statistical analysis

The responses provided by the veterinarians and producers from each survey and all evaluation sheets were compiled into a Microsoft Excel data sheet (© 2010 Microsoft Corporation). Any identifying information, such as name or location of farm or practice, was transcribed into a code known only to the principal investigator to protect the identity of the participants. Statistical analyses were conducted using the statistical analysis software SAS (version 9.3; SAS Institute Inc., Cary, NC, USA). PROC FREQ and PROC MEANS were used to determine the frequency of responses given for each of the completed pre and post-study surveys questions and the evaluation form questions. Several questions were asked in the pre-study survey as well as the post-study survey to determine whether there was a change in response after the study period. To account for the fact that the data were paired, a McNemar-Bowker test of symmetry was used to determine if there were statistically significant differences in the responses for questions with two possible responses (i.e., yes or no) or three possible responses (i.e., yes, no, or depends). A Wilcoxon signed-rank test was performed to determine if

there were statistically significant differences in the responses for questions with multiple possible responses (i.e., a Likert scale).

RESULTS

General description of participants

A total of 16 bovine veterinarians and 54 dairy producers participated in the study and were included in the analysis. All participants resided in southwestern Ontario. The average reported herd size was 123 milking cows (range: 14 to 694 cows). Veterinarians indicated that the average number of farms they attended (both herd health clients and dairy clients) was 39 farms, ranging from 8 to 240 farms.

Pre-study survey

A summary of the frequency of responses for questions asked in the pre-study survey completed by veterinarians (n = 15) and dairy producers (n = 47) are provided in Table 3.1 and Table 3.2, respectively. The average number of cows culled from the milking herds in the previous six months was reported to be 24 cows (range 2 to 250 cows). Of these, the average number of cows they sent to auction was reported to be 15 cows, (range: 0 to 200 cows). Overall, 17 farmers (36% of respondents) reported previously receiving feedback from a government-appointed veterinary inspector, about a cow they had transported to an auction market. Of all respondents, 42/47 (89%) indicated that it was the herd owner(s) who decided whether a cow could be transported. Veterinarians indicated that they were asked 19 times, on average (range: 2

to 50), to consult with a dairy client regarding culling or transporting during the previous 12 months.

Evaluation form results

Of the 54 dairy producers recruited by their veterinarian, 44 used at least one of the cull cow evaluation form during the seven-month study period. This resulted in the submission of 323 evaluation forms. Only 135 evaluation forms were fully completed.

Producers were asked to record the body temperature of the cow being evaluated. A total of 291 evaluation forms (90% of forms) recorded body temperature, with the average body temperature recorded being 38.4 degrees Celsius (range: 36.0 to 40.3°C). According to the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2015), a cow's body temperature must be between 37.9 and 39.4°C to be considered suitable for transport. Producers were asked to compare their findings to the Guide to the Uniform Disposition of Compromised Livestock requirements (OMAFRA, 2017), shown on the form and then report whether the cow was suitable for transport. A total of 293 evaluation forms (91%) were checked yes, and 4 evaluation forms (1.2% of the forms) were checked no. This means that there were six evaluation forms that did not provide a body temperature, but still indicated acceptability for transport. Ten of the 291 forms (3.4%) had a recorded body temperature outside the acceptable range for the cow to be fit for transport based on the standards of the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2015). Seven of those forms with temperatures recorded outside the acceptable range still checked-off that the cow was "okay" to be transported.

Producers were asked to record a BCS for the cow being evaluated in accordance with the Code of Practice for the Care and Handling of Dairy Cattle BCS scoring system (NFACC, 2009; BCS ranging from 1 (emaciated) to 5 (obese)). Results indicated that 319 forms (99%) had a BCS recorded and 4 evaluation forms had left the section blank. The most frequently reported BCS was 3 (n = 142/319). A total of 6 forms had a BCS of 1 recorded, 60 forms had a BCS of 2 recorded, 96 forms had a BCS of 4 recorded and 15 forms had a BCS of 5 recorded. If a half or quarter point was recorded, the score was rounded to the whole number (i.e., a score of 2.5 was considered a BCS of 2). According to the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2015), a cow must have a BCS of 2 or greater to be considered suitable for transport. Producers then compared their recorded BCS to the standards laid out by the Guide for the Uniform Disposition of Compromised Livestock, and indicated if the cow was suitable for transport (OMAFRA, 2015). Overall, 286 evaluation forms (90%) were checked yes, and 9 evaluation forms (2.7% of forms) were checked no. A total of 6 of the 310 forms indicated the cow had a BCS < 2, and of those, one form indicated that the cow was "okay" to be transported.

Producers were asked to record a lameness score also using the Code of Practice for the Care and Handling of Dairy Cattle scoring system (NFACC, 2009; lameness ranging from 0 (smooth and fluid movement) to 5 (unable to rise without assistance)). Overall, 307 of forms (95% of the forms) recorded a lameness score and 16 forms were left blank for that section. The most frequent gait score was zero (n = 199/306). A total of 70 forms had a gait score of 1 recorded, 28 forms had a gait score of 2 recorded, 6 forms had a gait score of 3 recorded, 2 forms had a gait score of 4 recorded, and 2 forms had a gait score of 5 recorded. According to the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2015), a cow must

have a lameness score of 0 or 1 to be considered suitable for transport. When producers were asked to compare their results to the Guide (OMAFRA, 2015), and was suitable for transport; 263 evaluation forms (81.6%) were checked yes, and 24 evaluation forms (7.4%) were checked no. Of the 307 forms, which had a gait score recorded, 33 (10.7%) indicated a score ≤ 2, which is considered to be unacceptable for transport. Twenty-three of those forms also indicated that the cow was "okay" to be transported, despite their assessment indicating that the lameness score was unacceptable.

The next portion of the evaluation form asked producers to assess whether the cow had been dried off and to record the last milking date. Overall, 187 evaluation forms (85%) had a milking date recorded that was the same as the assessment date recorded on the evaluation sheet, indicating that the cow had been milked that day, and therefore, was not dried off. A total of 33 evaluation forms (15%) had a last-milking date that preceded the assessment date, indicating the cow being assessed had been dried off, to some extent, prior to the time of assessment. There were 103 evaluation forms with no date provided (32% of forms). When asked to indicate whether the cow had been dried off completely, 119 evaluation forms (47%) were checked yes, and 132 evaluation forms (53%) were checked no. It is not mandatory according to Ontario transport regulations to dry off a cow prior to transport, therefore, there were no regulations for producers to use for a reference comparison.

Next, producers were asked to state whether any drug residues were possible in the cow being assessed, and asked to record the date that the cow had last been treated. Of the total number of forms received, 47 forms (14.5%) left this question completely blank, 101 forms (31%) recorded a date of last treatment, and 175 forms (54%) did not record a date but indicated

the suitability for transport in the last column. When asked to compare their recorded findings to transport requirements and indicate whether the cow was suitable for transport (withhold time for meat and milk is completed), 229 evaluation forms were checked yes (83%), and 46 evaluation forms were checked no (17%).

Producers were then asked whether there was a potential for mastitis to flare up by recording a California Mastitis Test (CMT) count for each quarter of the udder. Results for this evaluation point were somewhat divided, into forms with the section left blank, and forms having some indication that the producer checked each quarter for potential mastitis flare up. There were 39 evaluation forms that were left completely blank, and excluded from the analysis. A total of 137 evaluation forms did indicate that each quarter was evaluated in some way (48%), even if there was no CMT score provided. However, 157 evaluation forms were left blank (55%). When asked to compare their recorded findings to Ontario transportation requirements and indicate if the cow had no or only mild mastitis present and was suitable for transport, 228 evaluation forms were checked yes (80%), and 56 evaluation forms were checked no (20%).

For the final assessment point, producers were provided with a list of other potential problems that may impact the cow's suitability for transport, and asked to circle any that were present. There were 53 evaluation forms that were left blank for this section (16% of forms). Out of those that completed the section, 239 forms (88.5%) had no other problems circled out of the list provided and 31 (11%) had at least one of the problems provided, circled. When asked whether the cow being assessed was suitable for transport considering the presence of any of these conditions, 153 evaluation forms were checked yes (61% of forms), and 96 evaluation forms were checked no (38.5% of forms).

Aside from recording specific measurements related to the cow currently being assessed, producers were also asked to record the date the cow left the farm, and where they were sending the cow, with 4 possible options provided. Seven forms left this point blank. Of the 316 forms, that provided recorded a destination 239 (76%) indicated sales barn (auction market), 29 (9%) indicated sent direct to a local provincial slaughter plant, 8 (2.5%) indicated direct to a local federal slaughter plant, and 40 (13%) checked the "other" options and provided a space to write their destination. Of these 40 forms, 6 forms indicated that the cow was euthanized on farm.

Post-study survey

A summary of the frequency of responses for the post-study survey received from veterinarians (n = 9) and producers (n = 47) are presented in Table 3.3 and Table 3.4, respectively. Overall, all veterinarians who completed the pre-study survey also completed the post-study survey and 32 producers who completed the pre-study survey also completed the post-study survey. Five questions were asked on both the pre-study and post-study survey for veterinarians and seven questions were asked on both the pre-study and post-study survey for producers. When comparing differences in answers provided by participants between the pre-study survey and the post-study survey, only those who completed both surveys were included in the analysis. Five producers indicated that they used zero evaluation forms during the study, and two did not provide an answer. Producers used, on average, 7 forms throughout the study period (range: 0 to 53 forms).

Knowledge of culling and transportation standards. Participants were asked whether they would send a cow to an auction market if she had cancer eye, a left displaced abomasum

(LDA), or a hoof block, on both the pre- and post-study surveys. A McNemar-Bowker test was performed to determine if there was a change in the responses given from the pre-study survey compared to the post-study survey. For producers, there was no significant change in the responses given when asked if they would send a cow to an auction market with a cancer eye, an LDA or a hoof block ($P = 0.47$; $P = 0.77$; $P = 0.34$ respectively). With regards to veterinarian responses to the same question, there was also no significant change in their responses ($P = 0.32$; $P = 0.32$; $P = 0.95$).

Attitudes towards culling. Participants were asked, on the pre- and post-study survey, to score their confidence in their ability to determine whether a cow was fit for transport (1 = not confident, 5 = very confident). A Wilcoxon signed rank test was performed to determine if a respondent's confidence rating had changed from the pre- to the post-study survey. There was a tendency for a difference in the responses given by producers ($P < 0.01$). Nine of the 47 producers gave a higher confidence rating in the post-study survey, and two gave a decreased confidence rating. There was significant change in the responses given by veterinarians to this question ($P < 0.05$). Six of the 9 participants reported having higher confidence, while none gave a decreased confidence rating.

Producers were asked what options they would consider using when dealing with cows that could not be transported on both surveys. There was a significant increase in the number of producers who choose "contact a veterinarian" ($P < 0.01$), and "keep the cow to see if the problem resolves itself" ($P < 0.05$) as options for such cases.

Producers were also asked to score how involved their veterinarian was in helping them determine the suitability of a cow for transport on both surveys (1 = very not involved, 5 = very involved). There was a tendency for there to be a difference in the response given between the post-study and pre-study survey ($P < 0.01$). Overall, ten participants indicated increased involvement of their veterinarian.

Veterinarians were asked in both the pre- and post-study survey whether they recorded any information on cows that they assessed for their clients and there was no change in the response given in the post-study survey ($P = 0.39$).

Veterinarians were asked if they thought they were more likely, less likely, or just as likely to be asked by their dairy clients for their opinion about whether a cow is fit for transport since introducing the cull cow evaluation forms. One of the 9 veterinarians indicated that they thought they were more likely to be asked for their opinion.

DISCUSSION

In some instances, culled cows arrive at auction markets throughout Ontario with severe injury or health conditions, and are later condemned by government-appointed veterinarians despite there being federal regulations in place to prevent the transport of non-ambulatory cows (CFIA, 2017; Mike Draper, OMAFRA, Woodstock, ON, personal communications). As part of an attempt to prevent these occurrences this study provided Ontario dairy producers with an evaluation form that would assist them in inspecting cows they intended to cull, to ensure they were only shipping cows that meet the regulations set by Canadian standards (CFIA, 2016).

This is the first study, that we are aware of, that evaluated the use of a cull cow evaluation form by producers to systematically assess their cows prior to culling and loading. With our form, we attempted to directly give end-users specific guidance regarding acceptable thresholds for cow condition critical control points, oriented around suitability for transport. Some cows assessed did not meet the body temperature, BCS, and gait score requirements for transport, but were still subsequently evaluated, by the producer, as being "okay" for transport. Farmers may have chosen to willingly disregard the threshold, perhaps based on having previously shipped cows in similar condition. Another possibility is, they may not have understood that the thresholds provided arise from the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2017), used by veterinary inspectors at auction markets, to determine suitability. Finally, there may have been some misinterpretation of some questions asking whether or not cows were "okay".

Educating producers and veterinarians on Canadian Transport regulations

The first objective of this study was to educate participants on Canada's Human Transport regulations. Both the pre- and post-study surveys asked participants if they would transport a cow with the following conditions: cancer eye, a LDA or a hoof block. The dairy Code of Practice indicates that if a cow is experiencing any of the three conditions mentioned above, she should not be loaded, or should only by loaded with special provisions and sent directly to slaughter within 24 hours (NFACC, 2009). If participants were familiar with the Codes of Practice, they would consider refraining from transporting a cow to an auction market under all three conditions mentioned above. Similarly, the Guide to the Uniform Disposition of Compromised Livestock (2015) indicates that in the case of severe cancer eye or a displaced

abomasum, the animal should be condemned ante-mortem, be slaughtered in 24 hours, or euthanized.

After using the evaluation form, fewer producers reported they would send a cow with cancer eye to an auction market, while more veterinarians reported that they would send a cow with cancer eye to an auction market. Similarly, after using the form, both fewer producers and fewer veterinarians indicated they would transport a cow to an auction market that had a LDA or a hoof block.

Although the pre and post-study survey answers on the knowledge-testing questions did numerically change, there was no statistical difference in the responses. This may be due to a low number of participants, subsequently reducing the power of the analysis. Also producers were not asked to assess for cancer eye, a LDA, or a hoof block on the evaluation form, therefore limiting their opportunity to learn about these specific components prior to the post-survey. Additional research is needed to determine the most effective way of effectively informing producers on relevant requirements, so they can make informed decisions about whether or not to transport a culled cow.

Change behaviour in veterinarians and producers

Past research has shown that diseases or injuries are common risk factors for culling (Dohoo and Martin 1984; Grohn et al., 1997;). Therefore, it is important to assess the cow's health and general condition prior to loading to ensure they are fit for transport. Current research has shown that the transport of culled cows to auction, that are too thin or have an abnormal gait, still occurs in Ontario (Moorman et al. Accepted).

The second objective of this study was to determine if use of the evaluation form resulted in any change in behaviour. The number of participants already recording information on cull cows prior to transport was determined in the pre-study survey. Among veterinarians, there was no significant change in the number who recorded information on cull cows for their clients after completion of this study. The majority of producers responded that they would either use the form, or a modified version of the form in the future, indicating they planned to record information on their cull cows in the future. Thus use of the evaluation form on farm was successful in encouraging behaviour change in this regard.

The use of additional resources when assessing culled cows prior to transport also is presumed to be beneficial for ensuring that only cows suitable to withstand transport, or eligible for slaughter, are shipped. The study aimed to encourage consistent use of a written resource (such as a SOP or decision tree) to help producers and veterinarians decide what steps to take with a cow they want to cull from the herd. In the post-study survey, there was an increase in the number of producers who indicated that they would use the form, or use a modified version. Additionally, after the completion of this study, all veterinarians indicated they would recommend the evaluation form to other producers who did not participate in the study.

The amount of time allocated to assessing a cow prior to transport may help to ensure that the cow is thoroughly assessed and suitable for transport compared to producers who do not give any time to assessing their cattle. Results showed from the pre-study survey that almost half of the producers spent very little time (less than an hour) determining whether a cow is fit for transport. After completion of the study period producers were asked if the time they allocated to determine whether a cow was fit for transport had changed, and 38% indicated that it had

increased. Therefore, their experience using the evaluation form encouraged producers to spend more time deciding whether a cow was fit for transport. In some instances, the amount of time spent on assessing a cow prior to transport went from little to no time spent on the pre-study survey, to spending greater than five minutes assessing their cows after using the evaluation form. This result indicates that producers are becoming more aware that time and thought needs to be given to deciding whether to transport a cow off farm and is not a decision that can be made instantaneously.

Lastly, it is important that producers know what their options are in terms of dealing with a cow they feel cannot be transported. There was a significant increase in the number of producers who chose, on the post-study survey, that they would keep the cow to see if the problem resolves itself, and contact a veterinarian. Although keeping the cow to see if the problem resolves itself precludes, at least temporarily, the animal being transported, it is not a proactive way to manage the issue at hand. The increase in respondents who indicated they would contact their veterinarian for advice is encouraging in terms of dealing with cows that cannot be transported.

A follow-up study to determine whether the evaluation form has a continued effect on the behaviour of farmers and veterinarians would be beneficial. Additionally, future research is needed to determine if implementing this evaluation form translates into an actual reduction in the frequency of cull cows being transported to auction or abattoir in less than optimal condition, and to determine what producers do with cows they determine unsuitable for transport or slaughter. Producers may also be unaware of the amount of time a culled cow spends in transit from farm to auction market to abattoir. The NFAHWC (2017) indicated that culled cows can

spend up to 10 days in transit. Increasing producers' awareness of this possibility might encourage them to more thoroughly evaluate their cows prior to shipping, to ensure they are fit enough to withstand the potential journey duration.

Determining the utility of the evaluation form

Considering that this is a preliminary study, and the evaluation form is the first of its kind to be tested, another objective of this study was to assess the utility of the form itself. There was a tendency for producers to indicate that they were more confident in assessing cows prior to transport after using the form. There was also a significant increase in the number of veterinarians who gave an increased confidence rating in the post-study survey. Additionally, producers reported feeling more confident in determining whether a cow was fit for transport after using the evaluation form. Almost no veterinarians had a similar improvement in their confidence. However, there were no producers or veterinarians that responded that they were less confident after using the evaluation form.

In the pre-study survey, about half of producers reported feeling adequately trained. This increased to three-quarters of producers feeling adequately trained as a result of using the cull cow evaluation form. Additionally, the majority of producers indicated that the form was somewhat or very useful.

These results are a positive indicator of the usefulness of the evaluation form. Future research is needed to conduct a similar study with a larger sample size to assess its efficacy. Additionally, implementation of the form in different regions (within Canada, the United States,

or Europe) could help to determine how effective the form is under different conditions, transport regulations, and perceptions of culling.

Veterinary involvement in their client's decision-making.

The final objective of this study was to include veterinarians in their client's decision-making by having them train their clients on the evaluation form and encourage more of a discussion surrounding cull cows and their suitability for transport and slaughter. In the post-study survey there was a tendency for producers to report that their veterinarians were more involved in helping them with culling decisions, with 10 out of 47 producers indicating that their veterinarians were more involved in helping them assess culled cows after the study period had been completed. Veterinarians may have originally been less involved with their clients regarding culling decisions for a variety of reasons. A possible explanation might be that culling and transport may not often be an area of focus when assessing overall herd-health. Additionally, producers may be unlikely to consult their veterinarian about culling decisions because it is not advertently about the health of the cow, or because of past attitudes surrounding culling and transport. Thus our results are encouraging in terms of improving the narrative between veterinarians and their clients around culling.

Veterinarians were also asked to rate how likely they thought their dairy clients would be to ask them for their opinion about whether a cow was fit for transport. In the pre-study survey half of veterinarians thought they were either fairly likely or very likely to be asked for their opinion. Afterwards one out of nine veterinarians indicated they felt they were more likely to be involved by their client. In the post-study survey 15% of producers indicated that they were more

likely to involve their veterinarian in determining whether a cow is fit for transport, since using the form. These results are not indicative of the evaluation form being effective in causing more veterinary involvement, from the veterinarian's point of view. It is important that veterinarians communicate to their clients that they are able to help them with culling decisions. If veterinarians can show their clients the benefit of consulting them regarding transport decisions, producers may be more likely to involve their veterinarian. Future research is needed to determine ways to encourage veterinary involvement in their client's decision-making, and assessment of its effectiveness on transport decisions.

Improvements to the cull cow evaluation form

The post-study survey provided a space for participants to comment on ways they thought the evaluation form could be improved. Overall, ten producers and five veterinarians provided feedback. The most common suggestion for improvement from producers was to simplify the evaluation form to make it more user-friendly. Additionally, it was suggested that the form should improve and clarify the section which asked producers to record a CMT. No specific suggestions were provided, however, and due to the lack of compliance with completing this section, it may be best to remove it from future forms. The most common suggestion for improvement from veterinarians was also to simplify the form and address the confusing wording.

Secondly, the research team met to review the form after the study period had finished to determine areas of improvement. The research team identified ways that the layout of the form could be improved and other aspects of design that could be changed to, hopefully, reduce

confusion. It is important to note, that because of the layout of the form, results may not be a completely accurate reflection of what the producer intended to record. The research team decided that removing the first column of the form would be beneficial as it is a potential source of confusion for participants.

Additionally, the research team came to the conclusion that asking producers to record the CMT for every quarter was not effective, as there was only a 45-46% response rate for each quarter. This research team concluded that this section of the form should ask if there is good milk quality in all milking quarters, as opposed to recording a CMT.

Limitations

Considering the method of recruiting participants for this study, the occurrence of selection bias was possible. Veterinarians and producers were recruited voluntarily. Participants could, at any time, withdraw from the study, or choose to omit their response or participation throughout any point in the study. Subsequently, the number of participants at the start of the study period was larger than the number at the end, which may have resulted in loss of follow-up bias. Additionally, veterinarians were voluntarily recruited for this study through annual veterinarian update meetings, hosted throughout Ontario, which is not a mandatory meeting for all practicing Ontario veterinarians. Therefore, those who chose not to attend the meeting did not have the opportunity to volunteer. Subsequently, only dairy clients of these veterinarians that volunteered had the opportunity to participate in the study. This may have led to non-response bias, because the participants may have differed substantially from those who did not participate. Lastly, there was the potential for selective entry bias, in that those who agreed to participate in

the study may have been more knowledgeable and confident in assessing cull cows and therefore more willing to participate compared to producers or veterinarians who were less confident.

Veterinarians and producers had the option to refrain from answering any question given to them, which could have introduced non-response bias. A number of survey questions and evaluation forms were not fully completed. Non-response can decrease the power of the study, resulting in reduced likelihood for finding significance (type II error). To improve participation an incentive or draw could have been provided only to those who did fully complete their forms and surveys.

There was also a possibility for social desirability bias. Participants may have provided responses that they think the research team would consider to be more acceptable and may have refrained from providing their actual opinion/results. There is reason to believe this as multiple forms from the same dairy would record the same results for body temperature, BCS, or gait score across all evaluation forms used, despite this being highly unlikely. Participants were made aware, through the consent form signed prior to the beginning of the study, that their participation was anonymous, therefore there was no risk of identifying individuals, and that there would be no consequences as a result of the answers provided.

Lastly, there was the potential for participants to misinterpret the questions asked and provide an answer that is different from what they would have answered, if they understood the question. Producers indicated on the post-study survey that they would like the form to be clearer, indicating there was a possibility for misinterpretation of questions due to the layout of the form. We attempted to prevent this by peer reviewing the surveys and forms prior to their

distribution to participants and by seeking feedback in the post-study survey to draw our attention to any widespread problems with specific questions.

CONCLUSION

If a cow is culled from the herd and transported to auction with a disease or injury, their ability to withstand the stress of transport may be reduced, resulting in their welfare being at risk (NFACC, 2009). In order to prevent this an evaluation form was developed to assist producers and veterinarians in inspecting cows that were to be culled. Results showed that the use of this form was ineffective in educating producers and veterinarians about Canadian transport requirements, as laid out by the Codes of Practice (NFACC, 2009) and the Guide to the Uniform Disposition of Compromised Livestock (OMAFRA, 2015). The form was effective in changing, at least in the short–term, the behaviour of producers. They were more likely to record information on the cows they were going to be assessing in future, to use a specific physical resource, such as a documented SOP or a decision tree, to help with their decision making, to increase the amount of time allocated to deciding whether a cow can be transported, and to use the form as a documented SOP, as required by proAction. The form was also an effective tool for the participants in this study. Participants felt more confident in assessing cows for the suitability of transport after using the evaluation form. Participants also reported finding the evaluation form to be useful, and reported feeling adequately trained to assess cows for transport as a result of using the form. Lastly, the evaluation form did not prove to be successful in involving veterinarians in their client's decision-making on cull cows and transport. There was no increase in the amount of veterinarian involvement after implementation of the form. Future research is needed to test the efficacy of a revised version of the form used in this study, as there were many

areas of improvement possible for this current version. A revised form, or alternative methods to educate producers, are needed to reduce the shipping of culled cows, not suitable for transport.

Table 3.3 The questions, possible responses and frequency of responses given for the pre-study survey distributed to participating Ontario bovine veterinarians (n = 15).

Question	Possible responses	Frequency of responses[1]
On a scale from 1 to 5 (1= not confident, 5=very confident), how confident are you in your ability to help your client determine whether a cow is fit for transport?	1 2 3 4 5	0 0 3 12 0
What resources do you use when helping a client to decide about transporting a cow they are removing from the milking herd? Circled all that you use routinely	a) Documented (written out) standard operating procedure b) A decision tree/flow chart c) Past experience/ personal knowledge d) Consult other veterinarians or OMAFRA staff e) No criteria	2 3 15 11 0
Do you record any information on cows you assess for clients	Yes No Depends	3 8 4
Would you send a cow to the auction market that has cancer eye?	Yes No Depends	0 8 7
Would you send a cow to the auction market that has an LDA (Left displaced abomasum/twisted stomach)?	Yes No Depends	1 11 3
Would you send a cow to the auction market that has a hoof block?	Yes No Depends	2 2 11
On a scale from 1 to 5 (1=not likely, 5=very likely), how likely is it that you are asked by your dairy clients for your opinion about whether a cow is fit for transport?	1=not likely 2 3 4 5=very likely	0 1 5 6 3

[1]Participants had the option to refrain from responding to any questions provided in the survey, thus the frequency of responses may not equate to the number of participants

Table 3.2 The questions, possible responses, and frequency of responses given for the pre-study survey questions distributed to participating Ontario dairy producers (n = 47).

Question	Possible responses	Frequency of responses[1]
Who on this farm decides whether a cow being removed can be transported?	Herd owner (one person, always the same person) Herd owners (more than one person, can vary) Herdsman (one person, but not the owner) Hersdmen (more than one person, not the owners) Someone else	29 13 6 1 3
On a scale from 1 to 5 (1= not confident, 5= very confident), how confident do you feel in determining whether a cow is fit for transport?	1= not confident 2 3 4 5= very confident	0 1 7 32 7
What resources do you use when deciding what to do with a cow you are removing from the milking herd?	a) Documented (written out) standard operating procedure b) A decision tree/flow chart c) Past experience/ personal knowledge d) Consult veterinarian e) No criteria	3 3 45 24 1
Do you record any information on cows before you ship them?	Yes No Depends	11 26 10
Would you send a cow to the auction market that has cancer eye?	Yes No Depends	7 27 11
Would you send a cow to the auction market that has an LDA (Left displaced abomasum/twisted stomach)?	Yes No Depends	4 26 17
Would you send a cow to the auction market that has a hoof block?	Yes No Depends	19 17 11
On a scale from 1 to 5 (1=not involved, 5=very involved), and thinking	1=not involved 2 3	22 16 4

about the last 10 cows that you culled, how involved was your veterinarian in helping you to determine the suitability of those cows for transport?	4 5=very involved	3 2
On a scale from 1 to 5 (1=very limited time, less than 5 minutes, 5=a lot of time, days) how much time do you allocate when deciding whether or how to transport a cow you are removing from your herd?	1 2 3 4 5	11 11 14 10 1
What options would you choose for dealing with cows that you feel can't be transported? Circle all that apply	a) Keep the cow to see if the problem resolves itself b) Treat the cow if appropriate c) Contact a veterinarian for euthanasia d) Euthanize the cow myself immediately e) Get someone else to euthanize the cow immediately	30 40 13 29 6
Have you received any feedback about shipping cows in the past	Yes No	30 17
Do you feel as though you are adequately trained to assess cows for suitability of transport?	Yes No Somewhat	26 0 21

[1]Participants had the option to refrain from responding to any questions provided in the survey, thus the frequency of responses may not equate to the number of participants

Table 3.3 The questions, possible responses and frequency of responses given for the post-study survey distributed to participating Ontario bovine veterinarians (n = 9).

Question	Possible responses	Frequency of responses[1]
On a scale from 1 to 5 (1= not confident, 5=very confident), how confident are you in your ability to help your client determine whether a cow is fit for transport?	1 2 3 4 5	0 0 0 4 5
Since becoming familiar with the cow evaluation form, has your confidence in helping determine whether a cow is fit for transport increased, decreased or stayed the same?	a) Increased b) Decreased c) Stayed the same d) I don't know	1 0 8 0
On a scale from 1 to 5 (where 1 is not likely and 5 is very likely) how likely are you to share or recommend this evaluation form with other clients who did not participate in this study?	1 2 3 4 5	0 0 3 4 2
Do you record any information on cows you assess for clients	Yes No Depends	2 3 4
Would you send a cow to the auction market that has cancer eye?	Yes No Depends	0 4 5
Would you send a cow to the auction market that has an LDA (Left displaced abomasum/twisted stomach)?	Yes No Depends	0 8 1
Would you send a cow to the auction market that has a hoof block?	Yes No Depends	1 2 6
Since introducing the cull cow evaluation forms, would you say you are more likely, less likely or just as	a) More likely b) Less likely c) Not more or less likely compared to before	1 0 6 2

likely/unlikely to be asked by your dairy clients for your opinion about whether a cow is fit for transport?	d) I don't know

[1]Participants had the option to refrain from responding to any questions provided in the survey, thus the frequency of responses may not equate to the number of participants

Table 3.4 The questions, possible responses and frequency of responses given for the post-study survey distributed to participating Ontario dairy producers (n = 47).

Question	Possible responses	Frequency of response[1]
On a scale from 1 to 5 (1= not confident, 5= very confident), how confident do you feel in determining whether a cow is fit for transport?	1=not confident 2 3 4 5=Very confident	0 0 7 24 16
As a result of using the cull cow evaluation form, do you now feel adequately trained to assess the fitness of cows for transport?	Yes No Somewhat I don't know	34 12 0 0
Would you like more training?	Yes No Somewhat I don't know	28 6 11 1
Going forward, I plant to:	a) Use the evaluation form for all of my cows b) Use the evaluation form for some of my cows c) Not use the form at all d) Use a modified version of the form	7 18 13 9
Would you send a cow to the auction market that has cancer eye?	Yes No Depends	1 27 15
Would you send a cow to the auction market that has an LDA (Left displaced abomasum/twisted stomach)?	Yes No Depends	8 27 11
Would you send a cow to the auction market that has a hoof block?	Yes No Depends	16 19 11
On a scale from 1 to 5 (1=not involved, 5=very involved), and thinking about the last 10 cows that you culled, how involved was your veterinarian in helping you to determine the	1=not involved 2 3 4 5=very involved	16 10 9 6 4

suitability of those cows for transport?		
Since using the cull cow evaluation forms are you more likely, less likely, or just as likely to involve your veterinarian in helping you determine whether a cow is fit for transport?	a) More likely b) Less likely c) About the same as before d) I don't know	7 4 35 0
Since using the Cull Cow Evaluation Form, has the amount of time that you allocate to deciding whether or not a cow is fit for transport increased, decreased or stayed the same?	a) Increased b) Decreased c) Stayed the same d) I don't know	18 1 28 0
What options would you choose for dealing with cows that you feel can't be transported? Circle all that apply	a) Contact veterinarian b) Euthanize the cow myself c) Call deadstock removal d) Keep the cow to see if the reason for culling resolves itself e) Treat the cow is appropriate	32 30 16 18 35
Have you received any feedback about shipping cows since starting this project?	Yes No	3 43
Since using the cull cow evaluation form, has your confidence in determining whether a cow is fit for transport changed?	a) I am more confident b) I am less confident c) My confidence has not changed d) I don't know	20 0 26 0
On a scale from 1 to 5 how useful was the cull cow evaluation form for you in helping you decide whether your cows were fit for transport?	1= not helpful 2 3 4 5= very helpful	5 8 11 15 8
Would you consider using this form as your SOP for shipping cows, required by proAction?	Yes No Somewhat I don't know	25 6 13 3

[1]Participants had the option to refrain from responding to any questions provided in the survey, thus the frequency of responses may not equate to the number of participants

Cow Evaluation Form: *Please complete one form for each cow evaluated*

Date of evaluation: (dd/mm/yy) ___/___/___ Cow ID (Name/Number): _____

Evaluation done by: _____ Last 4 digits in NLID number: __ __ __ __

Consider these questions before shipping the cow:	**Measure and record:**		Compare your findings to requirements for transport:	This cow is ok: (Only "yes" circles are checked)
1. Is her body temperature normal?	Body Temp _____ °C or °F		Is the body temp. 37.9 – 39.4 °C? (100.2 – 102.9 °F)	YES ○ NO ○
2. Is she too thin?	Body Condition Score: _____ *(see chart to score)*		Is the score 2 or higher out of 5?	YES ○ NO ○
3. Is she lame?	Lameness Score: _____ *(see chart to score)*		Is the score 0 (none) or 1 out of 5?	YES ○ NO ○
4. Has she been dried off?	Last milking: (dd/mm/yy) ___/___/___			YES ○ NO ○
5. Are drug residues possible?	Last treated: (dd/mm/yy) ___/___/___		Is the withhold time for meat and milk completed?	YES ○ NO ○
6. Could mastitis flare up?	CMT: RF ___ RH ___ LF ___ LH ___		Is no or only mild mastitis present? (no udder swelling or hardness)?	YES ○ NO ○
7. Any other problems?	*Circle any problems:*		Are visible problems acceptable for sale? (check with your vet if unsure)	YES ○ NO ○
	Sunken eyes Twisted stomach Nasal (nose) discharge Discharge from vulva	Diarrhea Swellings/lumps Abscesses Surgery sites		

Date cow left the farm: _____

Destination of cow:
- ☐ Direct to local slaughter from the farm (provincial plant)
- ☐ Direct to local slaughter from the farm (federal plant)
- ☐ Salesbarn, name: _____
- ☐ Other: _____

Other comments:

Figure 3.1 Evaluation form for dairy producers to use to assess dairy cows prior to culling

CHAPTER FOUR

SUMMARY AND GENERAL DISCUSSION

The overall goal of this thesis was to contribute to the research surrounding the cull cow industry, and the transportation of dairy cattle. The studies reported in this thesis assessed the general condition of culled dairy cows sold at auction markets, and the utility of an evaluation form to encourage producers to evaluate their cows, prior to culling and transport.

The first objective in this thesis was to determine the frequency of culled dairy cows sold at Ontario auction markets in suboptimal condition, according to recent industry imposed expectations, and to determine if condition affected the sale price of the cow. Results showed that 27.2% of culled cows scored had a hock injury with greater than 1 cm of swelling, balding, and/or a lesion present. Past research using a similar scoring criteria for hock injuries found that approximately 47% (Zaffino Heyerhoff et al., 2014) and 52% (Nash et al., 2016) of cows measured had a hock injury present on at least one leg with swelling and/or a lesion present. A total of 40.7% of culled cows scored had a BCS≤2, which is considered too thin by proAction standards (2017). Past research has shown that lower body condition is related to lower milk production and reduced fertility (Roche et al., 2009), which are two of the most common risk factors for culling in dairy cattle (Bascom and Young, 1998). Over 70% of culled cows had an abnormal gait, which ranged from an inability to track up to an obvious limp or reluctance to bear weight. A study was conducted in Ontario Canada, and assessed 40 free-stall barns for the presence of lameness (Solano et al., 2015). Results showed that the average prevalence of lameness was from 20-30% but was as high as 69% of the milking herd. Again, lameness has reported in past studies to negatively effect reproductive performance (Barkema et al., 1994),

which may further increase a cow's risk for being culled (Bascom and Young, 1998). Therefore, although the prevalence of lameness is high in this study, lameness is a condition that impacts multiple aspects of a dairy cow's life, subsequently dramatically increasing their likelihood of being culled. Finally, 12% of culled cows had docked tails, at or above the switch. The National Animal Health Monitoring System reported in 2014 that 50% of dairy cow farms in the U.S. had at least one or more cows with a docked tail in the herd. As of 2017, the practice of tail docking dairy cows will be prohibited, by proAction®, unless deemed medically necessary by a veterinarian. It was determined that both BCS and gait had a significant effect on price, whereas hock injury and the presence or absence of a tail did not. Results showed that culled cows with a BCS≤2 sold for $0.20 less/kg compared to those with BCS>2, which equated to an average loss of $117 per thin cow sold. Similarly, culled cow with an abnormal gait sold for $0.05 less/kg compared to culled cows with a normal gait, resulting in an average loss of $32 per cow. There was also a significant interaction between BCS and gait, with cows that were well conditioned having a larger difference in price depending on gait status, than the difference seen in thin cows, due to gait status.

This study is the first of its kind to benchmark the condition of culled dairy cows sold at auction markets in Ontario. Results indicate that in many cases culled cows are transported to auction markets and sold in less than optimal condition, according to recent industry standards. These instances occur despite there being legislation that describes when an animal cannot be transported, due to certain health conditions such as emaciation and lameness (CFIA, 2017). Additionally, Ontario is the only province that requires inspection of animals arriving at sales barns prior to the sale, ensuring that non-ambulatory or fallen animals are not sold.

If this study were to be repeated, changes could be made to improve the study design. Assessing cows condemned by the government-appointed veterinarians would provide a more comprehensive understanding on the condition of the full spectrum of cull cows entering Ontario auction markets, as this sub-population was not examine in the present study. Additionally, other factors such as knee injury, udder score, and cleanliness could be evaluated, again, to provide a more comprehensive overview of the general condition of the cows assessed. Knee injuries, like hock injuries, are a common injury on dairy cows (Zaffino Heyerhoff et al., 2014; Nash et al., 2016). It could be beneficial to compare the prevalence of knee injuries in culled cows to cows on-farm. Additionally, dairy cows are not required to be dried off prior to being transported, and may experience pain or discomfort from udder distension. By evaluating udders, we could determine the number of dairy cows that are shipped prior to being dried off. Lastly, the presence of dirt on a cow may make it difficult to assess the cow from a far distance (for example, accurately assessing the hocks for a hock injury score). If a cleanliness score was recorded, it could be determined if this factor influences the accuracy of the observations made on that cow. Lastly, it would be most beneficial if the researchers were able to observe the cows in their holding pens prior to the sale, instead of in the sale ring. This would give the observers more time, and the opportunity for a more thorough inspection. In this study, inspecting cows in the holding pens, or when being unloaded, was not possible because of stocking density. If future relations are made with the auction managers, perhaps this could be made possible.

The second objective of this thesis was to assess the utility of a cull cow evaluation form, intended to aid producers in the decision-making of whether or not to transport a cow. Knowing that there are many instances of culled cows sold at auction in less than optimal condition, as

determined by the previous study, this evaluation form presented producers with the opportunity to be informed about transport standards, and ensure the cow they plan to cull is suitable for transport. This study also aimed to increase veterinary involvement in their client's practice, and encourage veterinarians to work their clients to develop a standard operating procedure (SOP) for evaluating cull cows. The evaluation form allowed producers to record the cow's body temperature, BCS, gait score, last date of milking, a California Mastitis Test for each udder quarter, a last treatment date, and any other health problems the cow may be facing. Several of the questions asked on the pre-study survey were also asked on the post-study survey, to determine if there was a change in response by the participants. Results showed that knowledge of Canadian transport requirements, laid out by the Codes of Practice for the Care and Handling of Dairy Cattle (NFACC, 2009), did not improve after completion of the study period. The majority of producer participants indicated they would use the form, or some version of the form in the future, and 38% of producer participants indicated they spent more time assessing their cattle prior to culling. Both producer and veterinarian participants reported feeling more confident in their ability to assess cows for transport, after using the evaluation form. Additionally, the number of producer participants who felt adequately trained to assess cows for transport increased from half to three quarters of the participants. With regards to veterinary involvement, there was a significant increase in the number of producer participants who indicated that they would contact a veterinarian to deal with a cow they felt could not be transported, and producers reported that their veterinarians were more involved in their decision-making.

This pilot research study is the first to use an evaluation form with the goal of aiding producers in assessing their cattle prior to transport in Ontario. The results from this project highlight areas of concern and confusion for producers and veterinarians in terms of transporting livestock, and can give a better understanding how useful an assessment tool could be for producers. In this current study, veterinarians were responsible for training their producers on the use of the evaluation form. To allow for more consistency and control in the training process, in future studies the research team could be responsible for training the participants through the use of a work shop session. Additionally, those who did not complete the pre- or post-study survey were still eligible to use the evaluation form, however, this potentially lead to gaps in the data. If a producer completed the post-study survey, which was intended to gather feedback on the evaluation form, but did not complete any evaluation forms, there responses do not accurately represent their experience. Subsequently, their responses could influence the results. In the future, the research team could ensure that all participants are compliant with completing both surveys, through the use of incentives.

Future research

Although these research projects have contributed to understanding the condition of culled dairy cows on farms, and at auction markets, there are still many questions that can be answered to fill the knowledge gaps.

The first study benchmarked the condition of culled dairy cows sold at auction markets in Ontario, however, the study excluded any dairy cows that had been segregated by government-appointed veterinarians, and deemed to be unfit for sale. This results in a proportion of the cull dairy cows arriving at auction markets not being truly represented in this study. The condition of

these cows could ultimately influence the results of this study, and impact the discounts applied to cull cows depending on certain health conditions. Future research that is able to assess the condition of all dairy cows entering auction markets, and not only those that are offered for sale could give a more comprehensive overview of the general condition of culled dairy cows. Additionally, this study was done for a relatively short period, was done exclusively over the summer months, and included three auction markets based on them being conveniently located to the University. Similar studies that include more auction markets, and have a longer study period may provide more comprehensive understanding on the condition of culled dairy cows that enter auction markets in Ontario, depending on the time of year. Future research that assesses how the health disorders investigated in this study impact a cow's ability to withstand the stress of transport would be greatly beneficial in identifying how health and suitability for transport influences the welfare of cull cows. Additionally, more research is needed to survey the conditions livestock may be subjected to during transit in Canada. It is unknown what travel distances, environmental circumstances, and travel conditions can be expected for cattle that are transported throughout Ontario. It can be expected that the environmental and transport conditions, along with the health status of the cow can all contribute to their welfare status.

The second study has many potential areas for future research, as this was a pilot research study exploring the use of an evaluation form for aiding dairy producers. A follow up study to this project, using a modified version of the cull cow evaluation form that takes into consideration the feedback of the participants from this study is needed. Additionally, this study explored the use of a tool to cause voluntary behavioral change in producers. Research that assesses alternative methods that is effective in causing behavioral change for producers (i.e.,

workshops, online training, social groups) would be beneficial to apply to future studies when behavioral change is required.

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APPENDICES

Appendix 3.1 The enrolment form used by veterinarian participants to collect information on their dairy clients at time of enrolment into the study

Assessing Cows Prior To Transport Project

Herd Enrollment Form

Practice: _____

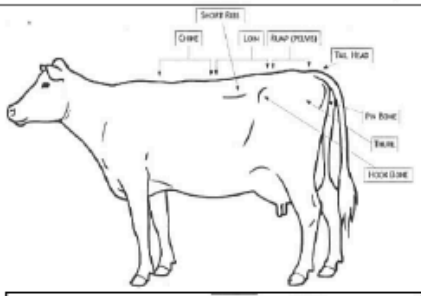
We are hoping for 10 herds per vet or per vet practice, depending on what works best for your situation. Ultimately we would like to have 200 producers participate so if you are "sharing" enrollment across vets in a practice, more than 10 total producers per practice can be enrolled. Up to 10 per vet are acceptable. ***Contact Ann if you need more materials (Producer Packages).***

Number Of herds enrolled	Herd Owner's Name	Farm Name	Number of cows milking	Vet Name	Date enrolled	Project Identification (***can be name, initials or other unique ID***)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Appendix 3.2 A body condition scoring guide for dairy cattle to be used by producer participants when assessing the cows they intend to cull. References from the Codes of Practice for the Care and Handling of Dairy Cattle (NFACC, 2009)

Body Condition Scoring (BCS) of Dairy Cattle

(from the Code of Practice for the Care and Handling of Dairy Cattle)



BCS 1

SHORT RIBS:
- Ends sharp to touch
- Loin prominent, shelf-like appearance
- Obvious scalloping over top and ends

BACKBONE:
- Vertebrae prominent in chine, loin and rump area
- Individual bones easily visible

HOOK AND PIN BONES:
- Sharply defined, very angular in appearance
- No discernable fat pad

THURL (area over pelvis):
- Severe "V shaped" depression without fat cover

TAIL HEAD:
- Sunken and hollow on either side of tail head with obvious folds of skin
- Ligaments connecting pin bones to spine are sharply defined
- Vulva prominent.

BCS 2

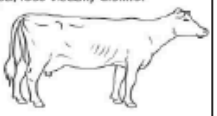
SHORT RIBS:
- Ends not as prominent as BCS 1, but can be felt
- Edges easily felt, with slight fat cover, and slightly more rounded appearance
- Overhanging shelf effect less apparent

BACKBONE:
- Vertebrae in chine, loin and rump area, less visually distinct
- Easily feel individual vertebrae

HOOK AND PIN BONES:
- Bones still prominent, angular
- No fat pad palpable

THURL (area over pelvis):
- Less severe "V shaped" depression
- Little tissue cover

TAIL HEAD:
- Both sides of the tail head are sunken and hollow
- Sharply defined ligaments connecting pin bones to spine



BCS 3

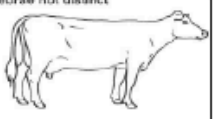
SHORT RIBS:
- Ends can be felt with moderate pressure
- Ribs appear smooth without noticeable scalloping
- Overhanging shelf effect much less apparent

BACKBONE:
- Vertebrae in chine, loin and rump area appear rounded
- Backbone visible, but individual vertebrae not distinct

HOOK AND PIN BONES:
- Visible, but smooth, with rounded appearance
- Fat pad palpable

THURL (area over pelvis):
- Forms "U shaped" depression

TAIL HEAD:
- Both sides of tail head somewhat hollow, but skin folds not distinct
- Ligaments connecting pin bones to spine are rounded in appearance



BCS 4

SHORT RIBS:
- Ends can be felt with moderate pressure
- Ribs appear smooth without noticeable scalloping
- Overhanging shelf effect much less apparent

BACKBONE:
- Vertebrae in chine, loin and rump area appear rounded
- Backbone visible, but individual vertebrae not distinct

HOOK AND PIN BONES:
- Visible, but smooth, with rounded appearance
- Fat pad palpable

THURL (area over pelvis):
- Forms "U shaped" depression

TAIL HEAD:
- Both sides of tail head somewhat hollow, but skin folds not distinct
- Ligaments connecting pin bones to spine are rounded in appearance

BCS 5

SHORT RIBS:
- Ends can't be seen or felt
- No overhanging shelf effect

BACKBONE:
- Vertebrae in chine, loin and rump not visible
- Difficult to feel individual vertebrae

HOOK AND PIN BONES:
- Very round, buried (almost disappearing) in fat tissue

THURL (area over pelvis):
- Appears flat
- Filled in between the hooks and pins

TAIL HEAD:
- Hollow filled in
- Areas on both sides of tail head buried in fat tissue

Appendix 3.3 A lameness scoring guide for dairy cattle to be used by producer participants when assessing the cows they intend to cull. References from the Guide to the Disposition of Compromised Livestock (OMAFRA, 2016).

Cow Lameness Scoring and Suitability for Transport

Class 1 Lameness

Animals with a class 1 lameness are characterized by the following:

- can keep up with the group but gait is abnormal
- weight bearing at rest and while ambulating
- may have an arched back while walking; not at rest

Class 2 Lameness

Animals with a class 2 lameness are characterized by the following:

- visibly lame
- unable to keep up with the group and gait is noticeably abnormal
- weight bearing at rest and while ambulating
- some difficulty climbing ramps
- may have an arched back while standing and walking

Severely overgrown claws are included in this class or higher.

In rare instances when an animal has a functional lameness and the animal is NOT suffering due to the lameness, it can be transported to local slaughter or care with special provisions.

Class 3 Lameness

Animals with a class 3 lameness are unable to keep up with the group, gait is noticeably abnormal, with one or more of the following findings:

- reluctant to rise
- requires assistance to rise
- pronounced arched back while standing and walking
- showing additional signs of pain (teeth grinding, vocalizing, head pressing)
- reluctant to walk (e.g. laminitis)
- reduced ability to bear weight on one or more limbs.

Class 4 Lameness

Animals with a class 4 lameness are characterized by all the characteristics of a class 3 lameness and/or one or more of the following findings:

- halted movement
- non weight bearing on one or more limbs

Class 5 Lameness

Animals with a class 5 lameness are characterized by:

- inability to rise without assistance
- inability to remain standing

Lameness Classes

These categories can be used to determine the status of an animal's mobility, from normal to non-ambulatory.

Transport as soon as possible

Class 1
Visibly lame but can keep up with the group: no evidence of pain.

Class 2
Unable to keep up; some difficulty climbing ramps. *Load in rear compartment.*

Do Not Load or Transport*

Class 3
Requires assistance to rise, but can walk freely.

Class 4
Requires assistance to rise; reluctant to walk; halted movement.

Class 5
Unable to rise or remain standing.

**** Any animal, including Lameness Classes 3, 4 or 5 may be transported for veterinary treatment, on the advice of a veterinarian.***