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# Relationship of observed parlor practices and producer attitudes with bulk tank somatic cell counts in the Southeast USA

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To the Graduate Council:

I am submitting herewith a thesis written by Chandler Lauren Moats Blakely entitled "Relationship of observed parlor practices and producer attitudes with bulk tank somatic cell counts in the Southeast USA." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

Gina M Pighetti, Major Professor

We have read this thesis and recommend its acceptance:

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(Original signatures are on file with official student records.)

# Relationship of observed parlor practices and producer attitudes with bulk tank somatic cell counts in the Southeast USA

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# DEDICATION

This work is dedicated to my son, Jude. He came into this world with a fiery spirit and has pushed me to find the strength to reach my goals.

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## ABSTRACT

Inflammation of the mammary gland is indicated by a rise in somatic cell count (SCC) and impacts milk quality. The Southeast (SE) USA has a higher proportion of herds with elevated SCC compared to other USA regions. The SE also has the least information available about parlor procedures. The goals of this thesis are to explore the level of implementation of parlor procedures, determine which practices promote low SCC in Southeast USA dairy herds and investigate the association of attitude towards parlor management methods with BTSCC.

In chapter I, researchers performed on-farm assessments in Kentucky, Mississippi, Tennessee, and Virginia. The evaluations included a management survey and observation of milking procedures. In chapter II, dairy producers in Georgia, Mississippi, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia were mailed a survey to gather information about producers' attitudes regarding mastitis management. The reported level of effectiveness and practicality of each parlor management practice was summed, and were used to create a Practicality and Effectiveness Index, or PEI.

To understand the level of implementation, frequencies for observed practices were developed. Next, the GLMselect procedure which performs a stepwise selection of terms that best fit the general linear model identified a) practices strongly associated with BTSCC, and b) association between the PEI of parlor management practices and BTSCC.

A higher percentage of operations (88%) use gloves compared to a national survey (55%). When evaluating towel use, a majority (66%) of operations used single service towels: less so than nationally (77%). Practices associated with BTSCC were: post-milking disinfectant active ingredient, interaction of pre-

milking disinfection removal method and post-milking disinfectant active ingredient.

Responses by producers to the mail survey indicated three parlor management practices were significantly associated with BTSCC: 1) disinfecting teats of all cows before milking (pre-milking disinfectant; p=0.01), 2) training employees in milking procedures to reduce BTSCC (p=0.03), 3) having and implementing a mastitis management plan (p=0.02). The strongest association (p=0.01) was between PEI for pre-milking disinfectant and BTSCC.

Overall, implementation of practices in the dairy parlor and a producer's attitude toward its effectiveness and practicality are associated with the BTSCC of their herd.

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# INTRODUCTION

Consumers in the dairy industry are increasing their demand for higher quality milk because it has a longer shelf-life, is more economical to produce, and is an overall improved product (Ma Y, 2000, Barbano et al., 2006, Dufour et al., 2011). Inflammation of the mammary gland, or mastitis, leads to a rise in somatic cell count (SCC), which is indicative of reduced milk quality. The average bulk tank SCC (BTSCC) of herds in the Dairy Herd Information Association had a BTSCC 204,000 cells/mL in 2015 (Walton, 2015). Per the National Animal Health Monitoring Service (NAHMS), average SCC was 206,500 cells/mL in 2014 (USDA, 2016). Each of these are near the recommended goal of 200,000 cells/ml or lower which represents milk of higher quality. A bulk tank SCC (BTSCC) of 400,000 cells/ml is required to export milk to the European Union and represents a common cutoff imposed by processors in the USA. Nationally, 12% of herds participating in the Dairy Herd Information Association (DHIA) had a SCC over 400,000 cells / ml, while 22% of herds in the SE, including Tennessee, Virginia, Mississippi, and Kentucky, fell into this category (Walton, 2015).

Management practices in the parlor have been demonstrated to impact milk quality at the cow and bulk tank level (Pankey, 1988, Dufour et al., 2011). Herds that implemented a comprehensive mastitis management plan, such as keeping records of mastitis cases, maintaining hygienic conditions of cows, performing dry cow therapy, and post-disinfecting teats had lower BTSCC than herds that did not (Barkema et al., 1999). Udder care in the parlor also can reduce the risk for new intramammary infection (Barkema et al., 1998, Schreiner and Ruegg, 2003, Dohmen et al., 2010, de Pinho Manzi et al., 2012). Hygienic practices, such as use of disinfectant, have been significantly associated with fewer bacterial infections of the mammary gland. Pre and post milking disinfection of teats decreased SCC by significantly reducing bacteria on teats (Erskine et al., 1987, Barkema et al., 1998, Ruegg et al., 2000, Dufour et al., 2011). Decrease of bacteria on teats also was associated with use of towels to dry udders after pre-milking disinfection (Faye et al., 1997).

Why parlor practices are not adopted by producers has been largely unevaluated, however the attitude held regarding the effectiveness or practicality of a particular practice may provide some insight into milk quality issues (Beaudeau et al., 1996, Kuiper et al., 2005). In 2005, a study concluded that attitude about self-efficacy or an individuals' belief they can succeed at a task, normative beliefs or thoughts held by ones' peers, and incentives were key factors associated with the utilization of general practices and strategies within a dairy herd (Kuiper et al., 2005). Producer characteristics, such as education level, satisfaction, attitude, and risk willingness explained a quarter of the variation in diseases such as metritis, retained placenta, culling, and other reproductive disorders, while only one-seventh was explained by adoption of those practices (Bigras-Poulin et al., 1985). These studies indicate that attitudes and perceptions were associated with disease and farm performance. Another more recent study determined that almost half the variance in BTSCC was related to attitudes and behaviors (Jansen et al., 2009). However, the strategic practices used by dairy producers, their subsequent contributions to elevated BTSCC, and the impact of attitudes towards these practices are not as well understood due to the limited focus of most studies.

The goals of this thesis are: identify the level of implementation of parlor practices, determine the practices that promote low SCC in Southeast USA dairy herds and the relationship between attitudes and perceptions toward parlor management methods with respect to BTSCC. For the first objective, we hypothesized that herds in the Southeast differentially implement practices demonstrated to minimize the risk of mastitis, lower BTSCC, and improve milk quality. Secondly, we hypothesized that producers who find mastitis control and prevention methods to be highly effective and practical will have lower BTSCC than those who find common management methods not effective or practical.

# LITERATURE REVIEW

## Milk Quality

The quality of milk has direct impacts for both producers and consumers relative to product shelf-life, nutrient values, and profitability (Ma Y, 2000, Barbano et al., 2006, Dufour et al., 2011). Low quality milk can be defined by 1) increased somatic cell count (SCC) or number of leukocytes over 200,000 cells/mL (Dohoo and Meek, 1982, de Haas et al., 2004) in response to inflammation from infection (Djabri et al., 2002, Schukken et al., 2003) or 2) an elevation in bacteria denoted by increased standard plate counts (SPC) over 10,000 colony forming units/ mL (Barbano et al., 2006). Both SCC and SPC in bulk tank milk are well-known reliable methods commonly used to determine milk quality (Hayes et al., 2001, M. Costello, 2003). The shelf life of high quality milk (SCC= 45,000) is 21 days, compared to 14 days for low quality milk (SCC=849,000) (Ma Y, 2000). The reduction in shelf life is partly due to increases in rancidity and bitterness resulting from greater lipolysis and proteolysis that occurs in milk of poorer quality. Furthermore, high levels of bacteria in milk decrease nutrient values of fat and protein due to the contribution of heat stable proteases and lipases (Barbano et al., 2006). Both the degradation of nutrients and off-flavors impact the economic bottom line for the dairy producer as the marketability of milk is decreased (Dufour et al., 2011). Costs can also increase for consumers due to diminished shelf life and supply.

The bulk tank SCC (BTSCC) preferred by industry processors and customers is less than 400,000 cells/ml which leads to a better tasting nutritive product (Ma Y, 2000, Barbano et al., 2006). Quality testing begins on the farm from the bulk tank, which is a system that stores milk at 4 degrees Celsius until it is transported to the processing plant. At each pickup, a sample of milk is taken and stored on the truck, then left for processing with the milk shipment at the processing plant. Once at the plant, the SCC and SPC of the milk are determined. Legally, dairy producers cannot market milk with a SCC over 750,000 cells/ml without incurring a penalty per the Pasteurized Milk Ordinance (PMO) (Administration, 2011). Penalties result in reduced money paid per hundred weight of milk by the co-op or processor and suspension of milk shipments (at the discretion of the FDA). The suspension is enacted if 3 out of 5 monthly samples are above the specified limits (Administration, 2011).

## Mastitis

One prominent cause of reduced milk quality is an intramammary inflammatory response, known as "mastitis", commonly due to presence of environmental or contagious microorganisms. Mastitis' most causative agent is bacteria, with fungi, yeast, and viruses occurring less frequently (Zhao and Lacasse, 2008) with the primary area of inflammation being the mammary gland (de Pinho Manzi et al., 2012). Clinical mastitis, or a case of inflammation with visible adulteration such as clots or flakes in the milk, mammary gland edema, and systemic signs, and subclinical mastitis, or an elevated SCC wherein no visible signs are present, lead to reduced milk production and milk quality (Seegers et al., 2003). The drop in milk yield due to both clinical and subclinical mastitis is believed to be as significant as five percent of production during the infected period (Seegers et al., 2003). Also, intramammary infection often requires antimicrobial treatment, which leaves the dairy farm at a higher cost for treatment and increased risk for antibiotic presence in the bulk tank milk (Seegers et al., 2003).

These situations lead mastitis to impact the profitability of dairy operations (Seegers et al., 2003). Economic loss in the dairy industry due to mastitis is estimated to be $1.3 billion, or approximately $30 per cow per year, with almost 70% of the detriment examined to be caused by decreased milk production, discarded milk, increased treatment costs, and greater culling of cows (Blosser, 1979, Dohoo and Meek, 1982, Halasa, 2007).

## Parlor Management

The procedure in the parlor to prepare a cow's udder for milking can significantly influence the health of the udder and the presence of mastitis causing organisms (Goodger et al., 1993). Milking practices have been studied at multiple levels for their impact on milk quality. Use of hygienic items such as gloves, pre-milking disinfection, method of pre-disinfectant removal, fore-stripping, post-milking disinfection, and udder hair management have been associated with milk quality status and the presence of bacteria (Pankey, 1988). Glove use during milking was negatively associated with SCC (Bach et al., 2008, Cicconi-Hogan et al., 2013). A review on the literature available about management practices also suggests that the overwhelming majority of studies find evidence to support the use of gloves during milking because of its relationship to SCC (Dufour et al., 2011).

Pre-milking disinfection has been associated with a decrease in bacteria present on the teat end leading to reduced risk of new mastitis cases (Galton et al., 1986, Rasmussen et al., 1991). The type of compound used to disinfect teats has been shown to be important in bacteria removal. Galton et al (1986) concluded that iodine, sodium hypochlorite, and dodecyl benzene sulfonic acid dips all caused significant bacterial reduction on the teats, with no differences between the types of compounds; however, Pankey et al (1988) concluded that iodine based disinfectants were best at reducing bacteria levels and intramammary infection rates. Although the active ingredient was important, the disinfectant contact time influenced effectiveness. Ensuring that the contact time, or kill time, of the pre-milking disinfectant equaled 30 seconds was necessary for reduction of bacteria from the teat skin (Enger et al., 2015). Drying teats completely after pre-disinfection also significantly lowered the amount of bacteria present on teats

(Pankey, 1988). Use of a single-service towel per cow also has been demonstrated to reduce the risk of transmitting microorganisms between cows (Galton et al., 1986, Elmoslemany et al., 2010). In 2008, it was suggested that paper towels, instead of cloth towels, were more strongly associated with lower SCC (Bach et al., 2008).

Fore-stripping, or removal of a few streams of milk from each teat prior to milking, was reported to improve milking performance when compared to herds that did not include fore-stripping in their pre-milking routine (Sandrucci et al., 2007). Other studies suggested discarding the first few streams of milk due to a higher prevalence of organisms and somatic cells (Harmon, 1994, Fahr, 2002). Fore-stripping allowed milking personnel to visually see clinical signs of mastitis in milk, such as clots and flakes, and increased the ability to make informed choices regarding control of an ongoing disease response.

Several studies discussed post-milking teat disinfection and concluded its use to be associated with decreasing bulk tank SCC. In a study by Barkema (1998), post-milking teat disinfection was associated with herds having a bulk tank SCC below 150,000 cells/mL versus those with higher SCC. In another study, herds that had lower SCCs had increased use of post-milking disinfection compared with those who had higher counts (Erskine and Eberhart, 1991). Chlorhexidine based, post-milking disinfectants also were more associated with herds in the low SCC category, while acrylic latex disinfectants were more associated with high SCC herds (Erskine and Eberhart, 1991).

In addition to pre- and post-milking routines, improved udder hygiene was effective in decreasing SCC. Herds with dirtier udders had more bacteria, which was associated with an increased risk of infection (Murphy, 1997, Barkema et al., 1999, Schreiner and Ruegg, 2003, DeVries et al., 2012). Another study suggested that dirty teats increased mastitis risk because teat cleaning became more difficult during milking preparation (Dohmen et al., 2010). Dufour et al (2011) reported that clipping udders of cows was associated with lower SCC for herds that fell into categories of medium and high SCC. Another study also revealed that bacteria counts were lower in herds with clipped udders, resulted in a decreased risk of new infection (Elmoslemany et al., 2010).

Teat end condition and its association with mastitis are not well understood. However, research has demonstrated that the teat canal and sphincter were especially important in providing a barrier that prevents entrance of bacteria into the mammary gland (de Pinho Manzi et al., 2012). A relationship between the level of hyperkeratosis and clinical mastitis has been demonstrated. Greater surface area of the teat as a result of rougher teat ends can provide more area for bacteria to adhere to the teat, and may decrease the effectiveness of teat disinfection (Neijenhuis et al., 2001). Rougher teat ends, increased levels of keratin build-up, as well as dirty udders were associated with an increase in the number of mastitis cases (de Pinho Manzi et al., 2012).

Management style in the parlor represents another significant aspect of milk quality. Barkema and others reported in 1999 that herds that were managed more "clean and accurate" in the parlor had a lower SCC than those who were managed "quick and dirty." Clean and accurate producers were identified to have herds with better overall hygiene, increased collection of mastitis samples, record-keeping, and worked precisely rather than trying to move as quickly as possible. Those herds that were quick and dirty did not sample mastitis cows as often, did not focus on hygiene of the cows, and tended to be less familiar with cows in their herd (Barkema et al., 1999). The study concluded that management style influenced adoption of mastitis prevention practices (Barkema et al., 1999).

Another component of parlor management is timing of the milking procedure. Prep lag time has been defined as the time period from first tactile stimulation until unit attachment (Watters et al., 2012). Stimulation leads to oxytocin release and subsequent milk ejection for removal by the milking machine (Rasmussen et al., 1992). A study of both Jersey and Holstein cows reported that a prep lag time of 1.3 minutes allowed for optimum milk yield (Rasmussen et al., 1992). Another study reported that 60 seconds was the optimum prep lag time for milk yield (Watters et al., 2012). A third study concluded that SCC increased with a bimodal milk curve when prep lag reached 3 minutes (Sandrucci et al., 2007). An average of 60 to 90 seconds also was reported as sufficient time for oxytocin to cause milk ejection and maximize milk yields (Reneau and Chastain, 1995). The results from these studies also suggested that shorter prep lag times increased dry milking after unit attachment and contributed to teat health complications.

One area of milking parlor management that is frequently overlooked is the role of communication. A study performed on 12 Michigan dairies suggested a need to develop further understanding of communication barriers found between owners and employees and how to best approach issues (Erskine et al., 2015). A majority (71%) of farm employees received milking parlor training on their own or from other employees, and rarely met with farm management. This finding suggested improved education for on-farm employees by management was needed to increase the collective knowledge of the dairy operation (Erskine et al., 2015). A second study expanded upon this by drawing a direct connection between employee actions and SCC impact (Schewe et al., 2015). They reported that employee's compliance with protocols, a quality penalty system, and the producer's attitude toward reduction of the cost of labor were associated negatively with SCC (Schewe et al., 2015). These studies highlighted the importance of employee management decisions relative to training and education of milking parlor personnel as protocol compliance was key to ensuring mastitis prevention methods were being properly carried out.

## Social Concepts

The theory of planned behavior, crafted by Icek Ajzen, has been implemented in agricultural research on a consistent basis. His theory states that combining the attitude toward a behavior, actions considered socially acceptable, and the level of control an individual perceives to have toward a behavior all increase the ability to account for variation that occurs when the actual behavior is performed or implemented (Ajzen, 1991). A study performed on Dutch dairies reported a significant association of a producers' goals and intentions with behavior, which became a stronger association when perceived control over a behavior was taken into account (Bergevoet et al., 2004). Furthermore, socio-psychological characteristics including a producer's attitudes about their operation were more significantly associated with a farm's performance than stand-alone behaviors (Dohoo et al., 1984). From a study performed in 1985, socio-psychological characteristics, such as education level, satisfaction, attitude, and risk willingness were able to explain 24.5% of differences in farm performance relative to reproductive disorders, calving interval, and culling versus the 15.5% explained by practices alone (Bigras-Poulin et al., 1985).

In 2009, a survey of 336 Dutch dairy farms reported that attitude and behavior characteristics, such as the producer's perception of how much control they have over mastitis, explained 48% of the variation in bulk tank SCC (Jansen et al., 2009). Another study reported that although producers understood recommended milk quality practices would benefit their operations, they did not adopt them. Why that is the case was unknown (Beaudeau et al., 1996). The same study examined the relationship between a producer's goals, motivations, demographics, and herd characteristics, and the practices implemented in their herds. They concluded that an assessment of both management style and practices would have an increased contribution to improving farm performance rather than only studying practices (Beaudeau et al., 1996).

These previous studies have indicated the need to take all of these factors into account when studying management practices that influence milk quality in a dairy herd. Beginning to understand the knowledge about southeastern dairy producer's attitudes and perceptions toward parlor management can increase the efficacy of disseminating information about the most effective practices for the region, as well as improve communication abilities of industry and extension personnel.

## Rationale

Previous studies readily suggest that practices used in the milking parlor have a significant effect on milk quality. The specific practices implemented in the SE USA and their associations with BTSCC, however, are not known. Furthermore, the association between attitudes and BTSCC, as well as the effect on non-adoption of particular practices, is not well understood. Studies suggest that a producer's attitudes towards milk quality control can impact the universal adoption of practices demonstrated to address mastitis.

The goals of the first study are: determine the frequency of parlor and udder hygiene practices and the practices that promote low SCC in Southeast USA dairy herds. We hypothesize that herds in the Southeast differentially implement practices demonstrated to minimize the risk of mastitis, lower BTSCC, and improve milk quality.

The goal of the second study is to determine the level of effectiveness and practicality perceived toward management strategies by dairy producers in the southeast USA and the extent of its association with BTSCC. We hypothesize that producers who find mastitis control and prevention methods to be highly effective and practical will have lower BTSCC than those who find common management methods not effective or practical. The secondary objective is to examine the factors, such as farm goals, and producer demographics, that could influence a producer's attitudes and perceived level of effectiveness and practicality to determine if certain producers and types of farms are more or less apt to have a certain social perception.

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# CHAPTER I

## Parlor practices utilized in the Southeast USA and their relationship to bulk tank somatic cell count

## ABSTRACT

The demand for high milk quality from consumers and processors is on the rise; however, southeast (SE) USA has decreased milk quality (SCC) compared to other regions of the country. Inflammation of the mammary gland, or mastitis, commonly causes reduced milk quality and is indicated by a rise in somatic cell count (SCC). Certain parlor practices, such as not using gloves or not fore-stripping, multiple use towels, and no disinfectant, increase the possibility that bacteria can be introduced to the teat end. The goal of this study was twofold: determine the level of implementation of parlor practices and which practices promote lower SCC in southeastern USA dairy herds. We hypothesize that herds in the southeast differentially implement practices demonstrated to minimize the risk of mastitis, lower BTSCC, and improve milk quality. Researchers performed a total of 283 voluntary on-farm dairy assessments in Kentucky (KY; n=96) Mississippi (MS, n=9), Tennessee (TN; n=83), and Virginia (VA, n=96) between June 2014 and June 2015. The average BTSCC was 284,029 cells/mL (SD= 115,150 cells/mL) with 22.9% of herds with a BTSCC less than 200,000 cells/mL and 15.5% of operations having a BTSCC over 400,000 cells/mL. Average herd size was 228 cows (SD=330 cows), including all lactations and dry cows. Evaluations consisted of a management survey and parlor observation conducted by a core team of individuals in each state to reduce bias. Steps of udder preparation procedures for milking, which included use of water to wash udders, fore-stripping, pre-disinfecting, drying of teats, and post-milking disinfectant, were logged after visual observation. Observers gathered information on type of pre- and post-milking disinfectant used as well as prep lag time, defined as time from first tactile stimulation to unit attachment, and kill time, defined as the length of time pre-milking disinfection was applied to teats to kill bacteria.

The frequency procedure in SAS, 9.4 was used to determine the percentage of herds that implemented practices. The GLMselect procedure in SAS was used to identify the practices most strongly associated with BTSCC.

Practices associated with BTSCC were post-milking disinfectant active ingredient (p=0.01) alone and the interaction of pre-milking disinfection removal method and post-milking disinfectant active ingredient (p=0.04). When the interaction between pre-milking disinfection removal method and post-milking disinfectant active compound was considered, dodecyl benzene sulfate and lactic acid post-milking disinfectant had a consistently lower BTSCC across all methods of pre-milking disinfection removal. Hydrogen peroxide, however, had a BTSCC of approximately double compared to all other ingredients when used with single service paper.

Producers in the SE USA generally perform recommended procedures in their dairy parlors. This suggests something other than practice implementation is attributing to the higher BTSCC in the SE USA.

## INTRODUCTION

The demand for high milk quality is on the rise due to a longer shelf-life and better profitability to overall industry (Ma Y, 2000, Barbano et al., 2006, Dufour et al., 2011). One cause of poor milk quality, mastitis or inflammation of the mammary gland, is indicated by a rise in somatic cell count (SCC). A report from the National Animal Health Monitoring Service (NAHMS) stated the average SCC was 206,500 cells/mL in 2014 (United States Department of Agriculture's Animal and Plant Health Inspection Service, 2016). Herds enrolled in the Dairy Herd Information Association (DHIA) were slightly better with approximately 204,000 cells/mL in 2015. Each of these averages are near the recommended goal of 200,000 cells/ml or lower which represents higher quality milk. A bulk tank SCC

(BTSCC) of 400,000 cells/ml is required to export milk to the European Union and represents a common cutoff. In the USA as a whole, 12% of herds participating in the Dairy Herd Information Association (DHIA) had a SCC over 400,000 cells / ml, while 22% of herds in the SE, including Tennessee, Virginia, Mississippi, and Kentucky, fell into this category (Walton, 2015).

Management practices in the parlor have been demonstrated to influence the rate of mastitis within a herd. (Goodger et al., 1993, Barkema et al., 1998, Wenz et al., 2007, Elmoslemany et al., 2010). Pre-milking disinfection, use of towels (especially single service) to dry teats, and post-milking disinfectant of teats were reported to decrease SCC by depleting bacteria levels on teats (Erskine et al., 1987, Faye et al., 1997, Barkema et al., 1998, Ruegg et al., 2000, Dufour et al., 2011). Removal of udder hair, such as singing or clipping, was associated with decreased risk of dirty udders (Barkema et al., 1998, Dufour et al., 2011) and thus a lower bacteria level present on the teats (Murphy, 1997, Elmoslemany et al., 2010). Although, another study has shown udder hair management had no association with bacteria levels on the udder (Silk, 2003). Udder preparation, such as use of fore-stripping and towels, also decreased risk for new intramammary infection (Barkema et al., 1998, Schreiner and Ruegg, 2003, Dohmen et al., 2010, de Pinho Manzi et al., 2012). Research has shown that recommended inclusion of hygienic actions, such as fore-stripping and use of gloves decreases risk or new infection and BTSCC (Kingwill et al., 1970, Ruegg et al., 2000, Elmoslemany, 2008, Dufour et al., 2011, Cicconi-Hogan et al., 2013).

Udder and teat health were impacted by prep lag time, or the lapse between first tactile stimulation to unit attachment (Lollivier et al., 2002, Watters et al., 2012). Prep lag time had a positive impact on yield, efficiency, and flow. Poor yield, efficiency, and flow led to teat tissue damage resulting from no flow or bimodal milk let-down (Bruckmaier and Blum, 1996, Neijenhuis et al., 2001). The stimulation provided by prep lag time, projected to be between 60 and 120 seconds, allowed for oxytocin let-down, which ensures milk-flow begins as soon as the milking unit is attached (Rasmussen et al., 1992, Reneau and Chastain, 1995, Bruckmaier, 2001).

These studies suggested that milking practices have a significant effect on the quality of milk. However, the specific practices employed in the SE USA and the subsequent contributions to elevated BTSCC are not known. The National Animal Health Monitoring Service conducted a nationwide survey in 2007 (USDA, 2008). The survey represented 36% of all US dairy operations, of which 38% were from Eastern US and 14% from the Western US. No surveys regarding parlor practices were collected in the Southeast USA other than Kentucky and Virginia. The survey was not specific to the southeast USA with no states south of Kentucky being evaluated. This leaves a gap in what practices were understood to be ongoing in dairy parlors throughout the southeast.

The goals of this study are: determine implementation of parlor and udder hygiene practices and which practices promote low SCC in Southeastern USA dairy herds. We hypothesize that herds in the Southeast differentially implement practices demonstrated to minimize the risk of mastitis, lower BTSCC, and improve milk quality.

## MATERIALS AND METHODS

The University of Tennessee, University of Kentucky, Virginia Polytechnic Institute, and Mississippi State University performed a total of 283 voluntary on-farm dairy assessments in Kentucky (KY; n=96) Mississippi (MS, n=9), Tennessee (TN; n=83), and Virginia (VA, n=96) between June 2014 and June 2015. BTSCC yearly average for 2012, for on-farm categories, and 2014, for statistical analysis, was generated using the time series procedure in SAS (9.3) which calculated a monthly mean using data reported to state regulatory agencies for dairies with a Grade A milk permit. BTSCC for operations in KY, MS, TN, and VA during the 2012 calendar year was used for initial categorization of operations. Dairies were sectioned into thirds representing the lowest (0 to 220,000 cells / ml), middle (221,000 to 340,000 cells / ml), and highest (340,000 cells / ml and greater) BTSCC. The goal was to have even representation throughout the different BTSCC levels. Percentages by state within each category can be found in Table 1.01. Observations from 283 herds were included in analysis. The average BTSCC was 284,029 cells/mL (SD= 115,150 cells/mL) with 22.9% of herds with a BTSCC less than 200,000 cells/mL and 15.5% of operations having a BTSCC over 400,000 cells/mL (Table 1.02). Average herd size was 228 cows (SD=330 cows), including all milking and dry cows.

***On-farm Evaluation***

The on-farm evaluation consisted of a management survey and parlor observation. Practices to be reviewed in the parlor (Table 1.03) were selected based on prior research demonstrating their association with mastitis. Steps of udder preparation procedures for milking, which included use of water to wash udders, fore-stripping, pre-disinfecting, drying of teats, and post-milking disinfectant, were logged after visual observation. Observers gathered information on type of pre and post-milking disinfectant used as well as routine timing. These timings were prep lag time, or first tactile stimulation to unit attachment, and kill time, or length of time pre-milking disinfection was applied to teats to kill bacteria. Teat condition scoring was performed during milking on 20% of the herd or 80 cows whichever was greater. All lactating cows were scored in herds with less than 80 cows (D.J.Reinemann, 2001). Cows were scored on a scale of 0 to 4 denoting level of keratin buildup present (Mein et. al ,2001). Briefly, a score of zero or one was no ring, two was a slightly raised ring, three was a ring extending one to three millimeter from the teat surface, and four was a much raised ring with fronds extending greater than four millimeters from the teat surface. If any roughness, fronds, or cracking of the skin was apparent, a half score (0.5) was added (D.J.Reinemann, 2001, Mein et al., 2001). In addition to observations made within the parlor, managers/owners were interviewed by study personnel regarding multiple management practices and included two specific questions of interest (Appendix 1): glove use, and the level of udder hair management. Pre and post milking disinfectant compounds as well as prep lag time and kill time for Mississippi were not recorded.

### *Statistical Methods*

The frequency procedure in SAS, 9.4 was used to determine the percentage of herds that implemented specific parlor and udder hygiene practices (Table 1.03). To test the hypothesis that differential implementation of practices was associated with BTSCC, the GLMselect procedure in SAS was used to identify the practices most strongly associated with BTSCC through stepwise entry and removal from the model (Table 1.04). BTSCC for operations from 2014 was used for statistical analysis because it was more current than the 2012 data that was used for initial categorization of operations. Yearly average BTSCC was the response variable. Explanatory variables assessed in the GLMselect procedure were use of gloves, udder hair management, percent of herds with greater than 10% of cows with a teat condition average of 3, milking practices (water, pre-wiping, pre-milking disinfection method and active ingredient, method of pre-milking disinfection removal, and post-milking disinfectant active ingredient), and preparation timing (prep lag and kill time). As teat health can be evaluated at multiple levels, we first evaluated the correlation between teat score. Little to no correlation (-0.06) was observed until a score of 3 or greater was reached. As a result, teat condition was evaluated on a per herd basis by percent of quarters in the herd that were scored as 3 or greater. If a pre-milking disinfection or post-milking disinfectant active ingredient was less than 5% of the total, it was grouped into an “other” category. Gloves use was recorded as “always”, “sometimes”, or “never”; however, because frequencies were low in the sometimes category, the “sometimes” and “yes” categories were combined. Prep lag time was defined as recommended (60 to 120 seconds), too short (less than 60 seconds), or too long (greater than 120 seconds), and pre-disinfection kill time as recommended (>30 seconds) or too short (<30 seconds) (Rasmussen et al., 1992, Reneau, 2001). Prep lag time and kill time were categorized due to a high frequency of numbers, which greatly decreased the efficiency of the model. Overall, practices were selected to enter and stay in the model when the probability of being less than the F-statistic was below 0.15. The model with the lowest Akaike’s information criterion (AIC) was used to determine the final model that best explained the variation associated with BTSCC. Next, this final model was used in an analysis of variance to determine the strength of the relationship between BTSCC and the selected practices, as well as provide estimates of BTSCC associated with differing implementations of each practice.

The linear variables, kill time, prep lag time, teat condition, and percent rough, were examined for any potential relationship with BTSCC using the correlation procedure in SAS. (Table 1.05)

## RESULTS and DISCUSSION

The goal of this study was to provide more detailed information about parlor practices implemented by SE dairy producers and determine those most associated with BTSCC. Initially, we reviewed the frequency at which producers adopted practices recommended by the National Mastitis Council as part of their mastitis control program. These frequencies can be found in Table 1.03.

BTSCC is known to decrease with use of gloves during milking (Bach et al., 2008, Cicconi-Hogan et al., 2013). A recent literature review about management practices also suggests that the overwhelming majority of studies provide evidence that support the use of gloves during milking because of its relativity to SCC (Dufour et al., 2011). Glove use across the sample population in this study was 88%, while only 55% of herds surveyed in the 2007 NAHMS dairy survey reported the practice (USDA, 2008). The larger sample size within the NAHMS survey could contribute to the large variation (33%) in adoption of this practice, as well as the way the data was gathered. Our study combined the two categories of “always” and “sometimes” to provide a yes or no response.

Fore-stripping of milk is a positive practice because it provides stimulation of milk ejection, easier sight of abnormal milk, and removes highest bacteria milk from the teat canal (Harmon, 1994, Fahr, 2002, Sandrucci, 2002). In the SQMI sample population, 5% more herd’s fore-strip (64%) compared to the 59% of operations who use fore-stripping in the parlor nationally (USDA, 2008). The NAHMS study did record whether they stripped all cows, some cows, or no cows, while the evaluation process here only assessed whether stripping was noted as part of the milking procedure, which could account for the percentage difference.

Using a towel to dry teats after pre-disinfection lowered the amount of bacteria present on teats (Pankey, 1988). Use of a single towel per cow demonstrated a reduction in the risk of transmitting microorganisms between cows when compared with towels used multiple times (Galton et al., 1986, Elmoslemany et al., 2010). In 2008, it was suggested that paper towels instead of cloth towels were more strongly associated with lower SCC (Bach et al., 2008).
The most common dry wipe method observed in our study was single use towels (66%), which was lower than observed in the NAHMS study (77%)(USDA, 2008). The variation in percentages implementing single service towels could be due to the sample size difference between the surveys, with NAHMS examining 582 operations compared to the 282 assessed here. Also, some observers in our study recorded single service towels when each side of the towel was used for different cows as opposed to multiple services.

Use of a pre-milking disinfectant has been associated with a reduced risk of new mastitis cases (Galton et al., 1986, Rasmussen et al., 1991). Both NAHMS and the current survey revealed that almost half of all dairy herds apply pre-milking disinfectant with a dip cup containing a commercial ingredient, while less than a quarter used a sprayer for application. Post-milking disinfectant type and application method was similar across both surveys as well, with greater than 75% of all operations applying a commercial product using a dip cup.

The active ingredient in teat disinfectant is associated with bacteria removal. Galton et al (1986) concluded that iodine, sodium hypochlorite, and dodecyl benzene sulfonic acid dips all caused significant bacterial reduction on the teats, with no differences between the types of compound; however, there is varying information about which active ingredient is the most effective (Pankey, 1984, Fox, 1992, Enger et al., 2015). Some studies concluded that iodine was the most effective post-milking disinfectant, while hydrogen peroxide killed bacteria more efficiently (Philpot and Pankey, 1978, Enger et al., 2015). The most common active compound in pre and post milking disinfectants was iodine; however, almost 60% of herds in NAHMS used iodine for pre-milking disinfection, while only 41% of our sample population did. Comparable levels of iodine as a post-milking disinfectant (approximately 70%) were reported.

A secondary goal of this project was to define the practices in the SE USA that best explain the variation in BTSCC. This was accomplished using a stepwise approach to build a best fit model, which was then used in an ANOVA to evaluate each of the explanatory variables outlined in Table 1.03. The following variables represent those practices that best explain the variation in BTSCC (Table 1.04) within this study and were included in the final model: udder hair management, method of pre-milking disinfection removal, post-milking disinfectant active ingredient, and kill time.

Dufour et al (2011) reported that udder hair clipping was associated with herds who had lower BTSCC. Bacteria counts were lower in herds with clipped udders, thus a decreased risk of new infection was present (Elmoslemany et al., 2010). However, another study did not find udder clipping or singeing to be of any significance with the milk quality of a herd (Silk, 2003). This agrees with our study where udder hair management ($p=0.17$) was not significantly associated with BTSCC but may be of importance due to its selection by the GLMselect procedure. Further investigation is needed for more concrete evidence of its association with milk quality.

Prior research has demonstrated that bacteria load on teats was significantly reduced by drying, especially when performed with single-service towels because this further reduced the risk of transferring microorganisms (Galton et al., 1986, Pankey, 1988, Elmoslemany et al., 2010). In 2008, one study determined that paper towels, as opposed to cloth towels, were more associated with lowering BTSCC (Bach et al., 2008). In our study, method of pre-milking disinfection removal ($p=0.21$) was not significant when considered alone, but became important ($p<0.05$) when considered as an interaction with post-milking disinfectant active ingredient.

Disinfectant contact time, or kill time, influences efficacy of teat disinfection. When pre-milking disinfectant kill times equaled 30 seconds, bacteria were reduced on the teat skin (Enger et al., 2015). In our study, kill time ($p=0.43$) was not one of the strongest variables associated with BTSCC, but was selected by the stepwise regression speaking to its importance. It may be less important when compared to the strongly associated variables selected in the ANOVA.

Post-milking disinfectant active ingredient ($p=0.01$) was associated with BTSCC in our sample population. Our study concluded that the lowest BTSCC (195,464 cells/mL ±35,180) was associated with herds that used a product with dodecyl benzene sulfate and lactic acid. Unfortunately, in this study we did not have the opportunity to evaluate dip coverage, temperature and humidity, and organic matter load on teats relative to product efficacy in an on-farm environment versus controlled studies such as those discussed above (Chassagne et al., 2005).

An interaction of pre-milking disinfection removal method and post-milking disinfectant active ingredient (p=0.04) was observed (Table 1.04). Herds in our sample population that used an iodine active ingredient in the post-milking disinfectant had a BTSCC 191,024 cells/mL lower than herds using hydrogen peroxide. The lowest BTSCC (195,464 cells/mL ±35,180) was associated with herds that used a product with dodecyl benzene sulfate and lactic acid.

When the interaction between pre-milking disinfection removal method and post-milking disinfectant active compound was considered, dodecyl benzene sulfate and lactic acid post-milking disinfectant had a consistently lower BTSCC across all methods of pre-milking disinfection removal. Hydrogen peroxide, however, had a BTSCC of approximately double when used with single service paper towels versus multiple use or single use cloth towels. Within multi-service towels, herds that used iodine had a BTSCC approximately 120,000 cells/mL higher than those who used dodecyl benzene sulfate and lactic acid. Use of post milking disinfection, along with single service towel use has shown in previous research to decrease SCC (Erskine et al., 1987, Barkema et al., 1998, Ruegg et al., 2000, Dufour et al., 2011). However, examining specific active ingredients and interactions with towel use has no other studies reporting findings.

Our study provided a limited assessment of type of management. A study by Barkema et al. in 1999 addressed style of management and determined that herds of producers with a “quick and dirty” management style had a higher SCC than those with a “clean and accurate” style (Barkema et al., 1999). This related to a difference in milk quality and could confound the interpretation of management practices alone. Of the variables showing no significance with BTSCC, fore-stripping and use of gloves were most notable. It is well documented that these two practices are important toward mastitis control, but that significance was not observed in our model. Two areas that were difficult to account for in this observational study were a producer's management skills and effectiveness of implementation. These two areas may be tied together, as management skills can impact the training and efficacy of personnel.

## CONCLUSION

This study suggests that post milking disinfectant active ingredient and its interaction with method of pre milking disinfectant used in the dairy parlor have a significant positive association with BTSCC and thus milk quality. This significance allows us to make conclusions about which practices are most influential on BTSCC in the dairy parlor. We learned that producers in the SE USA perform more recommended procedures in their dairy parlors suggesting they are conscientious about BTSCC issues in the region. This also suggests something other than practice implementation is attributing to the higher BTSCC in the region. Continued focus on different areas of dairy operations that could be causing higher BTSCC is necessary to improve milk quality of the SE dairy industry.

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# CHAPTER I APPENDIX

***Table 1.01. Percent of herds falling within each BTSCC category by state***

| **BTSCC in cells/mL** | **State** | | | | |
|---|---|---|---|---|---|
| | **KY** | **TN** | **MS** | **VA** | **Total** |
| 0-220,000 | 38% | 16% | 0% | 41% | 31% |
| 221,000 – 340,000 | 43% | 41% | 38% | 40% | 41% |
| >340,000 | 20% | 43% | 63% | 20% | 28% |
| Total n= | 96 | 82 | 9 | 96 | 283 |

***Table 1.02. BTSCC and herd size on a by state basis.***

| State | BTSCC ± Standard Deviation (cells/mL) | Herd Size ± Standard Deviation |
|---|---|---|
| KY | 257,671 ±93,410 | 174 ±318 |
| TN | 333,586 ±119,132 | 221 ±257 |
| MS | 421,532 ±170,788 | 428 ±439 |
| VA | 263,713 ±129,954 | 274 ±377 |
| ALL | 284,029 ±115,150 | 228 ±330 |

***Table 1.03. Frequency of procedures carried out in the milking parlor by herds sampled in the Southeast.***

| **Procedure in the Parlor** | **Frequency** |
|---|---|
| Use water to wash the udder, either with or without disinfectant | 16.75% |
| Pre-wipe before beginning preparation procedure | 13% |
| Pre-milking disinfection product and method | |
| Homemade product as a foam | 0% |
| Homemade product using a spray applicator | 2% |
| Homemade product in a cup | 4.48% |
| Commercial product using a spray applicator | 13% |
| None | 13.1% |
| Commercial product as a foam | 15.43% |
| Commercial product in a cup | 52% |

***Table 1.03 cont'd***

| **Procedure in the Parlor** | **Frequency** |
|---|---|
| Active ingredient in pre-milking disinfectant | |
| Chlorhexidine | 2.16% |
| Homemade | 5.41% |
| Other | 8.65% |
| Lactic acid | 14.59% |
| Hydrogen peroxide | 28.65% |
| Iodine | 40.54% |
| Method to remove pre-disinfectant | |
| Air dry | 1% |
| Multi-use paper towel | 5.97% |
| Multi-use cloth towel | 15.43% |
| Single use cloth towel | 31.85% |
| Single use paper towel | 33.84% |
| None | 11.91% |
| Paper | 45.09% |
| Cloth | 54.91% |
| Multi-use | 24.68% |
| Single use | 75.14% |

***Table 1.03 cont'd***

| **Procedure in the Parlor** | **Frequency** |
|---|---|
| Fore-strip | 63.68% |
| Post-milking disinfection product and method | |
| Homemade product applied as a spray | 0% |
| Commercial or homemade applied as a foam | 0% |
| Homemade product applied in a cup | 3% |
| Commercial product applied as a spray | 7.46% |
| Commercial product applied in a cup | 79.1% |
| None | 10.44% |
| Active ingredient in post-milking disinfectant | |
| Homemade | 1.64% |
| Hypochlorous Acid | 7.9% |
| Homemade | 1.4% |
| DBSLA | 21.85% |
| Iodine | 67.21% |
| Singe or clip udders | 49% |

*Table 1.03 cont'd*

| **Procedure in the Parlor** | **Frequency** |
|---|---|
| Average kill time | |
| Too short (<30 seconds) | 25.36% |
| Recommended ( >29 seconds) | 74.64% |
| Average prep lag time | |
| Too long (>120 seconds) | 26.32% |
| Recommended (less than120 seconds) | 73.67% |
| Teat condition score of 3 | |
| Greater than 10% of herd | 27.11% |
| Less than 10% of herd | 72.89% |
| Use gloves in the parlor | 87.92% |

***Table 1.04. Analysis of variance of parlor variables selected in the stepwise selection model.***

| **Procedure in the Parlor** | **P-value** | **Est. BTSCC cells/mL ±Standard Error** |
|---|---|---|
| Method of pre-milking disinfectant removal | 0.21 | |
| Multiple use paper or cloth (MULT) | | 277,628 [a] ±21,536 |
| Single use paper (SPAP) | | 314,693 [a] ±22,754 |
| Single use cloth (SCLO) | | 288,474 [a] ±22,515 |
| None (NO) | | 288,569 [a] ±26,144 |
| Post-disinfectant active ingredient | 0.009 | |
| Hydrogen Peroxide (HP) | | 471,571 [a] ±58,732 |
| Iodine (ID) | | 280,547 [bc] ±10,333 |
| Dodecyl Benzene Sulfonic and Lactic Acid (DBSLA) | | 195,464 [d] ±35,180 |
| Hypochlorous Acid (HA) | | 405,125 [ab] ±67,717 |
| Homemade (HOME) | | 197,745 [cd] ±55,556 |
| Udder clipping or singing | 0.17 | |
| Yes | | 283,594 [a] ±20,542 |
| No | | 301,088 [a] ±19,173 |

*Table 1.04 cont'd*

| Procedure in the Parlor | P-value | Est. BTSCC cells/mL ±Standard Error |
|---|---|---|
| Kill time | 0.43 | |
| Recommended | | 302,926 [a] ±17,504 |
| Too short | | 281,756 [a] ±22,590 |
| Method of pre-milking disinfectant removal * Post-disinfectant active ingredient | 0.04 | |
| MULT * DBSLA | | 166,806 [d] ±49,858 |
| MULT * ID | | 286,626 [c] ±23,059 |
| MULT * HP | | 339,511 [cd] ±77,919 |
| MULT * HOME | | 124,446 [de] ±77,919 |
| | | |
| SPAP * DBSLA | | 142,108 [cd] ±110,311 |
| SPAP * HP | | 639, 836 [a] ±110,311 |
| SPAP * ID | | 303,521 [c] ±15,074 |
| SPAP * HA | | 395,991 [abc]±78,533 |

*Table 1.04 cont'd*

| Procedure in the Parlor | P-value | Est. BTSCC cells/mL ±Standard Error |
|---|---|---|
| Method of pre-milking disinfectant removal * Post-disinfectant active ingredient | | |
| SCLO * DBSLA | | 251,293 $^{cd}$ ±44,931 |
| SCLO * HP | | 435,366 $^{abc}$ ±110,311 |
| SCLO * ID | | 272,751 $^{ce}$ ±15,207 |
| SCLO * HOME | | 271,044 $^{cd}$ ±78,390 |
| | | |
| NO * DBSLA | | 221,653 $^{cd}$ ±49,602 |
| NO * ID | | 259.292 $^{cd}$ ±22,899 |
| NO * HA | | 414,259 $^{abc}$ ±110,209 |

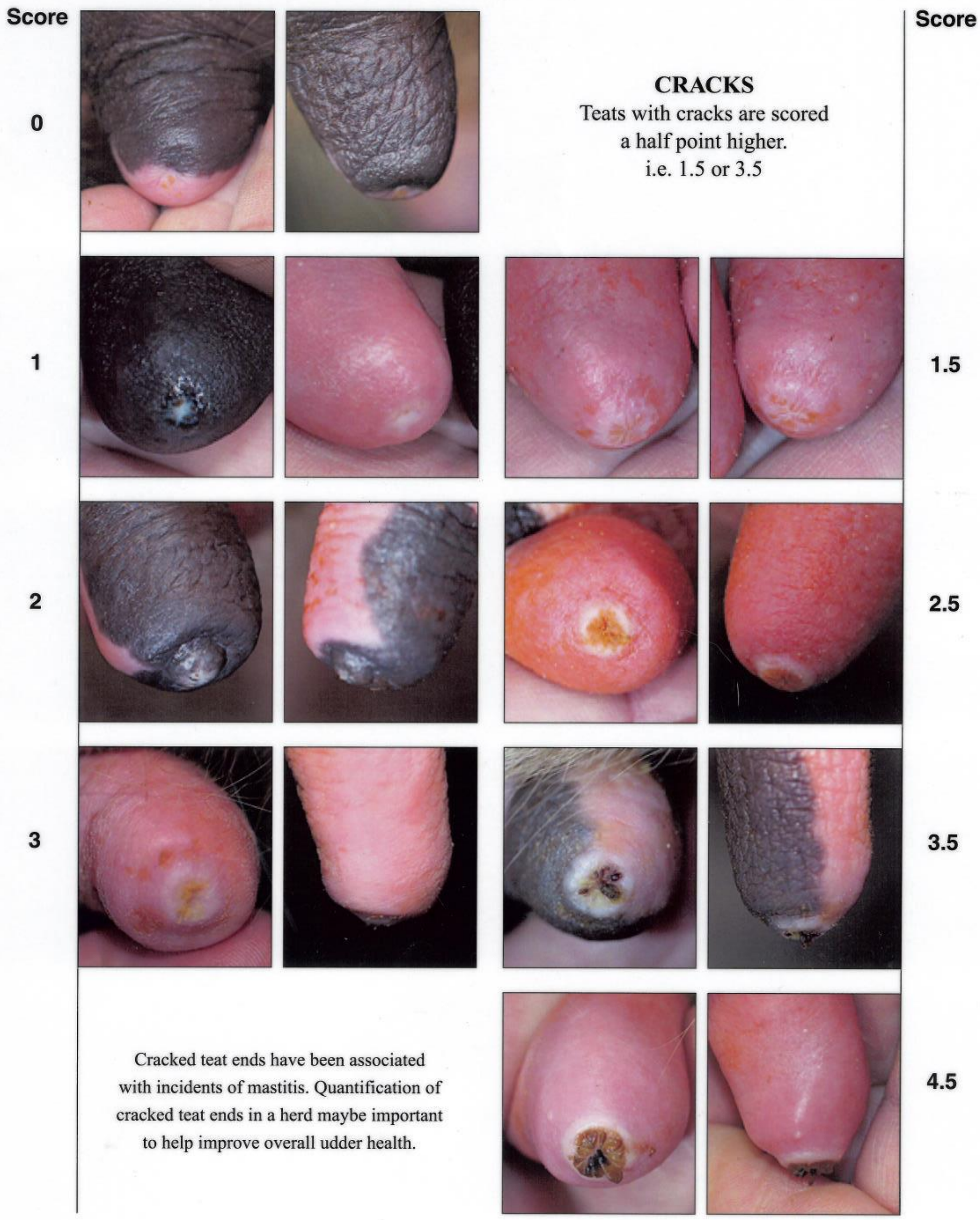
i: letter indicates least squares mean difference within a practice

***Table 1.05. Correlation between SCC and linear variables (kill time, prep lag time, teat condition average, and percent of teats rough).***

| **Practice** | **P-value** | **Corr. SCC** |
|---|---|---|
| Kill time average | 0.133 | 0.115 |
| Prep lag time average | 0.065 | -0.138 |
| Average teat condition | 0.343 | -0.066 |
| Percent of teats rough | 0.753 | -0.022 |

# TEAT CONDITION SCORE

**CRACKS**
Teats with cracks are scored
a half point higher.
i.e. 1.5 or 3.5




Cracked teat ends have been associated with incidents of mastitis. Quantification of cracked teat ends in a herd maybe important to help improve overall udder health.

# CHAPTER II

## Dairy producer attitudes in the Southeast USA regarding the effectiveness and practicality of mastitis management practices in relation to bulk tank somatic cell counts

## ABSTRACT

The primary objective of this study was to determine the perceived level of effectiveness and practicality toward management strategies by dairy producers in the southeastern US and the extent of its relationship to bulk tank SCC, a measure of milk quality. The secondary objective was to examine the factors, such as farm goals, and producer demographics, that could influence a producer's attitudes and perceived level of effectiveness and practicality to determine whether certain producers and types of farms are more or less apt to have a certain social perception. In 2014, Grade A dairy cattle producers in Georgia, Mississippi, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia were mailed a survey (Appendix A) (n =1,996) to identify dairy producers' attitudes regarding mastitis and mastitis management. Between October and December 2013, two survey packets and two reminder postcards were mailed at approximate two week intervals to licensed dairy producers in an attempt to maximize the overall response rate. A total of 588 surveys were returned for an overall response rate of 29.9%. A scale was created that summed the reported level of effectiveness and practicality of each parlor management practice to generate a practicality and effectiveness index, or PEI, for each practice. The PEI of three parlor management practices was significantly associated with BTSCC. They were disinfecting teats of all cows before milking (pre-milking disinfectant; p=0.01); training employees in milking procedures to reduce BTSCC (p=0.03), and having and implementing a mastitis management plan (p=0.02). These results suggest attitudes towards parlor management, and its effectiveness and practicality, play an important role in BTSCC.

## INTRODUCTION

Lower quality milk has reduced shelf-life, decreased profitability to producers, and is a poorer tasting, less nutritive product (Ma Y, 2000, Barbano et al., 2006, Dufour et al., 2011). Thus, demand for high quality milk by consumers and processors from dairy producers continues to increase. One prominent cause of reduced milk quality is an inflammation of the mammary gland, known as "mastitis," and indicated by a rise in SCC. Herds enrolled in the Dairy Herd Information Association (DHIA) were reported to have a bulk tank SCC (BTSCC) of approximately 204,000 cells/mL in 2015. A report from the National Animal Health Monitoring Service (NAHMS) stated the average SCC was 206,500 cells/mL in 2014 (United States Department of Agriculture's Animal and Plant Health Inspection Service, 2016). Each of these are close to the recommended 200,000 cells/ml or lower which represents higher quality milk. In the USA as a whole, 12% of herds participating in the Dairy Herd Information Association (DHIA) had a SCC over 400,000 cells / ml, while 22% of herds in the SE, including Tennessee, Virginia, Mississippi, and Kentucky, fit into this category (Walton, 2015).

The rate of mastitis incidence and bulk tank somatic cell count (BTSCC) in dairy herds are influenced by a producer's management practices (Goodger et al., 1993, Barkema et al., 1998, Wenz et al., 2007, Elmoslemany et al., 2010). Hygienic management methods, such as use of gloves, pre-milking and post-milking disinfection, method of disinfectant removal, fore-stripping, and managing udder hair have been demonstrated to impact milk quality at the udder level and reduce BTSCC (Pankey, 1988, Dufour et al., 2011). Furthermore, use of a comprehensive mastitis management plan that promoted practices known to decrease mastitis, such as record keeping of mastitis cases, improved hygienic conditions of cows, dry cow therapy, and post-disinfection of teats also was associated with a lower BTSCC when compared to those who did not (Barkema et al., 1999).

Adoption of practices such as those outlined above are critical for minimizing the risk of mastitis and elevated BTSCC. In a study by Beaudeau and colleagues (1996), some producers did not use most of the effective milk quality strategies as part of their management plan; however, why practices were not adopted was not evaluated (Beaudeau et al., 1996). A later study completed in 2005 with Dutch dairy herds concluded that perceptions of self-efficacy, normative beliefs and incentives were key reasons associated with whether practices known to control mastitis were utilized (Kuiper et al., 2005).

As employees are the individuals often implementing these practices, they have the potential to influence BTSCC. A study on Pennsylvania dairy farms, suggested evaluating employee performance based on BTSCC measures and training employees did not have a significant impact on BTSCC (Stup et al., 2006). However, recent data suggested that lower milk quality on-farms can be linked to insufficient training, misuse or nonuse of evaluating employees based on BTSCC measures, and a poor perception of human resource management by producers (Erskine et al., 2015, Schewe et al., 2015). The difference between the results of the studies is that Stup (2006) data was not collected based on a random sample population as stated in the paper, and did not represent Pennsylvania dairy herds as a sample population would. The other studies were based on a random sample population.

Practices on-farm as well as human resource decisions are all part of management decisions made by a producer. Attitudes were shown to impact these decisions when farm performance factors, one of which was BTSCC, were examined (Bigras-Poulin et al., 1985, Sato et al., 2008, Jansen et al., 2009). Socio-psychological characteristics, such as education level, satisfaction, attitude, and risk willingness, explained 24.5% of variation in the frequency of diseases such as metritis, retained placenta, culling, and other reproductive disorders versus 15.5% explained by adoption of practices (Bigras-Poulin et al., 1985). Although these are not milk quality related diseases, it does suggest that attitudes were impactful on farm performance in addition to the other socio-psychological characteristics.

More relevant to milk quality, a survey of 336 Dutch dairy farms determined that attitudes and behaviors explained 48% of the variation in BTSCC (Jansen et al., 2009). This variation was best explained by how the producer understood mastitis, and perceptions the producer held about mastitis control and efficacy of a penalty system. Jansen et al. (2009) suggested that attitude of a producer was more informative than practices alone in explaining why some herds had increased mastitis and future studies should assess attitudes along with behavior. Furthermore, surveys performed in 2004-2005 and again during 2009 in the Netherlands that examined the association between mastitis rate, attitudes about mastitis, and behavior reported that changes in farmers attitudes were more explanatory (24%) than practices regarding a decrease in mastitis rate (van den Borne et al., 2014).

Research has suggested that a producer's attitude towards milk quality control can impact the universal adoption of practices demonstrated to prevent or control mastitis. It is not known at what level of attitude about effectiveness and practicality BTSCC becomes related. We hypothesized that producers who find mastitis control and prevention methods to be very effective and practical will have lower BTSCC then those who find common management methods not effective or practical. The primary objective of this study was to determine the level of effectiveness and practicality perceived toward management strategies by dairy producers in the southeastern US, and the extent of its relationship with milk quality. The secondary objective is to examine the factors, such as farm goals and producer demographics that could influence a producer's attitudes and perceived level of effectiveness and practicality to determine whether certain producers and types of farms are more or less apt to have a certain social perception.

## MATERIALS AND METHODS

### *Survey*

In 2014, Grade A dairy cattle producers in Georgia, Mississippi, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia were mailed a survey (Appendix A) to identify dairy producers' attitudes regarding mastitis and mastitis management (n =1,996). Between October and December 2013, two survey packets and two reminder postcards were mailed at approximate two week intervals to licensed dairy producers in an attempt to maximize the overall response rate. A total of 588 surveys were returned for an overall response rate of 29.9%. Responses were from Georgia (n=38), Kentucky (n=170), Mississippi (n=18), North Carolina (n=52), South Carolina (n=20), Tennessee (93), and Virginia (178). Producers (n=160) also were surveyed over the phone to complete non-response bias testing. The purpose of this testing was to establish that those who had not responded to the survey were not leaving out vital information from the sample population. In our sample population, the average lactating herd size was 177 cows with a mean self-reported BTSCC of 254,142 cells/mL. Respondents were primarily owners (93%).

The survey covered demographic information, socio-psychological questions, motivations for mastitis action, perceptions of mastitis management, goals for the dairy herd, and generational information. We selected seven management practices specific to mastitis and parlor procedures (Table 2.01) for evaluation. The respondent ranked these practices in terms of practicality and effectiveness using the following Likert scales: not at all practical (score=1), not practical (score=2), neutral (score=3), somewhat practical (score=4), very practical (score=5), and not at all effective (score=1), not effective (score=2), neutral (score=3), somewhat effective (score=4), very effective (score=5). Producers also self-reported their use of each management practice using the following options: 1) use it now, 2) tried it but stopped, or 3) never used it along with their current BTSCC. To evaluate associations present with a producer's attitudes about the effectiveness and practicality, herd characteristics, producer goals, demographic variables, and incentive programs (Tables 2, 3, and 4) were included. A copy of the full survey is located in Appendix A and the questions evaluated in this paper highlighted in yellow. All survey related procedures were approved by the Institutional Review Board.

***Statistical Analysis***

The frequency procedure in SAS, 9.4 was used to evaluate the percentage of producers that responded at each level of effectiveness and practicality for each parlor management practice to determine the distribution of responses. Multiple management practices had individual Likert response frequencies below 2% that compromised our statistical power. To address this problem and provide a more integrated assessment, an index was created that summed the reported level of effectiveness and practicality to generate a practicality and effectiveness index, or PEI, for each practice. For example, a producer that ranked disinfecting teats of all cows before milking as very effective, or a five, and very practical, or a five, had a PEI score of 10. This developed a scale from zero to 10, where zero was no answer, scores one through four were not at all effective or practical, five and six were neutral, seven and eight were somewhat effective and practical, and nine and 10 were very effective and practical.

To determine the extent to which a producer's attitude regarding parlor and mastitis management practices was associated with the self-reported BTSCC of the herd, a mixed model analysis of variance (MMAOV) was conducted, and will be referred to as the attitude model. The PEI of all seven parlor or mastitis management practices were performed simultaneously in the model as fixed effects. The self-reported BTSCC was the response variable. A p-value of 0.05 was declared significant and 0.1 or less a trend. To determine the degree of variation in BTSCC explained by attitudes towards individual practices, individual

R2 values were determined by calculating the change in the overall R2 value as each practice was removed from the model (Table 2.08). As the PEI towards mastitis management practices most likely reflects the respondent's prior experiences, we evaluated the association of the effects as significant relative to demographic variables outlined in Tables 2.02, 2.03, and 2.04 using an ANOVA. Herd or producer demographics, management strategies, and goals and incentives (Table 2.02, 2.03, and 2.04) were the fixed effects and explanatory variables. Frequencies of each descriptors' responses were examined. If n was less than 5, they were put into groups. Grouped variables were age, number of individuals milking, average production, and number of lactating cows. The response variables included: the PEI of use of pre-milking disinfectant, training employees, and having and implementing a mastitis management plan.

Actual use of a practice could have a greater impact on BTSCC then attitudes towards that practice. To test this, the GLMselect procedure in SAS was used to identify the combination of practices used and attitudes towards those practices that were most strongly associated with BTSCC. Self-reported BTSCC was the response variable. The effect was selected to enter and stay in the model when the probability of being less than the F-statistic was below 0.15 and the effect left the model when the probability was 0.15 or greater. The best model was selected when the lowest Akaike's information criterion (AIC) was reached. Next, the identified effects were entered into an analysis of variance, termed the full model, to determine estimates of BTSCC associated with each level of use and PEI.

## RESULTS

### *PEI of parlor management practices associated with BTSCC in the attitude model*

The three parlor management practices significantly associated with BTSCC were disinfecting teats of all cows before milking (pre-milking disinfectant;

p=0.01); training employees in milking procedures to reduce BTSCC (p=0.03), and having and implementing a mastitis management plan (p=0.02).

Of these three, the greatest association (p=0.01) was observed between the PEI for pre-milking disinfectant and BTSCC. The largest percentage (51.5%) of respondents perceived pre-milking disinfectant to be very effective and practical. Furthermore, attitude about pre-milking disinfectant explained 13.1% of the variation in BTSCC. Producers that scored pre-milking disinfectant as greater or equal to nine (51.5%) on the PEI had a BTSCC 101,145 cells/mL less than those with a PEI that was neutral (score 5-6, 9.4%), and 22,609 cells/mL less than somewhat (score 7-8, 27%). In our sample population, the PEI of having and implementing a mastitis management plan explained 12.6% of the variation in self-reported BTSCC. Most producers (55.4%) found having and implementing a mastitis management plan as somewhat effective and practical or neutral, while only 11.8% found it to be very effective and practical. Those who scored a mastitis management plan as very effective and practical (score 9-10, 11.8%) on the PEI had a BTSCC 83,928 cells/mL less than those who only perceived it as neutral (score 5-6, 22.8%) and 38,955 cells/mL less than somewhat (score 7-8, 33.6%). Over 50% of producers perceived training employees to be somewhat or very effective and practical, while 23.3% perceived it as neutral or not effective and practical. When the PEI regarding training employees was a nine or higher (23.5%) on the PEI, BTSCC was reduced by 45,000 cells/mL compared to a perception of somewhat (7-8). The remaining four parlor management practices were not associated with BTSCC, regardless of perceived PEI.

Descriptors associated ($p \leq 0.05$) with the PEI of use of pre-milking disinfectant (Table 2.11) were whether an incentive was offered by the processor or co-op, the BTSCC level at which a producer became concerned, and the age of the respondent. When an incentive was offered by the processor or co-op, the associated PEI value was 0.73 points lower than when an incentive was not offered. Producers who became concerned when BTSCC reached 500,000 cells/mL had an associated PEI closer to neutral (score 5-6), while those who became concerned at BTSCC 400,000 cells/mL or lower had a PEI of somewhat effective and practical (score 7-8). Examining the association between age and PEI value revealed that those 60 or older were associated with PEI values lower than individuals who were under 59 years of age.

When examining descriptors associated ($p \leq 0.05$) with the PEI of training employees (Table 2.10), number of lactating cows, age, and likelihood of continuing operation in five years were associated with PEI value. Operations who had less than 100 cows valued the PEI at 4.54±0.66, while those who had 101 to 200 cows valued the PEI of training employees at 5.59±0.66. When the respondent was 60 or more years of age, the associated PEI of training employees was much closer to not at all effective or practical, compared to those 49 or less years of age who were likely to fall within the neutral (5-6) scores. Operations “not at all likely” to be operational in five years had a PEI almost a full point lower than in situations where it was at least “somewhat likely”.

The PEI of having and implementing a mastitis management plan was associated ($p \leq 0.05$) with the following descriptors (Table 2.09): BTSCC level at which a producer becomes concerned and the level of education reached by the respondent. When a respondent became concerned at a BTSCC of 300,000 cells/mL or lower, the PEI was scored at least 1 point higher than those who did not become concerned until 400,000 cells/mL or greater. When education was examined, respondents with a high school degree scored the PEI of a mastitis management plan a full point lower than those with a college degree.

***Pinpointing practices most associated with self-reported BTSCC using the full model***

Results from the full model by the GLMselect procedure indicated that both attitudes and use of select mastitis management practices best explained the variation associated with BTSCC. The three attitudes that were significantly associated with BTSCC in the attitude model discussed above, also were identified in the full model through GLMselect. The GLMselect procedure also indicated that using a mastitis management plan, training employees in milking procedures, evaluating employees based on milk quality, milking mastitis cows separately, and using hygienic supplies were associated with BTSCC more than use of pre and post dip. The full model selected with the lowest AIC=11233 explained 29.4% of the variation in BTSCC. Attitudes explained 13.4% of the variation in BTSCC, while use explained 5.3%. The interactions between attitudes and use explained 10.8% of the variation in BTSCC.

The subsequent analysis of variance (Table 2.12) based on the variables selected by the stepwise model revealed that attitude towards training employees in milking procedure and pre-milking disinfectant were significantly associated ($p<0.05$) with BTSCC. The PEI of having and implementing a mastitis management plan had similar ($p=0.12$) BTSCC whether PEI value was high or low. When examining the use of a practice, a significant association was present between training employees ($p=0.02$), having a mastitis management plan ($p<0.01$) and BTSCC. A trend was present ($p=0.10$) between evaluating employees, using hygienic supplies and BTSCC.

Closer examination of use of practices indicated that training of employees occurred in 77% of herds and was associated ($p=0.02$) with a lower BTSCC by 62,750 cells/mL than herds who had used it previously but stopped, which comprised 3.1% of respondents. Whereas, no differences in BTSCC were observed in herds currently training employees when compared to those that never trained employees. Those who currently used a mastitis management plan ($p=<0.01$), or 67.2% of herds, had a lower BTSCC by 78,335 cells/mL than in herds where it was implemented, but had stopped (2.6% of the responding producers). Current use of hygienic supplies tended ($p=0.09$) to have a similar

BTSCC of approximately 291,000 cells/mL when compared to those who had stopped; however when hygienic supplies were never used, a higher BTSCC was present (329,530 ±23,371). A large proportion (87.7%) of herds currently used pre-milking disinfectant, while only 4.5% had tried it but stopped and 7.8% had never used it. Evaluating employees based on BTSCC of the herd trended (p=0.10) toward a higher BTSCC in herds where it was currently used (325,704 ±17,767) versus those who had tried it but stopped (270,797 ±29,300); however, a significant amount of standard error can be seen between the two categories. The highest number of herds (64.4%) had never evaluated employees.

## DISCUSSION

Based on results from the attitude model, we concluded that attitudes of the producer toward specific parlor management strategies were associated with BTSCC, a measure of milk quality. Producers who perceived pre-milking disinfectant, training employees, and use of a mastitis management plan to be more effective and practical had improved BTSCC versus those with poorer perceptions of effectiveness and practicality. Concluding that attitudes are impactful on quality performance is relatable to prior research which reported a producer's attitudes had a significant impact on overall farm performance, specifically culling, milk quality, and reproductive related diseases (Bigras-Poulin et al., 1985, Sato et al., 2008, Jansen et al., 2009, Schewe et al., 2015).

Jansen and others examined the relationship, using self-reported data, between producer's attitude about mastitis treatment and prevention, average BTSCC, and the rate of clinical and subclinical mastitis incidence of Dutch dairy herds. Participation in the Dutch study was 378 respondents and an average BTSCC of 191,890 cells/mL, which was 62,000 cells/mL lower and a slightly smaller sample population when compared to our study (Jansen et al., 2009). Almost half (47%) of the variation in BTSCC was associated with attitudes specifically relating to mastitis control, perceived efficacy of the cooperative penalty system, and what they consider “normal” mastitis.  This is comparable to our report that 37% of variation in BTSCC was explained by the producer’s perceived effectiveness and practicality toward pre-milking disinfectant, training employees, and having a mastitis management plan.  The 10% difference in explained variation could be due to a difference in specificity of attitudes examined.  Our study examined attitudes specific to parlor management, while Jansen (2009) gathered information about broader areas of a dairy operation.  Although our study examined perceptions more specific to parlor management strategies, both studies reflect the importance attitudes have on BTSCC.

One of the most discussed parlor management practices in literature is the importance of using teat disinfection.  It is commonly proven to reduce bacterial load and mastitis risk (Reneau, 2001, Chassagne et al., 2005, Watters et al., 2012).  Our research indicates the attitude towards this practice also was associated with BTSCC. Over half of the respondents found using pre-milking disinfectant to be very effective and practical, and the PEI explained over one-third of the impact of attitudes on variation in BTSCC. While no other studies have examined the attitude toward this, many have reported on its level of use. In the 2007 NAHMS survey, almost 80% of the 2,194 dairy operations evaluated performed pre-milking disinfection in some capacity (USDA, 2008).  The PEI of pre-milking disinfectant usage was associated with the level of BTSCC at which the respondent became concerned also found by researchers Schewe and others in 2015.  They concluded that when an operator did not become concerned until BTSCC was greater than 300,000 cells/mL, the herd had a higher BTSCC.  In this study, respondents who did not become concerned until BTSCC reached 500,000 cells/mL had a lower perceived effectiveness and practicality of pre-milking disinfectant.

Training employees is essential to ensuring protocols are followed in an effective manner (Erskine et al., 2015, Schewe et al., 2015).  Our research supports this premise, as we observed a negative association between the PEI of training employees and self-reported BTSCC that explained 11.6% of the variation in BTSCC. Furthermore, training employees can address the gap caused by poor communication and training that leads to implementation or efficiency problems in the parlor (Erskine et al., 2015). This suggests that those who do not believe the practice effective or practical most likely do not effectively train employees. The PEI of training employees was influenced by the likelihood that an operation would continue in five years. This suggests that operators who view their dairy as more sustainable over time are willing to put forth more effort toward ensuring employees are trained to be efficient and beneficial in the parlor, and thus improve mastitis control and prevention, This agrees with conclusions drawn by Stup et. al (2006) that demonstrated continued training and investment in employees will increase human capital and lead to an increase in farm value, which is needed to increase longevity of an operation.

When use of a practice was combined into a model with attitude, the same three attitude factors were significant; however, use was associated as well. The same practices identified in the attitude model were identified again in the full model as having an important association between PEI and BTSCC. These were attitudes toward pre-milking disinfectant, training employees in procedures to reduce BTSCC, and having a mastitis management plan. The similarity between the attitude and full model lends credibility to the significance of the attitude toward these parlor management practices.

The impact of attitudes and use of certain practices towards milk quality was studied by Jansen et. al (2009) in 366 Dutch dairy herds. They performed a survey which asked producers to self-report their attitude toward mastitis, their frame of reference about mastitis, perception of control and other contexts, use of practices, and quality metrics. Multiple linear regression examining both attitudes and use explained 48% of the variance observed in BTSCC, which is greater than our study's results where attitudes, use, and the interaction of the two explained almost 30%. Broken down further, our sample population's attitudes alone explained 13.4% of the variation in BTSCC and use explained 5.3%, which is less than that reported by Jansen et. al (2009). One potential explanation for the differences between the two studies may be related to the specific questions being asked. The study on Dutch dairies questioned producers about their perception of the following: frame of reference about their BTSCC, a change in SCC penalty level, control and worry about mastitis, knowledge of mastitis, its treatment and management, and interest level in mastitis – which are broader questions. Whereas our study focused on perceived effectiveness and practicality of certain parlor management practices, which was more specific than those asked by Jansen et. al (2009).

A higher BTSCC was observed in herds where they had previously trained employees versus those currently implementing the practice. However, the herds that did train employees versus those that never trained employees had a similar BTSCC. This could partly be due to the majority (~73%) of operations having 4 or less family or paid employees and may limit the need for training non-family employees. The high percentage of operations with 4 or less employees also corresponds to the approximately 55% of herds with 100 or less lactating animals and 86% of herds with 200 lactating animals or less, as less cows requires less labor force.

Use of comprehensive mastitis management methods, like record keeping, hygienic conditions, dry cow therapy, and teat disinfection, has been noted in previous research to be associated with herds with a lower BTSCC (Barkema et al., 1999). Our data revealed that using a mastitis management plan lowered BTSCC by almost 80,000 cells/mL, which is comparable to Barkemas' results.

# CONCLUSION

Producers that perceive disinfecting teats of all cows before milking (pre-milking disinfectant), training employees in milking procedures to reduce BTSCC, and having and implementing a mastitis management plan as more effective and practical have lower BTSCC than herds of producers that find these practices to be ineffective or impractical. Prior research has indicated attitudes were important, but our research has begun to quantify specific practices and at what level perception begins to effect milk quality of a herd. Understanding the importance attitudes have towards milk quality demonstrates the need for producers, researchers, and industry professionals to include this aspect in developing more effective communication tools and management strategies that impact milk quality.

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## CHAPTER II APPENDIX

***Table 2.01. Producers ranked the use and perceived effectiveness and practicality of the following parlor management practices.***

| | **Parlor management practice experience:** |
|---|---|
| 1. | Having and implementing a mastitis management plan |
| 2. | Training employees in milking procedures to reduce BTSCC |
| 3. | Evaluating employees based on performance with mastitis and bulk BTSCC control measures |
| 4. | Milking mastitis and treated cows in separate groups |
| 5. | Using hygienic supplies (gloves and fresh towels for each cow) for milking |
| 6. | Disinfecting teats of all cows before milking (pre-milking disinfectant) |
| 7. | Disinfecting teats of all cows after milking (post-milking disinfectant) |

***Table 2.02. Herd and producer demographics evaluated for their association with PEI of each management practice scored***

| | **Questions pertaining to herd or producer demographics** |
|---|---|
| 1. | How many people (employees & non-paid family) milk cows on your dairy? |
| 2. | How many lactating cows are typically on your farm? |
| 3. | What is your current average milk production per day? |
| 4. | What was your total milk per cow last year (rolling herd average)? |
| 5. | How old are you? |
| 6. | Do your employees primarily speak the same language as you? |
| 7. | Do your operation’s owner and lead herdsman speak the same language as each other? |
| 8. | What is the highest level of education you’ve reached? |
| 9. | Approximately what percentage of your total 2012 household income was from off farm employment? |

***Table 2.03. Management strategies evaluated for their association with PEI of each management practice scored***

| | **Questions pertaining to management strategies** |
|---|---|
| 1. | How often are you in the parlor and observing milking? |
| 2. | How often are you in the parlor and doing the milking? |
| 3. | Do you participate in Dairy Herd Improvement Association (DHIA) testing? |

*Table 2.04. Goals and incentives evaluated for their association with PEI of management practices*

| Questions about a producers goals and incentives for the herd |
|---|
| 1. Does the co-op or processors you sell you milk to offer an incentive for achieving a particular BTSCC? |
| 2. Does the co-op or processors you sell you milk to impose a price penalty for exceeding a particular BTSCC? |
| 3. What is the lowest level of BTSCC that causes you concern? |
| 4. Please indicate how important each of these broad goals is for you and your dairy operation : |
| a. Taking good care of my cows and heifers |
| b. Making my farm better each day |
| c. Continuing farming as a way of life |
| d. Making choices my family is proud of |
| e. Increasing net on-farm income |
| f. Trying out new practices and technology to better my operation and the industry |
| g. Improving dairy products' image |
| 5. How likely is each of these scenarios? |
| a. You or a close family member will be operating your farms 5 years from now |

***Table 2.05. Frequencies of descriptor variables to be included in the stepwise selection examining the influence of herd and producer characteristics on producer reported PEI for each management practice.***

| **Questions regarding herd and producer characteristics** | |
|---|---|
| How many people (employees & non-paid family) milk cows on your dairy? | |
| • Greater than 20 | 1.3% |
| • 11 to 20 | 2.1% |
| • None | 2.8% |
| • 5 to 10 | 22.3% |
| • 1 to 4 | 71.5% |
| How many lactating cows are typically on your farm? | |
| • 1000 or greater | 2.3% |
| • 201 to 999 | 11.8% |
| • 101 to 200 | 31.5% |
| • Less than 100 | 54.4% |
| What is your current average milk production per cow per day? | |
| • Greater than 36 kilograms | 4.5% |
| • 13 to 18 kilograms | 7.1% |
| • Less than 13 kilograms | 9.2% |
| • 19 to 22 kilograms | 13.6% |
| • 32 to 36 kilograms | 18.4% |
| • 23 to 26 kilograms | 20.9% |
| • 27 to 31 kilograms | 26.3% |
| What was your total milk per cow last year (rolling herd average)? | |
| • Greater than 11,340 kilograms | 4.5% |
| • 9,072 to 11,340 kilograms | 29.0% |
| • 6,804 to 9,071 kilograms | 29.7% |
| • 0 to 6,803 kilograms | 36.7% |

***Table 2.05 cont'd***

| Questions regarding herd and producer characteristics | |
|---|---|
| How old are you? | |
| • 70 or older | 8.2% |
| • Younger than 30 | 8.3% |
| • 30 to 39 years old | 16.0% |
| • 40 to 49 years old | 19.0% |
| • 60 to 69 years old | 19.8% |
| • 50 to 59 years old | 29.7% |
| Do your employees primarily speak the same language as you? | |
| • No | 13.3% |
| • Yes | 86.7% |
| Do your operation's owner and lead herdsman speak the same language as each other? | |
| • No | 3.6% |
| • Yes | 96.4% |
| What is the highest level of education you've reached? | |
| • Some college or technical school | 14.9% |
| • Less than high school | 25.9% |
| • College degree | 28.0% |
| • High school degree | 31.2% |
| Approximately what percentage of your total 2012 household income was from off farm employment? | |
| • 51-75% | 7.4% |
| • 76-100% | 8.1% |
| • 26-50% | 8.8% |
| • 1-25% | 25.1% |
| • None | 50.6% |

***Table 2.06. Frequencies of descriptor variables to be included in the stepwise selection examining the influence of management strategies on producer reported PEI for each management practice.***

| **Questions about management strategies** | |
|---|---|
| How often are you in the parlor and observing milking? | |
| • Never | 1.3% |
| • About once a month | 1.7% |
| • Less than once a month | 2.2% |
| • About once a week | 11.5% |
| • About once a day | 30.7% |
| • Almost every milking | 52.8% |
| How often are you in the parlor and doing the milking? | |
| • About once a month | 4.5% |
| • Less than once a month | 7.8% |
| • About once a week | 11.4% |
| • Never | 13.7% |
| • About once a day | 21.3% |
| • Almost every milking | 41.2% |
| Do you participate in Dairy Herd Improvement Association (DHIA) testing? | |
| • No | 42.3% |
| • Yes | 57.7% |

***Table 2.07. Frequencies of descriptor variables to be included in the stepwise selection examining the influence of goals and incentives on producer reported PEI for each management practice.***

| **Questions about a producers goals and incentives** | |
|---|---|
| Does the co-op or processors you sell your milk to offer an incentive for achieving a particular BTSCC? | |
| • No | 11.6% |
| • Yes | 88.5% |
| Does the co-op or processors you sell you milk to impose a price penalty for exceeding a particular BTSCC? | |
| • No | 25.6% |
| • Yes | 74.4% |
| What is the lowest level of BTSCC that causes you concern? | |
| • 600,000 cells/mL or greater | 0.6% |
| • 500,000 cells/mL | 3.0% |
| • 100,000 cells/mL | 12.6% |
| • 400,000 cells/mL | 20.9% |
| • 200,000 cells/mL | 23.6% |
| • 300,000 cells/mL | 39.3% |
| Please indicate how important each of these broad goals is for you and your dairy operation : | |
| • Taking good care of my cows and heifers | |
| ○ Unimportant | 0% |
| ○ Neither | 0.2% |
| ○ Very unimportant | 7.1% |
| ○ Important | 16.6% |
| ○ Very Important | 76.2% |

***Table 2.07 cont'd***

| **Questions about a producers goals and incentives** | |
|---|---|
| • Making my farm better each day | |
| ○ Unimportant | 0.5% |
| ○ Neither | 3.5% |
| ○ Very unimportant | 6.4% |
| ○ Important | 31.2% |
| ○ Very Important | 58.4% |
| • Continuing farming as a way of life | |
| ○ Unimportant | 0.9% |
| ○ Neither | 4.1% |
| ○ Very unimportant | 6.7% |
| ○ Important | 30.0% |
| ○ Very Important | 58.3% |
| • Making choices my family is proud of | |
| ○ Unimportant | 1.3% |
| ○ Very unimportant | 7.1% |
| ○ Neither | 9.4% |
| ○ Important | 27.9% |
| ○ Very Important | 54.3% |
| • Increasing net on-farm income | |
| ○ Unimportant | 0.9% |
| ○ Neither | 1.8% |
| ○ Very unimportant | 6.1% |
| ○ Important | 25.9% |
| ○ Very Important | 65.4% |

*Table 2.07 cont'd*

| Questions about a producers goals and incentives | |
|---|---|
| • Trying out new practices and technology to better my operation and the industry | |
| ○ Unimportant | 4.3% |
| ○ Very unimportant | 6.0% |
| ○ Neither | 15.6% |
| ○ Very Important | 34.5% |
| ○ Important | 39.6% |
| • Improving dairy products' image | |
| ○ Unimportant | 2.7% |
| ○ Neither | 5.7% |
| ○ Very unimportant | 6.03% |
| ○ Important | 33.9% |
| ○ Very Important | 51.8% |
| How likely is it that you or a close family member will be operating your farms 5 years from now? | |
| ○ Not at all | 10.4% |
| ○ Very likely | 89.6% |

***Table 2.08. PEI reported by producers for each parlor management practice and its association with BTSCC, including standard error, least mean differences, and frequency from the attitude model.***

| Parlor Management Practice | P-value | $R^2$ | Estimated Somatic Cell Count (cells/mL) $^{\text{Least Mean Separation}}$ ± Standard Error<br>Frequency % | | | | |
|---|---|---|---|---|---|---|---|
| | | | **No Answer (0)** | **Not (1-4)** | **Neutral (5-6)** | **Somewhat (7-8)** | **Very (9-10)** |
| Having and implementing a mastitis management plan | 0.02 | 0.126 | $250,744^{b\,l}$ ±8,048<br>27.5 | $316,091^{a}$ ±20,485<br>4.4 | $288,615^{a}$ ±8,822<br>22.8 | $243,642^{b}$ ±7,343<br>33.6 | $204,687^{c}$ ±12,002<br>11.8 |
| Training employees in milking procedures to reduce BTSCC | 0.03 | 0.116 | $252,546^{b}$ ±8,936<br>23.1 | $306,856^{a}$ ±18,918<br>5.0 | $288,908^{a}$ ±9,930<br>18.3 | $258,699^{b}$ ±7,699<br>30.1 | $213,692^{c}$ ±8,524<br>23.5 |

***Table 2.08 cont'd***

| **Parlor Management Practice** | **P-value** | **$R^2$** | **Estimated Somatic Cell Count (cells/mL) [Least Mean Separation] ± Standard Error Frequency %** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **No Answer (0)** | **Not (1-4)** | **Neutral (5-6)** | **Somewhat (7-8)** | **Very (9-10)** |
| Evaluating employees based on performance with mastitis and bulk BTSCC control measures | 0.91 | --[ii] | 279,412 [a] ±10,195 54.1 | 275,431 [a] ±16,942 7.1 | 289,506 [a] ±12,915 16.7 | 288,323 [a] ±13,848 14.1 | 282,994 [a] ±17,484 8.0 |
| Disinfecting teats of all cows before milking (pre-milking disinfectant) | 0.01 | 0.131 | 263,148[bc] ±14,118 9.9 | 286,542[abc] ±28,237 2.3 | 336,080[a] ±13,697 9.4 | 257,544[b] ±8,123 27.0 | 234,935[c] ±5,784 51.5 |
| Disinfecting teats of all cows after milking (post-milking disinfectant) | 0.33 | -- | 310,131 [a] ±26,094 8.2 | 267,008 [a] ±28,217 2.8 | 262,586 [a] ±20,070 8.4 | 298,938 [a] ±15,169 27.7 | 277,004 [a] ±13,968 53.0 |

***Table 2.08 cont'd***

| Parlor Management Practice | P-value | $R^2$ | Estimated Somatic Cell Count (cells/mL) $^{\text{Least Mean Separation}}$ ± Standard Error<br>Frequency %<br>No Answer (0) | Not (1-4) | Neutral (5-6) | Somewhat (7-8) | Very (9-10) |
|---|---|---|---|---|---|---|---|
| Using hygienic supplies (gloves and fresh towels for each cow) for milking | 0.13 | -- | 270,548$^{ab}$ ±11,554<br>14.6 | 301,650$^{a}$ ±18,910<br>5.0 | 284,941$^{a}$ ±11,478<br>14.6 | 244,968$^{bc}$ ±7,813<br>29.9 | 237,073$^{c}$ ±7,093<br>35.8 |
| Milking mastitis and treated cows in separate groups | 0.43 | -- | 276,038$^{a}$ ±10,857<br>41.4 | 272,778$^{a}$ ±14,126<br>11.5 | 297,685$^{a}$ ±13,621<br>15.1 | 278,160$^{a}$ ±14,229<br>13.9 | 291,006$^{a}$ ±12,772<br>18.1 |

i: a, b, and c represent least significant difference mean separations within each parlor management practice
ii: $R^2$ only present for significant management practices

***Table 2.09. Estimated PEI of having and implementing a mastitis management plan associated with descriptor variables selected in the stepwise procedure.***

| **Descriptor** | **P-value** | **Estimates PEI** [Least Mean Separation] **±Standard Error** |
|---|---|---|
| Number of lactating cows | 0.14 | |
| Less than 100 cows | | 3.35[ab] ±0.55 |
| 101-200 cows | | 3.15 [b] ±0.56 |
| 201 to 999 cows | | 4.22 [a] ±0.67 |
| More than 1000 cows | | 3.89 [ab] ±1.12 |
| BTSCC level at which producer becomes concerned | <0.01 | |
| 100,000 cells/mL | | 4.53 [a] ±0.59 |
| 200,000 cells/mL | | 4.42 [a] ±0.51 |
| 300,000 cells/mL | | 4.29 [a] ±0.51 |
| 400,000 cells/mL | | 3.03 [b] ±0.55 |
| 500,000 cells/mL | | 2.71 [b] ±0.87 |
| 600,000 cells/mL or greater | | 2.95 [ab] ±2.20 |

*Table 2.09 cont'd*

| Descriptor | P-value | Estimates PEI Least Mean Separation ±Standard Error |
|---|---|---|
| Importance of: | | |
| Increasing net on-farm income | 0.12 | |
| Very unimportant | | 3.37 [ab] ±1.28 |
| Unimportant | | 3.03 [ab] ±1.60 |
| Neither | | 3.05 [ab] ±1.09 |
| Important | | 3.99 [b] ±0.69 |
| Very Important | | 4.82 [a] ±0.65 |
| Improving dairy products' image | 0.10 | |
| Very unimportant | | 5.29 [ab] ±1.16 |
| Unimportant | | 2.91 [ab] ±0.91 |
| Neither | | 2.64 [b] ±0.95 |
| Important | | 3.51 [ab] ±0.82 |
| Very Important | | 3.92 [a] ±0.84 |
| Level of education reached by the individual | <0.01 | |
| Less than high school degree | | 2.95 [b] ±0.65 |
| High school degree | | 3.51 [b] ±0.62 |
| Some college or technical education | | 3.66 [ab] ±0.69 |
| College degree | | 4.49 [a] ±0.62 |

i: a, b, and c represent least significant difference mean separations within each parlor management practice

***Table 2.10. Estimated PEI of training employees associated with descriptor variables selected in the stepwise procedure.***

| **Descriptor** | **P-value** | **Estimates PEI** [Least Mean Separation] **±Standard Error** |
|---|---|---|
| Number of people milking | 0.26 | |
| None | | 3.58 [b] ±1.06 |
| 1 t0 4 | | 5.58 [a] ±0.52 |
| 5 to 10 | | 5.53 [ab] ±0.55 |
| 11 to 20 | | 5.19 [ab] ±0.99 |
| Greater than 20 | | 6.86 [ab] ±1.55 |
| | | |
| Number of lactating cows | 0.05 | |
| Less than 100 cows | | 4.54 [b] ±0.66 |
| 101-200 cows | | 5.59 [a] ±0.66 |
| 201 to 999 cows | | 5.48 [ab] ±0.71 |
| More than 1000 cows | | 5.78 [ab] ±1.14 |

*Table 2.10 cont'd*

| Descriptor | P-value | Estimates PEI Least Mean Separation ±Standard Error |
|---|---|---|
| Average milk production per cow per day | 0.35 | |
| Less than 13.6 kg | | $5.07^{ab} \pm 0.78$ |
| 13.6 to 17.7 kg | | $4.47^{b} \pm 0.81$ |
| 17.8 to 22.2 kg | | $5.20^{ab} \pm 0.66$ |
| 22.3 to 26.8 kg | | $5.22^{ab} \pm 0.64$ |
| 26.9 to 31.3 kg | | $5.73^{ab} \pm 0.60$ |
| 31.4 to 35.8 kg | | $5.34^{ab} \pm 0.61$ |
| Greater than 35.8 kg | | $6.42^{a} \pm 0.79$ |
| Incentive offered by processor or co-op | 0.72 | |
| Yes | | $5.27^{a} \pm 0.53$ |
| No | | $5.43^{a} \pm 0.66$ |
| Participation in DHIA | 0.15 | |
| Yes | | $5.59^{a} \pm 0.59$ |
| No | | $5.11^{a} \pm 0.57$ |

*Table 2.10 cont'd*

| Descriptor | P-value | Estimates PEI [Least Mean Separation] ±Standard Error |
|---|---|---|
| Importance of: | | |
| Trying out new practices and technology to better my operation and the industry | 0.86 | |
| Very unimportant | | 5.14 [a] ±1.02 |
| Unimportant | | 5.31 [a] ±0.84 |
| Neither | | 5.23 [a] ±0.70 |
| Important | | 5.67 [a] ±0.68 |
| Very Important | | 5.41 [a] ±0.72 |
| Improving dairy products' image | 0.06 | |
| Very unimportant | | 6.69 [ab] ±1.08 |
| Unimportant | | 4.79 [ab] ±1.02 |
| Neither | | 4.44 [b] ±0.80 |
| Important | | 5.05 [b] ±0.63 |
| Very Important | | 5.78 [a] ±0.61 |

*Table 2.10 cont'd*

| Descriptor | P-value | Estimates PEI Least Mean Separation ±Standard Error |
|---|---|---|
| Age | 0.03 | |
| Less than 30 years old | | 5.73 [ab] ±0.77 |
| 30 to 39 years old | | 5.81 [a] ±0.65 |
| 40 to 49 years old | | 6.02 [a] ±0.62 |
| 50 to 59 years old | | 5.41 [ab] ±0.61 |
| 60 to 69 years old | | 4.81 [b] ±0.61 |
| 70 years old or greater | | 4.32 [b] ±0.72 |
| | | |
| How often individual milks | 0.544 | |
| Never | | 5.35 [a] ±0.59 |
| Less than once a month | | 5.53 [a] ±0.72 |
| About once a month | | 6.25 [a] ±0.82 |
| About once a week | | 4.90 [a] ±0.71 |
| About once a day | | 5.04 [a] ±0.65 |
| Almost every milking | | 5.03 [a] ±0.62 |

***Table 2.10 cont'd***

| **Descriptor** | **P-value** | **Estimates PEI** [Least Mean Separation] **±Standard Error** |
|---|---|---|
| How likely farm is operational in five years | 0.04 | |
| Not likely at all | | 4.88 [b] ±0.67 |
| Somewhat likely to Certainly | | 5.83 [a] ±0.53 |
| Do employees speak the same language as individual | 0.63 | |
| Yes | | 5.24 [a] ±0.57 |
| No | | 5.46 [a] ±0.63 |
| Level of education reached by the individual | 0.28 | |
| Less than high school degree | | 4.88 [a] ±0.66 |
| High school degree | | 5.55 [a] ±0.59 |
| Some college or technical education | | 5.72 [a] ±0.65 |
| College degree | | 5.26 [a] ±0.57 |

*Table 2.11. Estimated PEI of use of pre-milking disinfectant associated with descriptor variables selected in the stepwise procedure.*

| Descriptor | P-value | Estimates PEI [Least Mean Separation] ±Standard Error |
|---|---|---|
| Number of lactating cows | 0.87 | |
| Less than 100 cows | | 7.15 [a] ±0.49 |
| 101-200 cows | | 6.96 [a] ±0.48 |
| 201 to 999 cows | | 7.17 [a] ±0.56 |
| More than 1000 cows | | 7.34 [a] ±0.94 |
| Average milk production per cow per day | 0.19 | |
| Less than 13.6 kg | | 6.34 [b] ±0.67 |
| 13.6 to 17.7 kg | | 7.07 [ab] ±0.66 |
| 17.8 to 22.2 kg | | 6.88 [ab] ±0.57 |
| 22.3 to 26.8 kg | | 7.00 [ab] ±0.55 |
| 26.9 to 31.3 kg | | 7.41 [a] ±0.53 |
| 31.4 to 35.8 kg | | 7.64 [a] ±0.52 |
| Greater than 35.8 kg | | 7.75 [ab] ±0.72 |

*Table 2.11 cont'd*

| **Descriptor** | **P-value** | **Estimates PEI [Least Mean Separation] ±Standard Error** |
|---|---|---|
| Incentive offered by processor or co-op | 0.05 | |
| Yes | | 6.79$^{b}$ ±0.48 |
| No | | 7.52$^{a}$ ±0.57 |
| BTSCC level at which producer becomes concerned | <0.01 | |
| 100,000 cells/mL | | 7.48$^{ab}$ ±0.52 |
| 200,000 cells/mL | | 8.05$^{a}$ ±0.44 |
| 300,000 cells/mL | | 7.91$^{a}$ ±0.44 |
| 400,000 cells/mL | | 6.88$^{bc}$ ±0.47 |
| 500,000 cells/mL | | 5.82$^{c}$ ±0.74 |
| 600,000 cells/mL or greater | | 6.79$^{abc}$ ±1.83 |
| Importance of: | | |
| Increasing net on-farm income | 0.11 | |
| Very unimportant | | 7.35$^{ab}$ ±0.61 |
| Unimportant | | 6.81$^{ab}$ ±1.20 |
| Neither | | 7.81$^{ab}$ ±0.90 |
| Important | | 6.57$^{b}$ ±0.47 |
| Very Important | | 7.23$^{a}$ ±0.43 |

*Table 2.11 cont'd*

| Descriptor | P-value | Estimates PEI Least Mean Separation ±Standard Error |
|---|---|---|
| Age | <0.01 | |
| Less than 30 years old | | 7.99 [a] ±0.63 |
| 30 to 39 years old | | 7.43 [a] ±0.58 |
| 40 to 49 years old | | 7.71 [a] ±0.56 |
| 50 to 59 years old | | 7.19 [a] ±0.54 |
| 60 to 69 years old | | 6.50 [b] ±0.56 |
| 70 years old or greater | | 6.10 [b] ±0.60 |
| Level of education reached by the individual | 0.17 | |
| Less than high school degree | | 6.82 [a] ±0.55 |
| High school degree | | 6.91 [a] ±0.52 |
| Some college or technical education | | 7.38 [a] ±0.58 |
| College degree | | 7.50 [a] ±0.52 |

***Table 2.12. Results of the full model based on effects selected by the stepwise procedure, which examined implementation of practices and PEI association with BTSCC, including standard error, least mean differences, and frequency.***

PEI Associations

| **Parlor Management Practice** | **P-value** | **Estimated Somatic Cell Count (cells/mL)** $^{\text{Least Mean Separation}}$ **± Standard Error**<br>**Frequency %** | | | | |
|---|---|---|---|---|---|---|
| | | **No Answer (0)** | **Not (1-4)** | **Neutral (5-6)** | **Somewhat (7-8)** | **Very (9-10)** |
| Having and implementing a mastitis management plan | 0.12 | 326,173$^{ab}$<br>±23,384<br>27.5 | 310,795$^{abc}$<br>±27,925<br>4.4 | 317,900$^{a}$<br>±19,513<br>22.8 | 291,811$^{bc}$<br>±20,935<br>33.6 | 273,952$^{c}$<br>±23,458<br>11.8 |
| Training employees in milking procedures to reduce BTSCC | 0.02 | 302,091$^{ab}$<br>±23,242<br>23.1 | 325,901$^{a}$ ±26,221<br>5 | 314,167$^{a}$<br>±21,156<br>18.3 | 307,383$^{a}$<br>±21,372<br>30.1 | 271,091$^{b}$<br>±21,861<br>23.5 |
| Disinfecting teats of all cows before milking (pre-milking disinfectant) | <0.01 | 287,640$^{b}$<br>±25,919<br>9.9 | 272,010$^{b}$ ±36,537<br>2.3 | 373,579$^{a}$<br>±21,822<br>9.4 | 295,998$^{b}$<br>±17,400<br>27.0 | 291,405$^{b}$<br>±16,461<br>51.5 |

i: a, b, and c represent least significant difference mean separations within each parlor management practice, ii: $R^2$ only present for significant management practices

*Table 2.12 cont'd*

| Parlor Management Practice | P-value | Use it now | Never used it | Tried it, but stopped |
|---|---|---|---|---|
| Having and implementing a mastitis management plan | <0.01 | 285,740$^{b}$ ±18,413<br>67.2 | 262,564$^{b}$ ±21,145<br>29.7 | 364,075$^{a}$ ±29,146<br>3.1 |
| Training employees in milking procedures to reduce BTSCC | 0.02 | 291,691$^{b}$ ±17,117<br>77.0 | 266,247$^{b}$ ±23,713<br>20.4 | 354,441$^{a}$ ±28,914<br>2.6 |
| Evaluating employees based on performance with mastitis and bulk BTSCC control measures | 0.10 | 325,704$^{a}$ ±17,767<br>32.6 | 315,878$^{ab}$ ±15,893<br>64.4 | 270,797$^{b}$ ±29,300<br>3.0 |
| Using hygienic supplies (gloves and fresh towels for each cow) for milking | 0.09 | 291,497$^{b}$ ±17,304<br>87.7 | 329,530$^{a}$ ±23,371<br>7.8 | 291,352$^{ab}$ ±23,841<br>4.5 |
| Milking mastitis and treated cows in separate groups | 0.12 | 295, 247$^{ab}$ ±18,365<br>36.1 | 291,470$^{b}$ ±17,794<br>56.5 | 325,662$^{a}$ ±22,426<br>7.3 |

i: a, b, and c represent least significant difference mean separations within each parlor management practice, ii: $R^2$ only present for significant management practice

| **Your Dairy Operation** | | |
|---|---|---|
| **1. Are you operating a working dairy farm?** | ☐ Yes, Please continue | ☐ No, Year of last operation ______ Please continue, and report information from the last year of your dairy operation. |
| **2. Which of these best describes your dairy business?** *(check one)*<br>☐ Sole proprietorship ☐ Partnership ☐ Corporation ☐ Other __________ | | |
| **3. What year did you begin to work on any part of this dairy farm?** | | ______ |
| **4. How many people (employees & non-paid family) milk cows on your dairy?** | | ______ |
| **5. How many cows are typically on your farm?** | ______ # lactating | ______ # dry |
| **6. How has the total number of cows changed in the last 12 months?** *(check one)*<br>☐ Increased by ___ cows ☐ Decreased by ___ cows ☐ No change | | |
| **7. Are heifers raised on your farm?** | ☐☐Yes | ☐☐No |
| **8. What is your current average milk production per day?** | | ______ lbs. |
| **9. What was your total milk per cow last year (rolling herd average)?** | | ______ lbs. |
| **10. What is your somatic cell count (monthly average BTSCC):** *(answer all)*<br>Currently ______ One year ago Three years ago ______ | | |

| |
|---|
| ______ |
| **11. Does the co-op or processor you sell your milk to offer an incentive for achieving a particular BTSCC?** *(check one)*<br>☐ Yes, and the incentive is ______________________ ☐ No price incentive |
| **12. Does the co-op or processor you sell your milk to impose a price penalty for exceeding a particular BTSCC?** *(check one)*<br>☐ Yes, and the penalty is ______________________ ☐ No price penalty |
| **13. To which co-op do you belong or to which processor(s) do you sell milk?** *(identify all)* ____________________________ |
| **14. Do you participate in Dairy Herd Improvement Association (DHIA) testing?** ☐☐Yes ☐☐No |
| **15. Do you routinely use an electronic record keeping system, such as PC-DART or DairyComp-305, for:**<br>**tracking clinical mastitis events?** ☐☐Yes ☐☐No<br>**tracking mastitis treatment?** ☐☐Yes ☐☐No |
| **16. Do you have farm operations not related to your dairy?** (Feed production and value added dairy products are considered part of your dairy operation) ☐☐Yes ☐☐No |

| **BTSCC, Mastitis, and You** |
|---|
| **17. Please indicate what levels of BTSCC and clinical mastitis best match** |

| your thoughts and actions. | | | |
|---|---|---|---|
| **What is the lowest level of BTSCC that causes you concern?** | **What is the lowest level of BTSCC that causes you to take action?** | **What is your goal for cases of clinical mastitis in your herd (as a % of all cows)?** | **What is the lowest incidence of clinical mastitis cows in your herd that would cause you to change how you address mastitis?** |
| □ 100,000 cells/ml | □ 100,000 cells/ml | □ 5% | □ 5% |
| □ 200,000 cells/ml | □ 200,000 cells/ml | □ 10% | □ 10% |
| □ 300,000 cells/ml | □ 300,000 cells/ml | □ 15% | □ 15% |
| □ 400,000 cells/ml | □ 400,000 cells/ml | □ 20% | □ 20% |
| □ 500,000 cells/ml | □ 500,000 cells/ml | □ 25% | □ 25% |
| □ 600,000 cells/ml | □ 600,000 cells/ml | □ 30% | □ 30% |

| | | | |
|---|---|---|---|
| ☐ >600,000 cells/ml<br>☐ other ______ | ☐ >600,000 cells/ml<br>☐ other ______ | ☐ 40%<br>☐ other ______ | ☐ 40%<br>☐ other ______ |

**Effects of Mastitis**

**18. Please indicate the extent to which you disagree or agree with each of the following statements about troublesome things about mastitis. (***Mark one "X" for each row.)*

| A troublesome thing about mastitis is… | STRONGLY DISAGREE | DISAGREE | NEITHER | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| Uncertainty about my cows' recovery. | ☐ | ☐ | ☐ | ☐ | ☐ |
| The extra labor needed to manage mastitis. | ☐ | ☐ | ☐ | ☐ | ☐ |
| That cows suffer. | ☐ | ☐ | ☐ | ☐ | ☐ |
| The financial consequences. | ☐ | ☐ | ☐ | ☐ | ☐ |
| The worries it causes me. | ☐ | ☐ | ☐ | ☐ | ☐ |

**Motivations**

**19. Please indicate how important each of these is as a motivation for work on your dairy, including actions to manage mastitis. (***Mark one "X" for each*

| *row.)* | | | | | |
|---|---|---|---|---|---|
| | **VERY UNIMPORTANT** | **UNIMPORTANT** | **NEITHER** | **IMPORTANT** | **VERY IMPORTANT** |
| Reducing antibiotic usage for mastitis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reducing antibiotic residues in milk | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improving milk quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| Receiving financial incentives for milk quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| Avoiding financial penalties for poor milk quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increasing milk production | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Perceptions of Mastitis and Mastitis Management** | | | | | |
| **20. Please indicate the extent to which you disagree or agree with each of these statements.** | | | | | |

*(Mark one "X" for each row.)*

| | STRONGLY DISAGREE | DISAGREE | NEITHER | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| Mastitis is a significant concern to the dairy industry in the Southeast. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mastitis is a significant concern of mine relative to other issues affecting my dairy. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mastitis causes are difficult to manage. | ☐ | ☐ | ☐ | ☐ | ☐ |
| The weather and climate play an important role in mastitis outbreaks. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Bad luck plays an important role in mastitis outbreaks. | ☐ | ☐ | ☐ | ☐ | ☐ |
| My dairy barn and equipment play an | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| important role in mastitis outbreaks. | | | | | |
| My milking practices play an important role in mastitis outbreaks. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mastitis is currently under control at my dairy. | ☐ | ☐ | ☐ | ☐ | ☐ |
| My dairy has had a serious mastitis problem one or more times. | ☐ | ☐ | ☐ | ☐ | ☐ |
| It is extremely important to me to reduce the number of clinical mastitis cases on my dairy. | ☐ | ☐ | ☐ | ☐ | ☐ |
| It is extremely important to me to decrease my BTSCC. | ☐ | ☐ | ☐ | ☐ | ☐ |
| I know what procedures to | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| use in the parlor to decrease my BTSCC or maintain my already low BTSCC. | | | | | |
| I can afford to do what is necessary to decrease my BTSCC or maintain my already low BTSCC. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Milk quality premiums available to me are adequate to cover the costs I incur in producing quality milk. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mastitis seems to persist despite my efforts to control it. | ☐ | ☐ | ☐ | ☐ | ☐ |
| The spread of mastitis from one cow to | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| others in the herd is difficult to control. | | | | | |
| There is uncertainty and conflicting information about controls and treatment of mastitis. | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mastitis is a disease of lactating and dry cows and not a problem in bred heifers. | ☐ | ☐ | ☐ | ☐ | ☐ |

| **Experiences with BTSCC & Mastitis Control** | | | |
|---|---|---|---|
| **21. Please indicate what experience you've had with each of these practices. First, indicate whether you're currently using it, never tried it, or tried and discontinued it. Then, evaluate each practice first based on your perception of its *effectiveness* and then for its *practicality/cost*.** | | | |
| **Practices:** | **Use this approach?** | **Effectiveness**<br>Not at all<br>Very<br>effective<br>effective | **Practicality / cost**<br>Not at all<br>Very<br>practical/<br>practical/<br>economical<br>economical |

| | | | |
|---|---|---|---|
| Having and implementing a mastitis management plan | □ Use it now<br>□ Never used it<br>□ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Training employees in milking procedures to reduce BTSCC | □ Use it now<br>□ Never used it<br>□ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Delegating responsibility to employees for mastitis treatment (including antibiotic use) | □ Use it now<br>□ Never used it<br>□ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Evaluating employees based on performance with mastitis and bulk BTSCC control measures | □ Use it now<br>□ Never used it<br>□ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |

| | | | |
|---|---|---|---|
| Culling based on BTSCC information or other mastitis indicator | ☐ Use it now ☐ Never used it ☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Milking mastitis and treated cows in separate groups | ☐ Use it now ☐ Never used it ☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Analyzing and then acting on bacterial culturing of milk samples | ☐ Use it now ☐ Never used it ☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Using hygienic supplies (gloves and fresh towels for each cow) for milking | ☐ Use it now ☐ Never used it ☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |

| | | | |
|---|---|---|---|
| Disinfecting teats of all cows before milking (pre-milking disinfectant) | ☐ Use it now<br>☐ Never used it<br>☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Disinfecting teats of all cows after milking (post-milking disinfectant) | ☐ Use it now<br>☐ Never used it<br>☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Using vaccines to control coliform mastitis (e.g., J5) | ☐ Use it now<br>☐ Never used it<br>☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Routinely using antibiotic therapy to treat clinical mastitis cases | ☐ Use it now<br>☐ Never used it<br>☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |

| | | | |
|---|---|---|---|
| Routinely using antibiotic therapy and/or teat sealant for dry cows | ☐ Use it now<br>☐ Never used it<br>☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |
| Using biosecurity practices, such as pre-testing or quarantine, for replacement heifers and cows | ☐ Use it now<br>☐ Never used it<br>☐ Tried it, but stopped | 1 2 3 4 | 1 2 3 4 |

| Sources of Information about Mastitis | | | |
|---|---|---|---|
| **22. Please tell us whether you've used these sources of information about mastitis management. Then rate each source twice: first according to your opinion about its reliability and second based on how easy you think the information is to understand and act upon. Please rate each source, whether or not you've used it.** | | | |
| **Information source:** | Have you sought information from this source? | **Is it reliable?**<br>Not at all Very reliable reliable | **Is it easy to understand and act upon?**<br>Not at all Very easy to easy to |

| | | | |
|---|---|---|---|
| | | | act upon<br>act upon |
| Veterinarian | Yes | 1 2 3 4 | 1 2 3 4 |
| Another dairy producer | Yes | 1 2 3 4 | 1 2 3 4 |
| Milk cooperative representative | Yes | 1 2 3 4 | 1 2 3 4 |
| County agent or other Extension representative | Yes | 1 2 3 4 | 1 2 3 4 |
| Farm journals | Yes | 1 2 3 4 | 1 2 3 4 |
| Drug company representatives | Yes | 1 2 3 4 | 1 2 3 4 |
| Information products from Extension online | Yes | 1 2 3 4 | 1 2 3 4 |
| Other online information sources (please identify): ________________ | Yes | 1 2 3 4 | 1 2 3 4 |
| Other: ________________ — | Yes | 1 2 3 4 | 1 2 3 4 |

**Your Goals**

**23. Please indicate how important each of these BROAD GOALS is for you and your dairy operation.**

*(Mark one X for each row.)*

| | VERY | UNIMPORTA | NEITHE | IMPORTA | VERY |
|---|---|---|---|---|---|

| | UNIMPORTA NT | NT | R | NT | IMPORTA NT |
|---|---|---|---|---|---|
| Taking good care of my cows and heifers | ☐ | ☐ | ☐ | ☐ | ☐ |
| Making my farm better each day | ☐ | ☐ | ☐ | ☐ | ☐ |
| Continuing farming as a way of life | ☐ | ☐ | ☐ | ☐ | ☐ |
| Making choices my family is proud of | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increasing net on-farm income | ☐ | ☐ | ☐ | ☐ | ☐ |
| Trying out new practices and technology to better my operation and the industry | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improving dairy products' image | ☐ | ☐ | ☐ | ☐ | ☐ |

**About You**

**24. In what state and zip code is your farm located?**

State _____________ Zip Code ___________

**25. How old are you?** ______

| 26. What is your position on the farm? *(check **all** that apply)* | | | |
|---|---|---|---|
| ☐ Owner (solely or jointly) | ☐ Manager | ☐ Non-family business partner | ☐ Other ___________ |

| 27. How often are you in the parlor and OBSERVING milking? | | | |
|---|---|---|---|
| ☐ Never | ☐ less than once a month | ☐ about once a month | ☐ about once a week |
| ☐ about once a day | ☐ almost every milking | | |

| 28. How often are you in the parlor and DOING the milking? | | | |
|---|---|---|---|
| ☐ Never | ☐ less than once a month | ☐ about once a month | ☐ about once a week |
| ☐ about once a day | ☐ almost every milking | | |

**29. How likely is each of these scenarios?** *(check one box for each row)*

| | NOT LIKELY AT ALL | SOMEWHAT LIKELY | VERY LIKELY | ALMOST CERTAINLY |
|---|---|---|---|---|
| You or a close family member will be operating your farm 5 years from now? | ☐ | ☐ | ☐ | ☐ |
| You or a close family member will be operating your farm 10 years from now? | ☐ | ☐ | ☐ | ☐ |
| Your farming operation will include dairy 5 years from now? | ☐ | ☐ | ☐ | ☐ |
| Your farming operation will include dairy 10 years from now? | ☐ | ☐ | ☐ | ☐ |

| | | |
|---|---|---|
| **30. Do your employees primarily speak the same language(s) as you?** | ☐☐Yes | ☐☐No |
| **31. Do your operation's owner and lead herdsman speak the same language(s) as each other?** | ☐☐Yes | ☐☐No |

**32. What is the highest level of education you've reached?**

☐ less than a high school degree ☐ high school degree ☐ some college or technical education ☐college degree

**33. Approximately what percentage of your total 2012 household income was from off farm employment?**

☐ None ☐ 1 – 25% ☐ 26% – 50% ☐51 – 75% ☐ 76 – 100%

**34. What veterinarian do you use?**

Name: ______________________ City __________________ State _______

# CONCLUSION

Producers in the SE USA are implementing practices which are part of the National Mastitis Council's mastitis control program regarding proper milking procedures suggesting they are conscientious about BTSCC issues in the region. A majority of producers wears gloves, fore-strip, disinfect teats pre and post milking, and use single service towels. When examining which of these practices were most associated with BTSCC, udder hair management, method of pre-milking disinfection removal, post-milking disinfectant active ingredient, and kill time were selected in a stepwise model selection process. Of those, post milking disinfectant active ingredient and its interaction with method of pre milking disinfectant removal had a significant association with milk quality. This significance allows us to make conclusions about which practices are most influential on BTSCC in the dairy parlor. This also suggests something other than practice implementation is attributing to the higher BTSCC in the region. Continued focus on different areas of dairy operations that could be causing higher BTSCC is necessary to improve milk quality of the SE dairy industry.

Understanding the importance attitudes have towards milk quality demonstrates the need for producers, researchers, and industry professionals to include this aspect in developing more effective communication tools and management strategies that impact milk quality. Producers with the attitude that disinfecting teats of all cows before milking (pre-milking disinfectant), training employees in milking procedures to reduce BTSCC, and having and implementing a mastitis management plan are at least somewhat effective and practical have lower BTSCC than herds of producers that find these practices to be ineffective or impractical. Prior research has indicated attitudes were important, but our research has begun to quantify specific practices and at what level perception begins to effect milk quality of a herd.

Our goals for this paper were: identify the level of implementation of parlor practices, determine the practices that promote low SCC in Southeastern USA dairy herds and the relationship between attitudes and perceptions toward parlor management methods with respect to BTSCC.  We were able to identify what practices producers are using in the SE, those that had the strongest association with BTSCC, and how a producer's attitudes have an effect on milk quality.  Next, it is important to further engage this information by distributing it to the dairy industry, and use these pieces to begin to put together the bigger picture for solving why the SE USA has a higher percentage of producers with lower quality milk then other regions of the USA.

Overall, the studies completed in this thesis allow us to conclude that both implementation of parlor practices and attitudes towards these and related practices are critical for low BTSCC. Defining and understanding the practices in place and what attitudes a producer has about parlor management allows for better understanding and more efficient communication in developing effective management strategies to improve milk quality.

# VITA

Chandler Blakely was born in Cleveland, Tennessee in April 1993. She was raised in Benton, Tennessee. Chandler graduated from Polk County High School in 2011, and proceeded to the University of Tennessee Knoxville for a Bachelor's degree in Animal Science, which was completed in May 2014. She continued her education in the Animal Science Department at the university.

In May 2014, she married and in April 2016 had her first son. Chandler enjoys spending time with her son and family. She is employed by Dairy Farmers of America as a field services representative and is at the service of cooperative members on a daily basis. She loves the dairy industry and is very thankful she has the opportunity to make a difference with DFA, as well as for opportunities given to her by the University of Tennessee and the Animal Science department.