UNDERSTANDING THE MASTITIS MINDSET: APPLYING SOCIAL PSYCHOLOGY IN PRACTICE

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Being successful in improving mastitis management is synonymous with behavior change, which is fully dependent on the mindset: is someone willing and able to change his or her behavior? Behavior of the farmer or his employees, behavior related to every day milking routines or to an ad hoc response to an outbreak of clinical mastitis, it all comes down to the same thing. We have a lot of technical knowledge, but when not applied, it is of no value. Social psychology provides us many tools for behavioral change, which are generally unknown to people professionally working in the dairy industry. The Theory of Planned Behavior, the Health Belief Model, the Elaboration Likelihood Model and "Nudging" are often applied to understand and change people's behavior related to health decisions. Interestingly, farmers and their workers are people too, and within a herd there are various health issues at stake. Understanding and applying these theories by policy makers, veterinarians, other advisors and farmers themselves could contribute to further improve udder health on a national or regional, as well as the farm level. In this paper some of the most relevant social psychology theories will be discussed, as will be some challenges that you may come across when trying to optimize the mastitis mindset on a farm.

Behavior cannot be Planned

From a historical perspective, agricultural extension specialists, researchers, and veterinarians assumed that dairy farming was an activity executed by an individual farmer, based primarily on rational, technical, and economic considerations (Burton, 2004; Leeuwis, 2004). Although such rational choices are crucial in farm management, we learned that farmers' decision making about mastitis management is hardly ever rational (Vaarst et al., 2002; Jansen, 2010). One of the most used theories to understand people's behavior is the Theory of Planned Behavior (TPB) (Ajzen, 1991; Fishbein and Yzer, 2003). The TPB, which is schematically presented in Figure 1, actually is an adaptation of the Theory of Reasoned Action (Ajzen and Madden, 1986). The TPB model is often used to explain famers behavior in various contexts. See e.g. Garforth (2010) who presented this theory in detail regarding mastitis management at NMC before. In short, the model says that if a farmer is actually willing to solve mastitis problems, is positively influenced by important peers and has the feeling he can actually control and perform his actions, he will change.

Although the TPB model is widely used, it is based on the assumption that behavior can be planned and rationalized if all signs are positive. We do know that real life is not that easy, and that there often is a big gap between a positive intention and actual behavior (Sheeran, 2002, Webb and Sheeran, 2006, Armitage and Connor, 1999, 2001). Research on TPB factors applied to mastitis has confirmed the complexity of understanding farmers preventive mastitis behavior,

the underlying mindset and the effect on mastitis (Jansen et. al, 2009, 2010a,b; Jansen and Lam, 2012). In these studies, 92% of the farmers wanted to improve udder health and thus reported the intention to change. However, when farmers' were asked about the implemented preventive measures, this self-reported behavior explained only 12% of the variance in clinical mastitis incidence and 14% of the variance in bulk milk somatic cell count (BMSCC), showing that asking farmers what they actually do- or not do- has a limited predicting value as well as asking about their basic intentions. This means that you have to find other ways to unravel their management decisions. For example, if you want to know if a farmer or employee cleans the cow's teats properly before milking, you can ask them: "Do you have the intention to clean teats before milking?" Most of them would say yes, but that does not mean it will actually always happen. This is called the intention-behavior gap. If you ask them "Do you always clean the teats before milking?" most would say yes as well, but that does not give you any information about how clean the teats actually will be, because the concept "clean" is perceived different from person to person. Probably the best predicting question to ask that correlates most with the actual behavior is: "How important is it for you that the teats are clean before milking?" Such "mindset" questions explain already a bit more about the differences in mastitis incidence between farms: 17% of clinical mastitis incidence and 47% of the variance in BMSCC (Jansen et al, 2009).

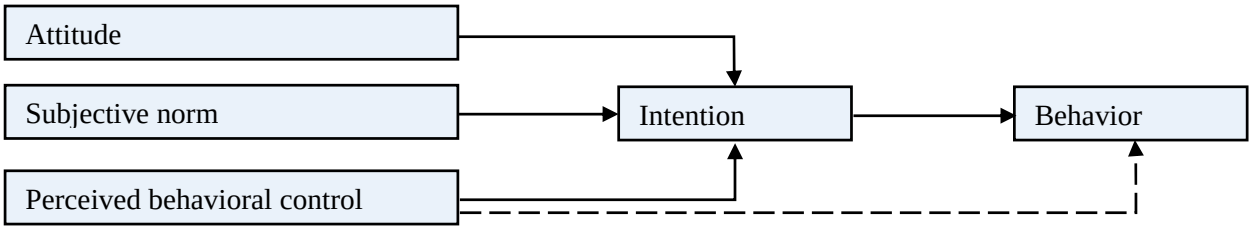

Figure 1. Schematic representation of the Theory of Planned Behavior (Ajzen, 1991; Ajzen and Madden, 1986).

Perceived Threat and Perceived Solutions

The results of several studies of the Dutch Udder Health Centre UGCN (Jansen and Lam, 2012, Jansen 2010) showed that two specific factors of the farmer mindset are important behavioral determinants for mastitis prevention: belief in a personal threat (influenced by perceived susceptibility to, and perceived severity of the disease), and belief in the efficacy of preventive behavior (influenced by perceived benefits from, and perceived barriers to prevention of the disease). Interestingly, these factors are also known to be indispensable in motivating people to work on their own health and are included in the so-called Health Belief Model (HBM), which is presented in Figure 2 (Janz and Becker, 1984). In our earlier studies 58% of the respondents worried about mastitis, and 60% had changed some of their management practices because of udder health problems in previous years (Jansen et al., 2004, 2009, 2010a). Although 79% of the farmers were interested in the prevention of mastitis, only 38% of the respondents thought that they should actually do more about mastitis prevention. Although most farmers considered mastitis as a serious problem and wanted to do more to prevent mastitis, they perceived they had low behavioral control, felt insecure and doubted the efficacy of preventive measures: only 32% of the farmers perceived that they had enough knowledge to prevent mastitis problems and 90%

said that mastitis is a difficult disease and very hard to tackle. Again, this shows a large intention-behavior gap. Efforts to stress the importance of mastitis prevention probably have less effect, as most farmers acknowledge that, and actually want to reduce mastitis incidence. Stressing effective solutions and the perceived benefits and removing possible barriers is probably more effective as that results in an action frame: "when I am in situation X, I will do Y, and that will have effect Z." As most people do not have the time to elaborate extensively on every action to take, these concrete action frames help to make life much easier and probably have more effect on herd health than only empathizing the problem itself.

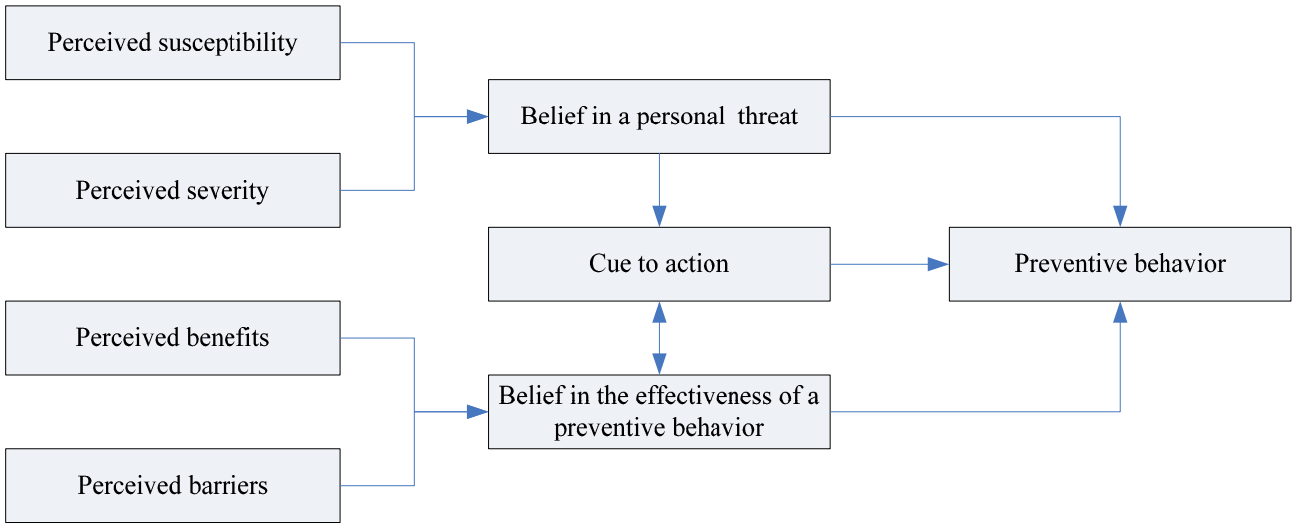

Figure 2. The Health Belief Model (Janz and Becker, 1984, adapted by Koelen and Van den Ban, 2004)

How to Overcome the Intention-Behavior Gap?

According to fundamental social psychological theories, basically two different approaches can be distinguished related to chancing behavior, such as mastitis management:
1) the comprehensive traditional "central" route, which assumes that people make rational decisions based on scientifically-proven information and argumentation.
2) a more indirect and unconscious "peripheral" route that includes cues or heuristics that automatically and unconsciously persuade farmers to change their behavior without using rational argumentation or reasoning.

Both approaches are part of the Elaboration Likelihood Model of Persuasion (Petty and Cacioppo, 1986; Petty and Wegener, 1999) and is presented in Figure 3. Generally interventions aiming at changing people's behavior on udder health follow the seemingly most logic approach, using rational arguments to convince people to change behavior; "when they have more knowledge, they will understand, and they will change" i.e. the central route. As described above when discussing the TPB and the HBM, we know that the central route has a limited effect (Leeuwis, 2004; Webb and Sheeran, 2006, Bargh and Morsella, 2008).

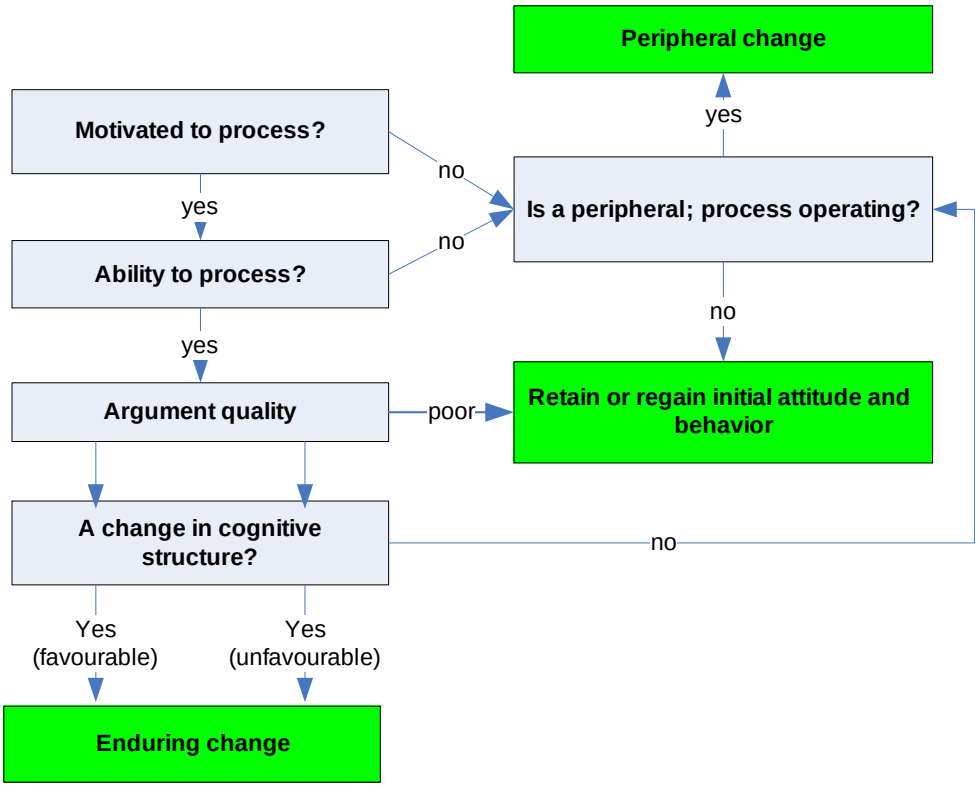

Figure 3. The Elaboration Likelihood Model of Persuasion (Petty and Cacioppo, 1986; Petty and Wegener, 1999), left aligned the central route, right aligned the peripheral route.

If people are not motivated, or not motivated enough, the central route will not work, but they may be effectively approached by the peripheral route. That approach uses cues, heuristics and "nudges" as an unconscious "push" in the desired direction. Heuristics are cognitive shortcuts. Instead of weighing all the evidence when making a decision, people rely on heuristics to save time and energy.

Our earlier findings showed that farmers' familiarity with the tools and their interest in using them, is associated with aspects of farmer mindset, such as the perceived importance of improving udder health and the perceived economic benefit of udder health improvement. This suggests that for farmers who are less motivated, that type of communication strategies is less effective and that other ways need to be explored to reach these farmers (Jansen, 2010b). In that situation, a peripheral communication strategies, where internal motivation is not an important prerequisite (Petty and Cacioppo, 1986; Petty and Wegener, 1999), and that do not use comprehensive science-based argumentation, can be successful, as for instance applied in the milking glove campaign (Jansen, 2010b). Using peripheral communication strategies multifaceted goals of decreasing a complex disease like mastitis will, however, not be met in the short term (Sheeran, 2002). The peripheral route is suitable to implement single management practices (e.g. wearing milking gloves during milking) and short-term behavior changes, because these are more easily adopted than a combination of multiple actions to achieve a certain goal (Sheeran, 2002). Thus, in order to change the management of suboptimal motivated people on a multifactorial disease such as mastitis, peripheral communication strategies can be effective, if a step-by-step approach is chosen.

Cues, Heuristics, and Nudges, and Other Peripheral Approaches

In the daily conversations with farmers or employees, very often the peripheral approach is chosen. Consciously and unconsciously peripheral "tricks" are used, and can be very effective. The fact that most behavior of people is based on routines and is executed more or less automatically and impulsive without thoughtful considerations, is effectively used in marketing, sales and advertising. Cialdini (2001) showed that cues such as authority or expertise (e.g. if my veterinarian says so, it must be right), or cues of social proof (e.g. if all farmers are doing it, then it must be good) are able to influence people without them being aware of it. Some of the tactics that can be used and are based on various sources from social psychology (Cialdini, 2001, Heemskerk et al, 2014, Renes et al. 2011) are:

- Feedback nudge: Give people direct feedback at the moment they perform the behavior, e.g. a thermosticker that reveals a smiley when the water is the right temperature for rinsing a milk cluster after a high SCC cow.
- Stimulans nudge: use a practical tool or change the environment to stimulate the desired behavior, e.g. disinfecting floor mat that is placed in such a way it cannot be avoided before entering the young stock barn.
- Default nudge: use default settings as basis for a choice, and ask people to actively change a default setting to create a barrier for the undesired behavior, e.g. default setting to rinse and clean after every cow in an automatic milking system.
- Kludges: stimulate people to control their own behavior, e.g. an app to install on a smartphone that regularly give reminders via pushed messages, e.g. assess body and teat condition score
- Injunctive norm: Connect social proof to the desired behavior: e.g. a "good farming practice" is to not give waste milk with antibiotics to calves, show them that the desired behavior fits their identity of e.g. being a good farmer, good breeder, good milker etc. by showcasing the national udder health awards winners.
- Descriptive norm: Show that the desired behavior is performed by most of the relevant peers, e.g use benchmarking tools like traffic lights to show how the farmer deviates from others, like i.e in antibiotic usage, or BMSCC.
- Use a role model: use a messenger that is seen as "one of us" to show that it is actually possible to perform the desired behavior. E.g. use story telling by giving local farmers a platform to share their experience in how they have succeeded to reduce BMSCC
- Commitment and consistency: Make sure people are emotionally involved to the subject by confronting them with previous promises. E.g. write down goals and wishes and put them in a visible place.
- Reciprocity: People tend to return a favor, e,g, give farmers the idea that they get something for free, such as distributing free collecting tubes for milk samples to stimulate to return them for diagnostic tests.
- Scarcity: stress the limited availability of certain products or resources, as they value things more when they are scarce. E.g. "Only a few seats left for evening lecture on mastitis."
- Priming: use peoples sensory system (smell, vision, taste etc) to evoke certain associations automatically. E.g. when the parlor looks clean (but not truly disinfected) and smells like citrus or bleach, staff will act more hygienically.

Bringing it to Practice: R.E.S.E.T. the Mindset

The above discussed theoretical models and the peripheral approaches are all ingredients to change the mastitis mindset of farmers and their employees, to change mastitis management, and ultimately to improve udder health. The different information and ingredients should be used in a coordinated way to make the approach successful. When talk about successful influencing the mindset, it's important useful to realize that different people respond different to stimuli. If you want to change behavior of a group of people, it is important to realize that a "one size fits all" approach, will not work. Some people are sensitive to a particular stimulus, while others are more responsive to something else. People's behavior, therefore, can be most effectively changed using of an intelligent mix of different stimuli. Theoretically an analysis and individually adapted approach of every farmer would work best, but in daily practice, this is impossible. Luckily, some successful intervention strategies are available, to make life easier. One of them is the R.E.S.E.T model, that we adapted from van Woerkum et al. (1999) and Leeuwis 2004, and has been applied in a slightly different form to describe effective communication strategies for reducing mastitis before (Lam, 2012; Jansen, 2010). The R.E.S.E.T. model is presented in Figure 4, and summarizes the above presented models and peripheral approaches in five important cues to action: rules, education, social pressure, economics and tools. Each of them is discussed below.

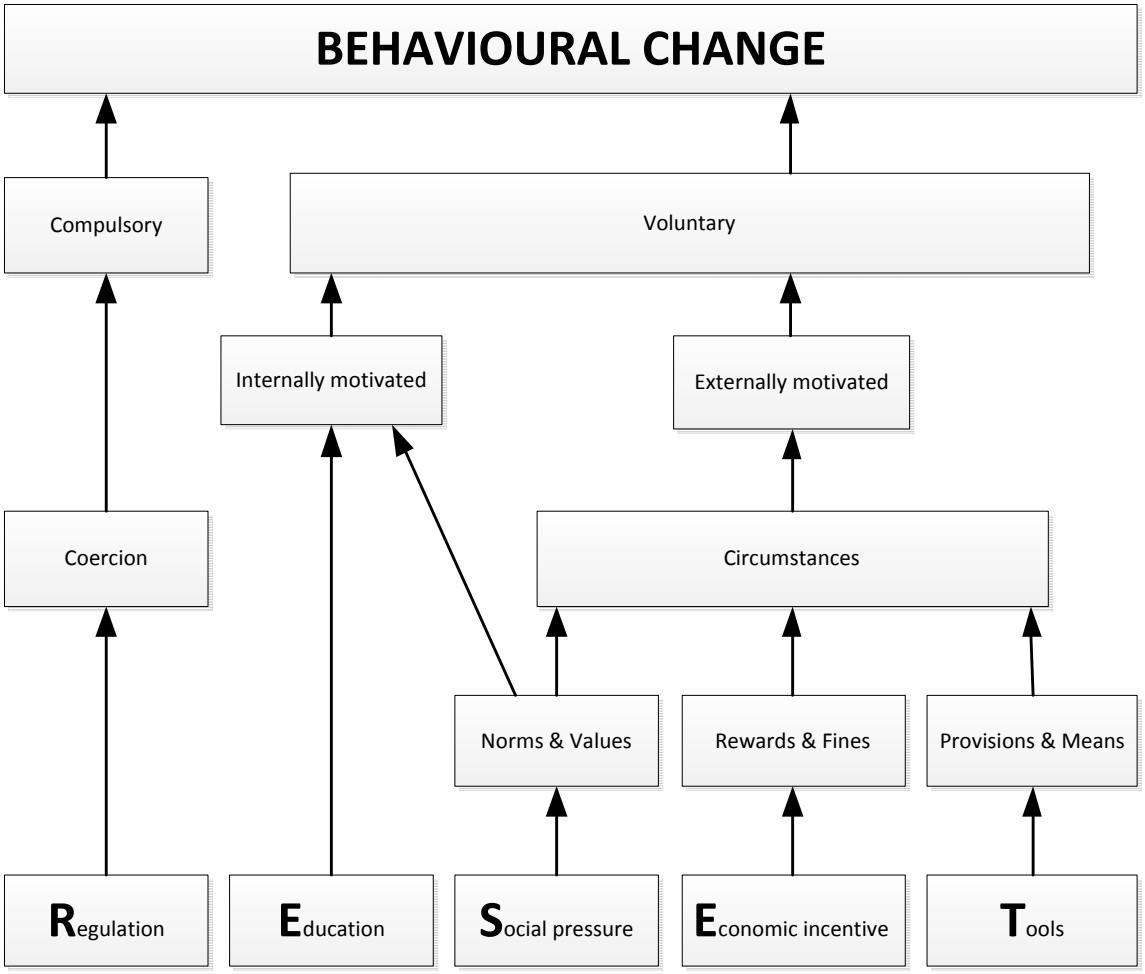

Figure 4. The R.E.S.E.T model (adapted from Van Woerkum et al. 1999, and Leeuwis, 2004).

R is for rules: the structure seeker

Rules and laws, as well as their enforcement, compel you to perform a desired behavior. You are forced to drive within the speed limit. If you exceed it, you commit an offence that could result in a fine, or sometimes worse. The rule and its enforcement then leads people to change their behavior, though not voluntarily. If the rules are relaxed or enforcement is discontinued, people eventually lapse back into their old behavior patterns. So, rules can be effective, but only as long as they exist and are enforced, for example milk quality or animal welfare regulations. Another part of this approach is that some people are sensitive to clear rules, in the sense of having clear directions on what to do.

E is for education: the information seeker

Education and awareness campaigns are an important stimulus for behavioral change. Some people are more willing to apply information that they fully grasp and understand. Education is mainly effective in behavior change in intrinsically motivated people. Nevertheless, they have to be convinced that their behavior will influence the desired result, although that often requires a long term learning process. Study programs for farmers and employees, lectures, online learning, knowledge tests, and handbooks can be part of an educational route.

S is for social pressure: the status seeker

When you think about teenagers, you likely understand exactly what we mean by social pressure. We humans impose certain norms and values on one another. Those who deviate from these are cast aside, which is not a pleasant experience. That is why most people in the US use dips for teat disinfection, while most people in New Zealand use sprays. That is what is considered "normal" behavior. Most people would do anything in their power to become or remain part of a certain group. We call this "herd mentality." The urge to belong, for social cohesion, is an important motivator for behavioral change. In the past, you were considered a wimp if you didn't drink alcohol because you had to drive home. Today, we have the "designated driver," who is a special guest at parties. Until recently, smoking was commonplace in public buildings. Now, in most countries, lighting up in a restaurant gets you dirty looks and an escort outside. Vets and other farm advisors play an important role in shaping this societal frame of reference as they have a strong influence on animal owners' opinions about animal health. Showcasing best practices and giving awards such as "employee of the month" are ways you can effectively use social pressure to help motivate behavioral change. People mimic good examples and draw inspiration from role models. Peer study groups make good use of this principle, because participants share good experiences with one another.

E is for economic stimuli: the price seeker

Costs and benefits influence decisions about whether to do something or not. This is logical, because money is a major stimulus in our free-market economy. Awarding financial bonuses for desired behavior is a strong motivator to continue that behavior or even to improve it. Think, for example, of setting up a bonus system to reward employees who have achieved goals on milk quality. Fines are an economic incentive too. They also motivate people to change their behavior. People do differ, however. One may respond better to rewards, while another is more sensitive to penalties. If you want to change people's behavior, you have to take these sensitivities into account. Remember, however, that when a farmer says that a treatment is "too expensive," this actually means there is misbalance between profits and costs, he may not think you are that good as an advisor, or may not believe that the treatment you are suggesting will work, or may use the "cost excuse" to hide other perceived barriers. Economic stimuli sometimes have a counter-productive side effect. Giving an overly generous discount, for example, might lead clients to doubt the quality of your services.

T is for Tools and technical facilities: the convenience seeker

Technical facilities and tools play an underappreciated role in stimulating behavioral change. You might receive ample information about the dangers of speeding, and the road fines in your country might be sky high, but if it's easy to drive too fast you will probably continue doing so. A speed bump, however, forces you to perform the desired behavior. You slow down. Tools can be used to change people's behavior without them even being aware of it. Most of the previously mentioned cues, nudges and heuristics are grouped under Tools. For example, if we want don't want milkers not to attach too quickly in a rotating milking parlor, we can make a fence that they cannot easily pass.

Conclusion

Changing behavior of people, whether these are veterinarians, farmers or employees, is a science on itself. Udder health specialist, farm advisors, veterinarians and farmers could learn from strategies and tactics used in marketing and should be creative in finding ways to stimulate people. Although the educational, central route is preferred by most policy makers, practice reveals that using solely this strategy has limited effect. Communicative approaches should be taken seriously, and alliances with social scientist could catalyze creativity in thinking of ways to implement peripheral cues in udder health programs. The "R.E.S.E.T. the mindset" approach integrates the different social psychological models in a practical way. It shows that there are more ways to change people's behavior. It's not just one button to push, but it's the combination of multiple strategies that makes communication successful in behavioral change.

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THE POSITIVE EFFECTS OF CONTINUOUS ON-FARM EDUCATION--A PRACTITIONER'S APPROACH

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Introduction

Veterinarians can play a key role in the success of dairy farm's employee management. Albeit not a traditional role for the veterinarian, it is a role that is sustainable. A veterinarian's role on a food animal operation is to provide the knowledge and tools to ensure the most efficient methods of production while advocating for the animal. In taking those roles one step farther, a veterinarian should lead employee teams to further understand the animals and their behavior. Thus, creating a team of knowledgeable, well trained and efficient animal handlers and food harvesters who take ownership and pride in their job. This paper, not research based, will describe a practitioners approach and provide insights of what has been successful and what to avoid based on experience.

Methods

There is no one set method to training employees. Each employee will have different skill sets, experiences and perceptions. Each farm has its own culture. It is important to identify these factors prior to planning the first session. Templates are a great base, however, it is absolutely necessary to make each meeting individualized for the target audience. In many situations, veterinarians are on the farm regularly for herd visits or sick animal calls. While on herd visits, identify the target areas for the next meeting.

On-Farm Meetings

The easiest way to get the team together is at the farm. The initial team meeting should be introductions, roles and experiences. This is a starting point to getting the team to trust that the leader will work in the best interest of all involved. Remember veterinarians are not the boss, never start a meeting with a negative. In a conversation with Phil Durst of Michigan State University regarding a study he is currently involved, it was described that employees are fearful of their boss. One response from an employee was that the boss thinks they are stupid like "donkeys." As the leader, one must encourage and educate rather than dictate. The producer typically sits in the meeting for a short time, addresses issues and then leaves. This allows more of a perceived safe atmosphere for the employees to ask questions. The veterinarian addresses them with a science based answer, "the why" verses "because I said so."

On-farm meetings are usually scheduled between shifts. Time is very limited and crucial. Remember many of the employees have already worked for 10-12 hours. 50 minutes is a good goal for meeting time, this leaves 10 minutes for questions, discussion or good company. Longer than 30 minutes sitting still often leads to drift. It is a good idea to keep them engaged with questions or examples or even food at that point in the meeting. Keep the meetings on a regular schedule. Schedule monthly or quarterly meetings, whatever is best for the farm. Herd health is a regularly scheduled appointment, make Team Meetings one as well. Regular meetings give the employer and the employee a set time to make recommendations, have measurable data, discuss goals and schedule follow up.

One challenge as a leader is when the team is multi-lingual. On one hand, it is best to have the team together to create unity and address issues. On the other hand, switching back and forth between languages can disengage employees and lengthen meetings in an already time restricted environment. Often times, the groups are split by language for a majority of the meeting then brought together for a summary and discussion. In addition, if personnel are available, two veterinarians or leaders, one for each language, at the same time addresses each challenge.

Variety is the key to maintaining attention and retention. The meetings are run a little differently each time. The last thing the employees want to do or hear is the same old thing over and over. A mistake made in the author's past was only using PowerPoint presentations. As in veterinary school, most of the curriculum was PowerPoint based. Do not fall into this trap. These employees did not go to veterinary school for a reason; most of them did not like "school." However, getting the basics across is essential and that is usually lecture based. Start from scratch, the pathophysiology of the cow. For example, oxytocin is a hormone that is essential for proper and shorter milk out. Figures that depict the milk letdown reflex are very helpful. Provide the employees with handouts or a protocol book. In PowerPoint lessons, include pictures from the individual farm. Employees take ownership and pride in where they work. It brings the points more in focus if it is their job.

Interactive media is very helpful to maintain employee engagement. Merck provides several videos and presentations on cow handling. The Merck cd compilations are very well done. Many farms have cameras in the parlor and barns. Use these tools for educational purposes, not punishment. The owners will reap more benefits from their investment. The occasional quiz or test is also a fun way to create variety in meetings. In correcting the quizzes, that in lies your meeting. After time, the employees have seen the same slides. In an effort to determine how much they understand, have the employees lead the meeting using the slides. This will help them fully understand the points.

On the job training

Team meetings are a great starting point. However, the best and most effective learning and teaching occurs when working. Routine scheduled time is made to do herd check. Schedule routine time to spend working with the employees amongst the animals. Working alongside the employees in their environment builds mutual respect and trust. Improvements and corrections made alongside the employee are taken more seriously. Proper dipping of the teats, proper wiping of the teat ends and timing of unit attachment are just words. While in the parlor, take pictures of teats and teat ends, use alcohol pads to check teat ends. Use a stopwatch, time the

procedure then show them their time. Employees, especially millennials, are eager for praise. Give it to them if deserved. In the follow up team meeting, put your data and research into your presentation. Follow up is essential.

Tools such as a Lactocorder, Vadia and even Affi graphs are helpful in providing feedback to the Dairyman and to the team. Veterinarians are trained to use science and animal knowledge to make the best most efficient recommendations. Often times, the human and animal aspect is lost. Let the tools prove if the shift length is too long, the procedure is too short or the employees are too fast. Spending time in the trenches will help make your recommendations more applicable.

In clinic meetings

In addition to farm specific meetings, this past year Thumb Veterinary Services began hosting open meetings for farm employees with a different focus each month. The idea is based on "rounds." Just as a group of veterinarian's meet weekly for rounds, the monthly meetings provide a platform for rounds discussion for farm employees. Groups can be herdsman, milking technicians, reproduction and calf personnel. Each meeting has a specific topic. A few examples of topics are product handling and effectiveness, calf scours—timing of the bugs, Calving, the process and corrections and effective animal handling. Again, like the on farm meetings, these are lecture and hands on based.

Measurements of Success

Although, this paper is not based on scientific research with a hypothesis, set methods or a significant p value; there are measurable results. One farm invited the author to have monthly meetings on their 3000 cow dairy. At the time, their employee turnover rate was over 300%. After one year, the turnover rate decreased to less than 100%. The following year they were named Michigan Dairy of the Year. In addition, in 2015, their somatic cell count was in the 130,000 range, higher than their goal of 125,000. The herd veterinarian and others had recommended digging out the sand free stalls. However, it was not until the employees (milking technicians and cow movers) strongly encouraged the owner to do it, as their bonus was relying on the somatic cell count, that the stalls were cleaned. Within 2 weeks, the SCC dropped to 118,000. Employee engagement is the ultimate measure of success. Employee's helping problem solve, making suggestions, meeting bonus requirements and being heard by the boss are all keys to success.

The following are example methods of measuring success: somatic cell counts, milk letdown curves and milk out times, employee retention rates, decreases in accidents, decreased traumatic injury to animals, faster identification of ill animals, and decreased incidence of new clinical disease. In addition, the employees requesting information, meetings and suggesting topics are all signs of engagement that proves interest.

Summary and Conclusion

Veterinarians have vast knowledge on animal wellbeing and disease pathology. Using that understanding of the animal to positively enhance production is a skill that will pay dividends. Prior to writing this paper, the author asked several dairymen why do they have meetings and

why send their employees to the clinic meetings. Their response, “It is someone other than me telling them what to do, they (the employees) think I say it just because.” Knowledge is power. Ask what the employees what they want to learn. Fun fact day was just as educational for the leader as it was for the employee.

THE QUALITY MILK ALLIANCE: BUILDING THE SCIENCE CLASSROOM

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The U.S. dairy industry is rapidly intensifying; farms with fewer than 100 cows accounted for 49 percent of the country's 9.7 million milk cows in 1992, but just 17 percent of the 9.2 million milk cows in 2012. In contrast, farms with at least 1,000 cows accounted for 49 percent of all cows in 2012, an increase from just 10 percent in 1992 (MacDonald and Newton, 2014). Additionally, 63% of the milk supply is produced by herds with more than 500 cows (von Keyserlingk et al., 2013). However, the percentage of herds with less than 100 cows only decreased marginally, from 83% to 77% (USDA:NAHMS, 2007).

Dairy farms are also becoming more diverse in terms of employment practices and organization (Jackson-Smith and Barham, 2001). Increasing numbers of Latino workers are being employed on many farms that had previously hired relatively few foreign-born laborers (Jenkins et al., 2009). Recent reports have estimated that about half of U.S. dairy farms depend on Spanish-speaking foreign labor and 62% of milk is produced from farms employing immigrant labor (Baker and Chappelle, 2012; von Keyserlingk et al., 2013). As the role of immigrant labor increases in the U.S. dairy industry, cultural and communication barriers complicate management–employee relationships as Spanish-speaking workers are increasingly seen in jobs traditionally held by individuals whose first language is English (Cross, 2006; Stack et al., 2006; Jenkins et al., 2009).

To address this potential cultural and language barrier, education, training and translation tools have been developed by land grant universities, consultants and agricultural agencies (Fuhrmann, 2002; Chase et al., 2006, Stack et al., 2006; Jenkins et al., 2009). However, these programs were developed from a management-directed perspective with minimal input from employees and the effectiveness of employee training, or education programs, relative to farm protocols and productivity, has not been evaluated for short or long term success. Additionally, many dairy managers have limited human resource knowledge and experience, this often leads to frustration with protocol drift and a sense that employees are not motivated to engage in the success of the farm beyond prescribed instructions. These and other workplace conditions can contribute to employee turnover, which has been attributed to relationships with management and co-workers (Billikopf and Gonzalez, 2012). Taken together, these gaps in the nation's dairy farms constitute a form of cultural lag. That is, there is a gap between the human resource needs arising within the industry's labor force and the capacity of producers and managers to address them.

Although somatic cell counts (SCC) continue to decrease among U.S. dairy herds (USDA:NAHMS, 2013), poor protocol compliance may contribute to variability in mastitis control among herds (Fuhrmann, 2002; Brasier et al., 2006). We contend that ineffective training of employees and ensuing protocol drift may prevent some herds from attaining their milk quality goals. This is particularly relevant for mastitis control protocols as Latino laborers are heavily concentrated in entry level positions on dairy farms that include milking, maintenance of

housing and administration of therapies such as intramammary infusions of antimicrobial drugs (Valentine, 2005; Stack et al., 2006). A recent survey of 628 herd owners and managers from Florida, Michigan, and Pennsylvania revealed that herds that offered quality incentives for employees, or ensured strict compliance of milking protocols had lower bulk tank somatic cell counts (BTSCC) than herds that did incorporate these management practices. Conversely, herds that responded that mastitis was a problem in their herd, or had difficulty with compliance of milking or treatment protocols, were more likely to have higher BTSCC (Schewe et al., 2015). Thus, issues of employee management and training, as well as producer values and attitudes regarding mastitis, are related to BTSCC.

In an attempt to enhance engagement on the part of dairy employees, we are developing an on-farm evaluation, the Quality Milk Alliance (QMA) that incorporates a unique aspect of assessing milk quality opportunities on a dairy farm, the management culture. Beyond identifying traditional opportunities for improving milk quality (e.g., improved bedding quality), the QMA evaluation can also serve as a platform for employee training and teaching.

What Do Employees Tell Us?

While there is a considerable body of research that links dairy producer beliefs and attitudes with the prevalence of mastitis and antimicrobial drug use (Barkema et al.; Vaarst et al., 2002; Wenz et al., 2007; Sato et al., 2008; Jansen et al., 2009), employee knowledge and attitudes as they relate to quality milk are not well documented (Stup et al., 2006). In a study of 14 farms from four states, employees received a paper copy of a 29 question survey (bi-lingual) and then were instructed to call a bi-lingual interviewer who asked the employees to respond to each question (Durst and Moore, unpublished). The responses were anonymous and a total of 174 employees participated. Owners and managers were also surveyed to determine how they thought their employees would respond. Employees overwhelmingly want to go beyond their current level of knowledge; rating their interest in learning as 4.73 on a scale of 1 to 5 where they were told that "1" corresponded with "I already know enough to do my job" and "5" corresponded to "I am interested in dairy and I want to keep learning". This is an opportunity to be seized by dairy owners (who ranked employee interest in learning as 3.27), rather than squandered.

In a pilot study in 12 Michigan dairies, when herd owners or managers were asked, "Who trains new employees how to milk cows?", 11 of the 12 management teams responded that they perform the training. However, when the employees were asked the same question, only 29% stated they learned how to milk from the managers or owners; 71% said they learned from other employees, or they just "learned on the job". Employee responses examined by language (Spanish-speaking and English-speaking) showed that only 14% of Latino workers said they learned the milking protocols from managers or owners, which was lower than English-speaking workers (42%; Erskine et al., 2015).

As part of a field trial to develop the QMA evaluation, we have started to gather more extensive information about employee training and communication that will ultimately have over 120 participating herds from Michigan, Pennsylvania, and Florida. Preliminary results suggest that communication and training barriers are similar to those found in our pilot study; on average about half or the employees on farms know the SCC goals for the herd, and a majority rely on

training from someone other than a herd manager, or state that team meetings among farm personnel only occur if there is a problem, or not at all (Table 1). Likewise, about half of employees in each herd believe the lag time between teat stimulation and unit attachment should be about a minute, with a variety of responses accounting for the remainder of respondents. Perhaps most intriguingly, when the proportion of employees within each herd was correlated to the percent of employees that were aware of herd SCC goals, there was virtually no association (Figure 2; coefficient of variation = 0.0337). This suggests that herds that offer incentives for milk quality don't have a greater proportion of employees who are aware of herd goals than herds that do not pay an incentive.

Discussion

Taken together, there are misperceptions among many herd owners and managers as to the effectiveness of employee training efforts. This may be exacerbated on farms that lack prescribed communication opportunities among personnel, for example, the high proportion of employees that responded that there was a lack of regular team meetings, or only met when there was a problem, could be perceived as a punitive management style among employees. Especially considering that on many farms, employee turnover is considered a problem (Erskine, personal observation), the need for effective and consistent communication, training, and education is critical for the prevention and control of mastitis.

To date, our studies suggest that employees lag behind the understanding of mastitis prevention and control, even though they are performing a greater role in the critical work of milking, cleaning barns, observing the health of cows, etc. From an extension education standpoint, we have possibly lagged behind the cultural changes brought about by the demographic changes in the labor force in the dairy industry. In a separate question from the pilot study, 36/74 (49%) of the employees stated that they receive no education regarding mastitis control and management, and only 12/74 (16%) stated they receive education (videos, consultant or veterinary visits, workshops, etc.) on a regular basis. Thus, a new approach for enhancing the education for dairy employees may be needed to augment extension education models by enlisting and facilitating "education amplifiers", who spend considerable time on individual dairy farms, develop professional relationships with employees, and apply their expertise in employee training and education.

During the course of our pilot project, we developed learning resources (lessons, learning objectives, metrics of farm goals) for use by veterinarians on each of the 12 farms. The learning resources varied by farm depending on the particular observations and deficiencies that were determined during the course of the milk quality evaluation. Additionally, we provided visual aids in the form of a "Quality Milk Corner" that included a poster board for employees to serve as a focal point for learning about herd goals, metrics, and educational materials. In effect, we tested the ability of veterinarians to serve as "on-farm science teachers" for the employees to help promote better understanding of the protocols on the farm, and ultimately to attain more consistent and sustained practice of mastitis control protocols.

During focus group discussions at the completion of the demonstration project, employees strongly expressed their appreciation for the education program, which helped them better

understand why they do their tasks and the importance of those tasks. The education program also instilled a sense of respect, to which one employee added, “Without understanding why we do things, it’s like being told as a kid ‘Not to touch the hot stove’ but never being told why you shouldn’t do it.” Dairy producers also noted the positive attitude of employees brought about by veterinarian-initiated education activities and cited several examples of improved interest and team effort on the part of the employees in the work they performed. Additionally, producers expressed interest in continuing this program and believed it held economic value for their operation. One of the critical comments brought forth by veterinarians was the need for support in educating Latino employees, both for interpretation and comprehension of learning materials, and to help navigate cultural differences (e.g., ensuring employees believe that the veterinarian is there to build a relationship with them and not to report back to the owner and get them in trouble).

We believe that engaged employees take the initiative and work to get the desired result for the dairy operation, beyond just “doing the job.” Engaged employees understand the goals of the farm, how things must get done to achieve those goals, and why they should follow protocols to attain those goals. We further believe that in order to close the gap between employee knowledge and dairy farm production, extension personnel should build capacity to support “on-farm education” and facilitate “science teachers,” be they veterinarians, herd managers, or other professionals who can make a more durable impact on employee engagement and thereby improve productivity on dairy operations in the context of the major changes in the industry. Employees who work long hours may not be fully receptive to learning after travelling to attend structured education programs such as a three-hour-long workshop. Additionally, literacy and education levels can be problematic for some employees, and the application of what has been learned on farm sites generally relies on the herd owners or managers, many of whom are not trained or inclined to serve in the role of educator. Our preliminary results indicate that there are considerable training and communication barriers between herd owners and managers and their employees, especially Spanish-speaking employees. These barriers provide opportunities for further research and implementation.

Acknowledgements

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Table 1. Mean percent of employees within herds (n=37 herds) that responded to questions regarding training and herd goals. Responses were attained anonymously from 194 employees (mean of 5.3 employees per herd) with remote response technology. Range of responses among herds was 0 to 100% for all questions.

Do you know the somatic cell count goals for this dairy farm?	Yes	No
	51	49
Who trains you to milk the cows?	Owners/Managers	Other Employees or Self-taught
	23	77
How often do you have team meetings with other employees and managers?	At least once per year	Only when there is a problem or never
	28	72

Figure 1. Mean percent of employees within herds (n=37 herds) that responded to the question "When should units be attached after teat stimulation"? Responses were attained anonymously from 194 employees (mean of 5.3 employees per herd) with remote response technology.

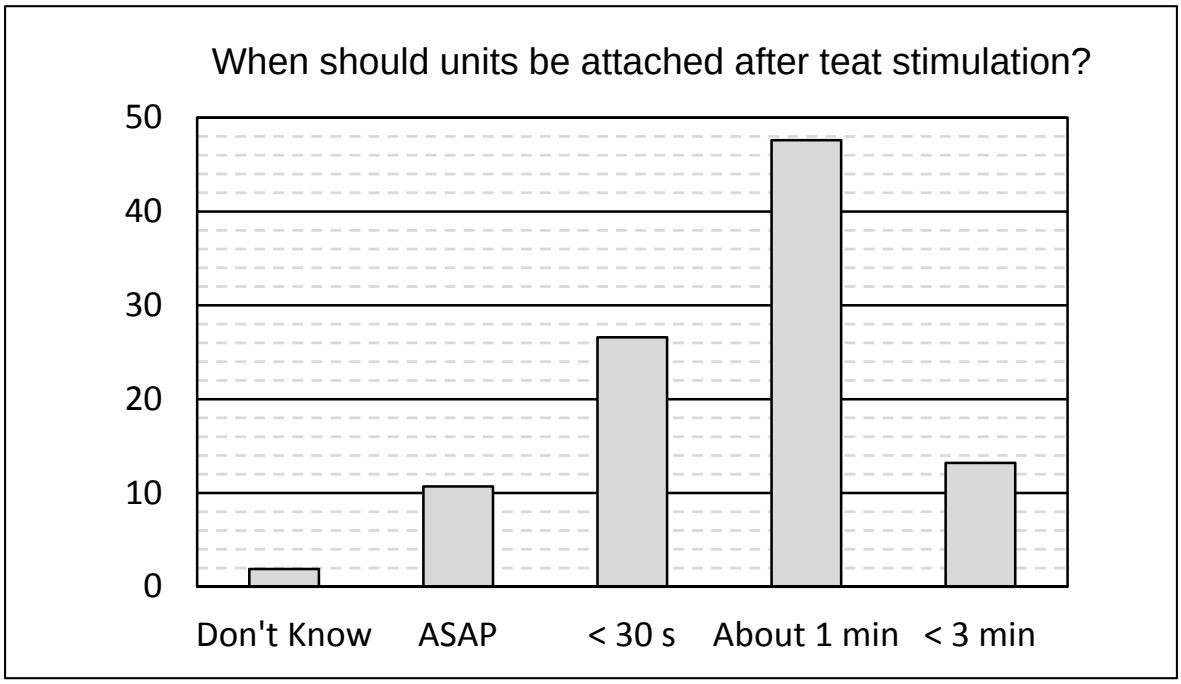
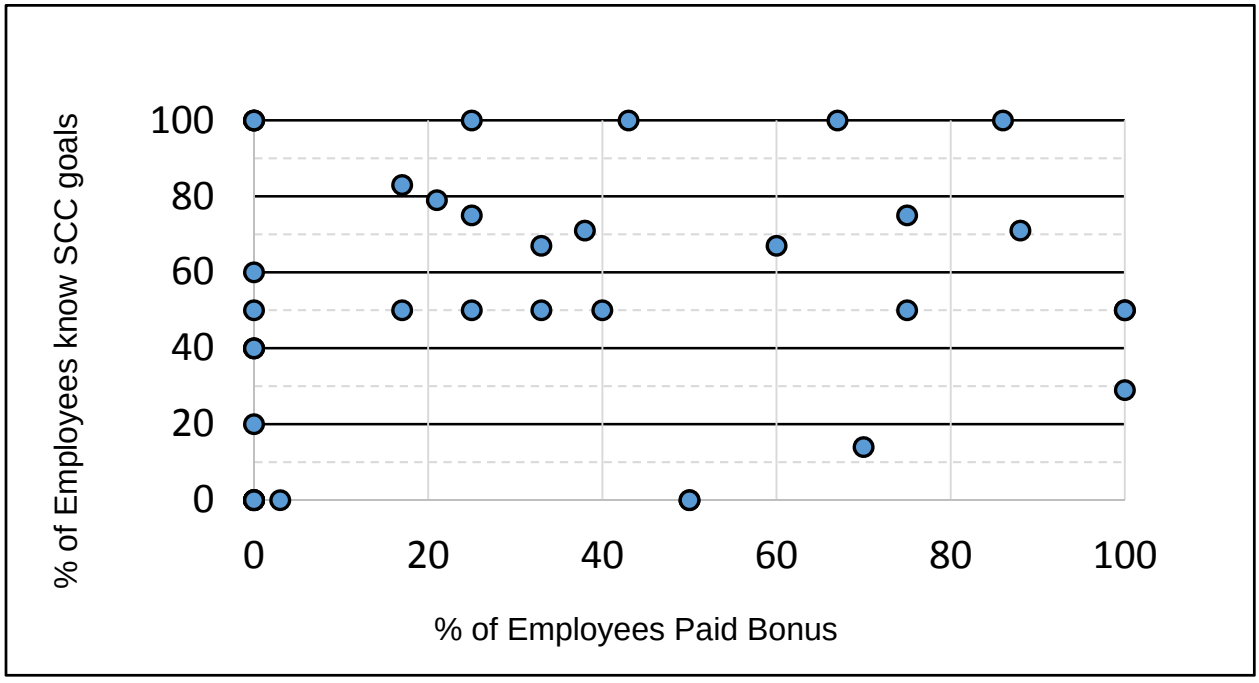


Figure 2. Relationship between the percent of employees that knew herd somatic cell count goals and percent of employees receiving a milk quality incentive within 37 herds



CULTURAL BARRIERS: DO WE BUILD SOME OF THEM OURSELVES?

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Cultural barriers exist in virtually all industries, particularly with the influence of globalization. The dairy industry is no exception. At the farm level many of the major global dairy industries have immigrant labor. Communicating expectations as well as engaging employees are further complicated by language differences.

Often media articles highlight the cultural differences between the country of origin and the host country. In Schein's book Organizational Culture and Leadership (1992) Schein defines the culture of a group as "A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid, and therefore to be taught to new members as the correct way to perceive, think and feel in relation to those problems".

Many of the obstacles faced by farm staff in achieving milk quality are independent of country of origin. In fact cultural diversities may offer synergy, with different perspectives, attitudes and solutions.

North America itself is a great example where immigrants successfully used their resourcefulness, experiences and tools from their homeland to build very synergistic successes from structural and agricultural to economic and political systems. This continues to this day, for example Jan Koum (an American citizen who emigrated from the Ukraine), cites the surveillance culture in his country of birth as a large influence when he co-founded WhatsApp an instant-messaging platform. The company sold to Facebook for $19 billion in 2014.

Reflecting inward on personal cultural identity can aid the recognition of which side the barrier exists. In the USA, men's soccer is often labelled as "effeminate" by many American Football fans. The game of American Football, where the players wear eye make-up, pantyhose, shoulder pads and frequently slap each other's buttocks may not be deemed to be masculine by other countries.

Cultural barriers can and do occur, they can be a frustrating bottleneck to dairy performance. However dairy leaders can build their own and miss the positive aspects of including people from diverse backgrounds to help solve milk quality problems. In this presentation I will discuss the obstacles we have encountered on Midwest USA dairies, illustrating both successes and failures in working with multiple cultures. Our experience with the recent shift in labor availability and demographics will also be addressed.

ANIMAL WELFARE IN THE CONTEXT OF SUSTAINABILITY

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Introduction

Questions concerning the sustainability of food-animal producing industries have become the focus of intense public debate by social critics, animal advocates, and scientists. Concerns about the welfare of dairy cattle undermine social support for dairy farming and thus threaten the social sustainability of the system. For those working within animal agriculture, good welfare is often seen as maintaining production and the absence illness or injury, but public concerns about farm animal welfare often stems from concerns about pain or distress that the animals might experience, and concerns that animals are kept under "unnatural" conditions, with limited space and often a limited ability to engage in social interactions and other natural behaviors.

For the purposes of this paper we have adopted the three part definition of animal welfare proposed by Fraser et al. (1997): 1) animals should exhibit good physical health and biological functioning, 2) animals should have the ability to live reasonably natural lives consistent with their evolutionary history, and 3) animals should experience minimal negative psychological states and the presence of at least some positive psychological states. These different types of concerns can and do overlap. For instance, a lactating dairy cow unable to seek shade on a hot day (natural living) will likely feel uncomfortably hot (affective state) and may show signs of hyperthermia, and ultimately reduced milk production (poor biological functioning) (von Keyserlingk et al., 2009). These three key concepts of animal welfare have been included in official definitions such as that of the World Organization for Animal Health (OIE) which describes animals with good welfare as "*healthy, comfortable, well nourished, safe, able to express innate behavior, and it is not suffering from unpleasant states such as pain, fear, and distress*" (OIE, 2013).

Definitions of sustainability frequently include three pillars, economic, environment and social (see von Keyserlingk et al., 2013). Academics working in agriculture (for example Steinfeld et al., 2006; Foley et al., 2011), and farmers and others working in food animal production systems, often placed greater emphasis on the economic pillar. The social pillar has received the least amount of attention, perhaps because it depends upon human values (Thompson, 1997), or because it is difficult to quantify using natural science based metrics. However, as we have argued elsewhere, the social pillar is deserving of attention discussions concerning sustainability (von Keyserlingk et al., 2013; Hötzel, 2014; von Keyserlingk and Hötzel, 2015), perhaps especially in the case of intensive farming systems that are the subject of increased societal concern (Thornton, 2010).

To better understand the overlapping a divergent perspectives of different stakeholders on the welfare dairy cattle, our group has begun to investigate peoples' views on dairy farming and practices common in the dairy industry (for a review please see Weary et al., in press). We

summarize some of our recent work below, focussing on four common management practices (tail docking, pain mitigation for disbudding/dehorning, access to pasture and cow calf separation). For each practice we briefly describe how research in the natural sciences and social sciences can be integrated to identify more sustainable practices.

Stakeholder Engagement on Contentious Practices in Dairy Industry

At The University of British Columbia (UBC) we have been using web-based "town hall" meetings to provide opportunities for people in the dairy industry to discuss specific dairy management practices with each other and with members of the public interested in these issues. UBC's Cow Views site provided the opportunity for people to state their views, and also 'vote' on the views of others. The idea was to get people interacting on uncomfortable issues in dairy farming that were rarely discussed even by people who work on dairy farms. Our immediate aim was that these discussions would provide farmers and the people within the dairy industry with a better sense of their common values, and of how their views fit with those of interested citizens who did not work in the dairy industry. Our longer-term aim was that a better understanding of common and divergent concerns would provide a research basis for making informed decisions about if and how to change management on farms and policy for the industry.

In each case participants were given a brief background of the perceived advantages and disadvantages associated with each practice (see tail docking below for example). Participants were then asked to vote on whether or not the practice should continue or not. Within each scenario (e.g. tail docking or pasture access) we established multiple virtual town hall meetings such that participants could see each other's responses, but participants in one meeting could not see the reasons discussed in other meetings; in this way each meeting provided an independent test of how this type of discussion unfolds, and an especially persuasive reason articulated within one meeting could only influence the votes within that cohort of participants.

The forum was made available on the Internet so anyone with Internet access could participate. To encourage participation of people within the North American dairy industry, we published brief articles in producer magazines (Progressive Dairyman and Ontario Farmer) that invited readers to participate. For the broader public samples we recruited online via Mechanical Turk (MTurk, www.mturk.com). Several studies have concluded that MTurk samples provide high-quality and reliable data (e.g. Buhrmester et al., 2011; Saunders et al., 2013; Rouse, 2015) that is more representative than many other sampling techniques (Mason and Suri, 2012; Rouse, 2015). That said, our intention was not to collect a sample representative Canadians or Americans, but rather to include a diverse range of participants, and ensure a strong voice for participants affiliated with the dairy industry.

Tail Docking

The responses to this question are fully described in Weary et al. (2011).

Briefly, 178 participants were provided the following context:

Tail docking dairy cattle first became common in New Zealand where workers thought this could reduce their risk of diseases like leptospirosis that can be carried by cows. Some milkers also preferred working with docked cows because the shortened tail was less likely to hit them in the parlor. Some people also felt that docking improved cow cleanliness, and cleaner cows should be exposed to fewer pathogens and have improved udder health.

There may also be disadvantages associated with docking. For some, at least, there is a "yuck" factor of seeing cows without their tails. Docking might also cause pain, and prevents cows from using their natural fly-swatter. For these reasons several European countries including Norway, Sweden, the Netherlands, the United Kingdom, and Switzerland have prohibited tail docking of dairy cattle.

More recently, Canada's new Code of Practice for the Care and Handling of Dairy Cattle states that dairy cattle "must not be tail docked.

In the United States, about 40% of dairy cows have docked tails.

Participants were then asked, "*Should we continue docking the tails of dairy cattle?*"

Approximately 79% of participants were opposed to docking (i.e. responded "No" to the question). Responses varied with participant demographics (e.g. females were more likely than males to oppose docking), but in every demographic sub-group (e.g. by gender, age, country of origin and dairy production experience) the majority of respondents were opposed to docking. Common reasons for opposition to docking included the lack of scientific evidence that docking improves cleanliness or udder health, that docking is painful for cows, that docking is unnatural and that tails are important for controlling flies. Some respondents in favour of docking cited cow cleanliness as an issue, despite the scientific evidence showing no positive effect of docking on cow cleanliness or udder health.

These results illustrate the range of reasons that are cited for supporting and opposing tail docking. We argue that this approach can be used to better target outreach efforts (e.g. improving farmer education on the lack of positive effects of docking on cleanliness and udder health while addressing concerns about producer safety).

Pain Relief for Dehorning and Disbudding

The responses to this question are fully described in Robbins et al. (2015).

For this issue participants were provided the following context:

The developing horns of dairy calves are typically removed to reduce the risk of injuries to farm workers or other cattle that can be caused by horned cattle. Horns of calves three months of age or older are normally removed surgically (dehorning) by scooping, shearing or sawing. Horn buds of younger calves are typically removed (disbudding) using a caustic paste or a hot iron.

There is considerable scientific evidence that all of these procedures cause pain. The immediate pain can be reduced using a local anesthetic to provide a nerve block – this procedure has been used safely for decades and costs just pennies a shot. Pain can persist 24 hours or more; this longer lasting pain can be reduced using non-steroidal anti-inflammatory drugs (like the ibuprofen you take for a headache). Providing calves a sedative before the procedure can reduce handling stress and make the procedure easier to carry out.

In many countries some pain relief is required. For example, Canada's new Code of Practice for the Care and Handling of Dairy Cattle requires that pain control be used. Approximately 18% of dairy farms in the United States report using pain relieving drugs for disbudding or dehorning dairy calves.

Participants then answered the question, "*Should we provide pain relief for disbudding and dehorning dairy calves?*"

Of 354 participants, 90% thought pain relief should be provided when disbudding and dehorning. This support was consistent across all demographic categories suggesting the industry practice of disbudding and dehorning without pain control are not consistent with widely held values both within and outside of the dairy industry. Causing pain to animals under our care, especially when this pain can easily be prevented, seems to be no longer acceptable. The challenge now is to find ways of getting pain control techniques applied widely on dairy farms. Meeting this challenge may be helped by better understanding the reasons participants put forward to explain their views. For example, some participants expressed concerns about drug efficacy and cost, suggesting that extension efforts are needed for farmers that that provide specific examples of effective and inexpensive drug protocols.

Pasture

The responses to this question are fully described in Schuppli et al. (2014).

For this issue participants were provided the following context:

On many dairy farms cows are always kept indoors. Some dairy farmers believe that well-designed indoor housing provides a more comfortable and more suitable environment for the cows. In addition, some farmers keep cows indoors to more easily provide and control diets formulated to sustain high milk production.

Others consider pasture access to be important. For example, some believe that grazing is more environmentally sustainable, that pasture provides a healthier and more comfortable environment for cows, and that grazing is a natural behaviour important for cows.

Participants then answered the question, "*Should dairy cows be provided access to pasture?*"

A total of 414 people participated. Providing access to more natural living conditions, including pasture, was viewed as important for the large majority of participants, including those affiliated with the dairy industry. This finding is at odds with current practice on the majority of farms in

the United States where less than 5% of lactating dairy cows have routine access to pasture (see USDA 2007). The question then is how can we help producers shift practices so that these fall into better alignment with both their own values and those of citizens not involved in agriculture. Here too the analysis of the comments provide by participants was helpful. These comments showed that participants were concerned that in some cases pasture access may be impractical (for example, when weather conditions were poor). The comments also illustrated that the perceived value of pasture access for dairy cattle went beyond the benefits of eating grass; participants cited as benefits exposure to fresh air and the ability to move freely. Together these results suggest the need for new research and development work that investigates different methods of providing outdoor access, and developing hybrid systems that provide a mixture of indoor confinement housing and grazing.

Cow Calf Separation

The responses to this question are fully described in Ventura et al. (2013).

For this issue 195 participants were provided the following context:

Dairy farmers often remove the calf from within the first few hours of birth. This is done in response to several concerns including the following: the calf may become infected from pathogens carried by the cow or her environment; the calf may become injured by the cow or the barn equipment; the calf will not be able to nurse from the cow and receive adequate colostrum (first milk produced by the cow after birth) and milk; the calf will drink too much milk which increases the farmer's cost of feeding and increases the risk of diarrhea; allowing the cow and calf to bond will result in greater separation distress when separation does occur; farms are often not well designed for cow-calf pairs, so keeping cows and calves together can be considered an extra chore.

Others consider that some form of cow-calf contact is an important element of natural behavior, and believe that this contact is beneficial to the cow and calf. On these farms the cow and calf are kept together for days or even weeks after birth."

Unlike the previous three issues for which participants were very consistent in their attitudes, participants disagreed about the proactive of early cow-calf separation. Opponents of early separation (typically from outside of the dairy industry) contended that the practice is emotionally stressful for the calf and cow, it compromises calf and cow health, it is unnatural, and the industry can and should accommodate cow-calf pairs. In contrast, supporters of early separation (often affiliated with the industry, for example as diary veterinarians) reasoned that emotional distress is minimized by separating before bonds develop, that it promotes calf and cow health, and that the industry is limited in its ability to accommodate cow-calf pairs.

Opponents of separating calves from their cows in the first few hours after birth often based their based their views on the emotional experiences of cows and calves. They compared the bond of a cow and her calf to the bond between mother and offspring in other species. Unfortunately, very little scientific work has been done on how the cow and calf may benefit from a prolonged

period of contact. This scientific work is required to develop reasonable solutions to this contentious issue.

One theme raised by proponents was that separation was inevitable, and that early separation was less distressing for the cow and calf than separation at a later age. There is scientific evidence in support of this claim; separating calves at an older age results in a stronger response (high rates of vocalization and other activities) in comparison with calves separated soon after birth (Flower et al., 2003). Some respondents also believed that early separation minimized disease transmission from the cow. Unfortunately, there is very little scientific work that addresses this claim. Thus in the case of cow-calf separation we see a considerable of disagreement among participants on how to proceed, and no clear science to inform the debate. We suggest that new scientific research is urgently required on the issues around cow-calf rearing and separation.

Conclusions

The examples illustrated in this paper show how social science methodologies can document the shared and divergent values of different stakeholders, the associated beliefs regarding the available evidence, and the barriers in implementing changes. We are encouraged by the fact that in some cases we found broad agreement amongst the majority of stakeholders (e.g. that dehorning causes pain) even if the values of the participants did not correspond with common practice (the failure to provide pain relief on many farms). Understanding the beliefs and concerns of participants affiliated and unaffiliated with the dairy industry allows for the identification of contentious topics as well as areas of agreement and is important in efforts to better harmonize industry practices with societal expectations.

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IMPACT OF STOCKMANSHIP ON PRODUCTION OF DAIRY FARMS

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Introduction

Dairy producers strive to reduce stressors, because they know that stress can negatively affect the wellbeing and production of their animals. Stockmanship is a term to describe best practices in animal care and in particular good cattle handling practices that use the cows' natural behavior to effectively move them. Although often underestimated in its impact, cattle handling can have a long lasting impact on stress levels, production, health, reproduction and behavior of cattle. Thus it can not only affect the animal's wellbeing, but it can also impact on the performance of a dairy operation. In order to fully understand the impact of stockmanship on cow wellbeing and production, the physiology of the stress response needs to be reviewed at least briefly first to highlight the significance of stress for dairy cows.

Stress is the physiological response to a challenge and can generally be divided into acute and chronic stress. The response to a stressor is driven by activation of the sympathic nervous system and the hypothalamic-pituitary-adrenal axis. The acute response to a stressor results in the activation of the sympathic nervous system. The triggered release of norepinephrine and epinephrine impacts the cardiovascular system (e.g., increase heart rate, blood flow and pressure), respiratory system (increased respiratory rate), digestive system (e.g. defecation/urination) and metabolic system (e.g., glycogenolysis). The resulting increase in oxygen and blood sugar supply to the brain and muscles readies the body for a 'fight or flight' response (Cannon, 1914).

Concurrently, the hypothalamic-pituitary-adrenal axis is activated, which results in an increased secretion of glucocorticoid hormones (mostly cortisol) from the adrenal cortex. Glucocorticoids, are catabolic and add to the blood glucose by inducing gluconeogenesis by mobilizing body reserves. Ultimately, catecholamines and glucocorticoids orchestrate the body's functions so that the animal can appropriately react to a challenge. Once the challenge is met, both systems are downregulated through a negative feedback mechanism without lasting negative effect. However, if the stressor persists, the animal experiences a chronic stress response, which is reflected in increased free cortisol concentrations (Hemsworth and Bartnett, 2000). Cortisol, the main glucocorticoid hormone, exists in 3 forms: bound to albumin, bound to the cortisol binding globulin (transcorin) or as free cortisol. The latter typically represents approximately 1-10% of the total cortisol (Burdick et al., 2011). Chronic or long term stress responses are associated with decreased growth, impaired reproduction and reduced immune function (Burdick et al., 2011; Hemsworth and Bartnett, 2000; Tsigos and Chrousos, 2002). Interestingly, glucocorticoid receptors are located in the part of the brain (lateral amygdala) that detects and stores fear memories (Burdick et al., 2011). Fear is a potent stressor and stressful experiences (e.g., handling) can have a long term impact on learning and fear behavior of cattle and therefore first learning experiences (e.g. milking) should be positive (Grandin, 2007).

Animals are not uniform in their reaction to stress. Their behavior is shaped by the environment, their past experiences and genetics (Arave and Albright, 1980). Differences in behavior and fear response or skittishness of cattle are called temperament; the trait is heritable. Temperamental animals are more susceptible to stress than calm animals (Sutherland et al., 2012). They will have higher cortisol baseline levels and higher cortisol surges than calm animals (Hopster et al., 1998). Studies have shown that cattle with high temperament or high baseline levels of cortisol ruminate less (Bristow and Holmes, 2007), had reduced growth (Cooke, 2014) and gave birth to calves with lower birth weight and reduced growth over 7 months (Turner et al., 2013).

Impact of Human-Animal Interactions

Stress during handling comes from a variety of sources. The caregiver/handler needs to be aware of this and needs to adjust her/his interventions or actions to minimize the stress for the animals and also to avoid injuries. Cattle are a prey species with strong herding instincts (Grignard et al., 2000). When startled or distressed they will try to escape, kick and/or defecate. Agitated cattle have a higher chance of injuring themselves, e.g., when they slip, and also dairy workers. Cattle related injuries represent the majority of non-fatal injuries on dairy farms (Sorge et al., 2014). In particular, kicks or defecation in the parlor are unpleasant and potentially dangerous experiences for workers. However, not only abrupt or averse handling, but also isolation of cattle from their herd mates has been shown to severely stress cattle (emotional stress). Isolating cattle from herd mates resulted not only in an increased heart rate, restlessness, vocalization, and defecation (Hopster et al., 1998; Rushen et al., 1999), but also increased SCC (Whittlestone et al., 1970), and lymphocytopenia (Hopster et al., 1998).

Cattle are strongly influenced by the information perceived through the long distance senses of sight, smell and hearing. This needs to be understood and accounted for when working with cattle. For instance, an interaction (visual) with cattle starts well before we enter the pen and aversive handling of one animal will negatively impact the behavior of herd mates (Munksgaard et al., 2001). This impact is not only through immediate visual or auditory, but also olfactory cues. Stressed cattle excrete alarm substances in the urine that are smelled by herd mates (Boissy et al., 1998). It had been hypothesized that stress-induced urination in the parlor could impact the cow flow into the parlor of subsequent groups. A recent study did indeed find defecation/urination frequency in the parlor was positively correlated with the average time it took cattle of a pen to enter the parlor, i.e., the more urination occurred the longer it took for the cattle to enter the parlor (Sorge et al., unpublished). The impact of sound on stress is another part of handling that is often underestimated when working with cattle. Cattle are very noise sensitive and cattle perceive noise as stressful and may show elevated heart rate and restlessness. Cows will avoid loud areas, such as a milking parlor, when given the choice (Arnold et al., 2008). Furthermore, Waynert et al. (1999) could demonstrate that shouting human voices are more stressful to cattle than being slapped, noise of banging metal gates or even the application of a (gentle) tail twist. Shouting was associated with significantly higher heart rates and more movements compared to the control groups (Waynert et al., 1999).

Although cattle behavior is largely shaped by their genetics, they do learn and react from experience. Breuer et al (2000) conducted an experiment where heifers were handled twice daily either aversive (hitting with plastic pipe) or gentle (e.g. patting, stroking) for 5 weeks. Not only

did the total cortisol levels immediately rise higher with aversive handling than gentle handling, but the free cortisol concentrations remained higher in aversive handled cattle even during the afternoon and without the presence of a human handler (collected through remote blood sampling). In addition, the avoidance distance was much larger in these heifers than the gently handled heifers. Similarly, bulk tank milk cortisol levels were positively correlated to the observed frequency of negative handling on 66 Australian dairy farms (Hemsworth and Bartnett, 2000). In that study, free cortisol was used to determine long term stress. The authors were also able to demonstrate a negative correlation between adverse handling and the avoidance distance of cattle, milk production and reproductive success on those farms.

The negative impact of stress through adverse handling or stockpersons' attitudes on cattle behavior and milk production has been described in several studies (Breuer et al., 2000; Panama Arias and Spinka, 2005; Rushen et al., 1999a; Seabrook, 1972; Seabrook and Wilkinson, 2000; Sorge et al., 2014; Waiblinger et al., 2002). An experiment applied either gentle or aversive treatments several times a day for 5 days by different handlers marked by different colored coveralls to measure the effect of handling on cow behavior and production. Gentle handling included the use of a soft voice, brushing, and offering of feed, while aversive handling included forcefully slapping the head or side of the cow with an open palm, applying a cattle prod on the flank, or "striking cow on the horn region or flank with the flat surface of a plastic shovel". Ultimately, the presence of an aversive handler at milking led to a 70% increase in residual milk (Rushen et al., 1999a). Similarly, Knierim and Waran (1994) found that heart rate at milking, a measure of acute stress, was negatively correlated with milk production in cattle and differed by milker. Bruckmaier and Blum (1998) also reported that stressful events inhibit the milk letdown of cattle, because catecholamines (epinephrine) inhibit the peripheral effects of oxytocin. Barowicz (1978) showed that intravenous application of adrenaline prior to udder preparation decreased the central oxytocin release and subsequent milk yield in ewes. Regardless of the exact mechanism of blockage of oxytocin, the impact of stress on milk let down has been well established (Bruckmaier and Blum, 1998). Breuer et al. (2000) found that cow behavior variables that indicate fear of humans (e.g. avoidance distance), were at least moderately correlated with milk yield and composition. They also determined that 19% of the variation in milk yield between farms was also driven by fear of humans. Similarly, Sorge et al. (2014) found that herds that trained their employees in stockmanship had, on average, a 810 ± 378 kg higher rolling herd average than those without stockmanship training.

A recent study followed six large dairy herds (400-1000 cows) for 6 months (Sorge et al., unpubl.). Cameras were installed over the home and holding pen as well as the parlor and human-animal interaction as well as cow behavior in the parlor quantified before and after an on-farm stockmanship training. The study found that the quality of the handling in the home pen affected the cattle behavior not only the holding pen, but also in the parlor. For instance, the more handling errors occurred in the pen, the longer it took to empty the home pen, the more cows showed escape behavior or vocalized in the home and holding pen, and the more cows defecated or urinated in the milking parlor. Since defecation/urination is considered a stress response in cattle, it was not surprising that urination/defecation frequency in the parlor was positively correlated with the percent of cattle showing escape behavior or slipped as well as with the frequency of whistling in the holding pen. Considering that it takes approximately 20 minutes for cattle to calm down (Grandin, 2007), the observations show that handling stress

already in the home pen can indeed impact behavior in the parlor and thereby production. Furthermore, Whittlestone et al. (1970) showed that milk SCC increased within 15-45 min in cows exposed to a stressor (chased by a dog), which could also explain higher SCC in more roughly handled herds (Ivemeyer et al., 2011).

In contrast, positive and gentle interactions were rewarding in behavior, health and production of cattle and people. Training of employees about cattle behavior and tips for effective cattle handling were appreciated by the vast majority of dairy employees who participated in an on-farm training – regardless of their prior experience level - and had a positive impact on the attitude towards cattle (Sorge et al., unpublished). Positive and low-stress handling were also beneficial for cattle. A study with 46 Swiss dairies (10-58 cows) also found that positive interactions were associated with improved udder health (fewer mastitis cases, lower SCS) (Ivemeyer et al., 2011). Furthermore, handling and acclimating heifers prior to milking reduced the stress response of heifers during first milkings and made parlor experience more pleasant for animals and milkers alike. Bertenshaw et al. (2008) and Das and Das (2004) showed less defecation and kicks and a better milk production in heifers that received brushing or udder massages before calving compared to negative controls (no additional handling).

Conclusions

Handling is an important part of dairy farming. It impacts the welfare of cattle and people. The stress of improper handling impacts milk production and quality and also may lead to more cattle related injuries on dairy farms. While cattle will cope with the stress of aversive handling, they will not adapt to it. Therefore, herds should focus on the implementation of good cattle handling practices, which can be learned by employees.

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HOW WE IMPLEMENTED DAIRYCARE 365 AND THE NATIONAL DAIRY FARM PROGRAM

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Scenario: You are sitting in your office and the police and news reporters drive onto your farm. Instant mass confusion starts. The police want to ask you questions about suspected animal abuse. Looking out the window you see the reporters walking around and see them talking to employees. More cars pull up and now you have picketers on the premise picketing your farm. As you stand there, you wonder, "what's happening and how did this happen?" Thoughts are going through your head as you stand there, thinking "what do I/we do?" Then the milk plant calls you wondering what is happening and they have decided to end their relationship with you because their customers are calling not wanting your milk in the product that they are buying.

This scenario plays through my head almost every day at Christian Hill Dairy and probably anyone in the dairy industry. So when Foremost Farms USA approached us back in 2010 to take part in the National FARM (Farmers Assuring Responsible Management) that National Milk Producers Foundation (NMPF) was launching, we were happy to take part of this program. I wanted to know what we were doing right, what was wrong, and what needed fixing. Christian Hill has now been through the program three times and we always learn something new. We also ended the practice of tail docking long before it was debated by NMPF.

Seeing the value in the FARM program left me looking for more. How can we get the employees more in line with the same values that the family had? We talked about animal care in our monthly meetings, discussing what they are to do and how to handle situations. My family and I stay very involved with animal care issues. One of us is there to assist with down cow situations.

Then, in 2014, Merck Animal Health launched DairyCare 365. Jeannie Bishop, our Merck representative, approached Dr. Darren Ruff, our herd veterinarian from Mayville Animal Clinic, about taking part in this program. After meeting with both of them and reading about the program, we agreed to participate. Dr. Ruff and I agreed we should include Foremost Farms USA, the farm's dairy co-op. We wanted to have the field representative and one of their FARM evaluators involved as we worked through the program. It was our feeling that these programs would work well together and Foremost Farms agreed.

Christian Hill rolled out the program over a couple of months. We first formed an animal care team that consisted of our representatives from Merck and Foremost Farms, Dr. Ruff and Dr. Sara Hanson, the clinics bilingual veterinarian and me. The meetings consisted of going through the DairyCare 365 manual one section at a time and using the PDF files that Merck has as a starting point. We then tailored the forms for Christian Hill's own animal care program. Dr. Sara would then translate the forms into Spanish so that she could present them to the employees at the monthly meetings. At the next monthly meeting we would do a follow up with our animal care committee and see if there is anything that we needed to change and improve.

The team and I also developed binders of the program and designed it after the handbook; we have them in Spanish and English versions. The binders include of all the forms that we reviewed through with the employees, as well as all the protocols and valuable diagrams that various companies have produced as a training aide. For example the correct way to inject Orbeseal, or the correct way to use an esophageal tube feeder with a new born calf.

At our employee meetings we would watch the videos that were included with the DairyCare 365 program. Employees would be tested on what they learned from the video. If they had incorrect answers Dr. Sara would discuss why the answer was wrong and guide them to the correct answer. Employees also would have the chance to ask questions of the veterinarian. When we hire new employees, they complete the program with other new employees. We also review the “Introduction to Dairy Stockmanship” and “Moving Cows to the Milking Parlor” videos every fall. This is a great way to refresh and talk about these topics. The employees will then watch the more specialized videos specific to their job like calf care.

We also instituted a walk-through program that Dr. Sara does monthly or every other month. She took the DairyCare 365 handbook and developed a travel sheet that the animal care team approved. On walk-through, she is also able to observe the employees and communicate if they are doing something wrong. In addition to our daily observations she adds another valuable set of eyes for us.

It’s our hope that by combining these two programs, we have built a on the foundation for the best animal care that we can provide. It is also our hope that the scenario at the start of this article never happens. If something does happen, we will be prepared to handle the mass confusion that could happen. No one in the industry wants it to happen. All we can do is our best and utilize what the industry provides us like FARM and DairyCare 365 programs.

MASTITIS, ANTIBIOTICS AND PRODUCTION OF HIGH QUALITY MILK

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Introduction

Bovine mastitis is one of the most important bacterial diseases of dairy cattle throughout the world. Mastitis is responsible for great economic losses to the dairy producer and to the milk processing industry resulting from reduced milk production, alterations in milk composition, discarded milk, increased replacement costs, extra labor, treatment costs, and veterinary services. Many factors can influence development of mastitis; however, inflammation of the mammary gland is usually a consequence of adhesion, invasion and colonization of the mammary gland by one or more mastitis pathogens such as *Staphylococcus aureus*, *Streptococcus uberis*, *Escherichia coli* and many others.

Antibiotics are used extensively in food-producing animals to combat disease and to improve animal productivity. On dairy farms, antibiotics are used for treatment and prevention of diseases affecting dairy cows, particularly mastitis, and are often administered routinely to entire herds to prevent mastitis during the dry or non-lactating period. Use of antibiotics in food-producing animals has resulted in healthier, more productive animals; lower disease incidence and prevalence rates, reduced morbidity and mortality; and production of abundant quantities of nutritious, high-quality, and low-cost food for human consumption. In spite of these benefits, there is considerable concern from public health, food safety, and regulatory perspectives about use of antibiotics in food-producing animals (Oliver et al., 2011).

Antibiotic Use in Food Animals and Antimicrobial Resistance

Over the last two decades, development of antimicrobial resistance resulting from agricultural use of antibiotics that could impact treatment of diseases affecting the human population that require antibiotic intervention has become a significant global public health concern. When closely related antibiotics are used in human and veterinary medicine, cross-resistance can occur and disease-causing bacteria may become resistant to antibiotics used in humans. For example, in a review by Economou and Gousia (2015), new strains of multi-resistant foodborne pathogens including Salmonella, Campylobacter and *Escherichia coli* have been reported that produce extended spectrum beta-lactamases and/or AmpC enzymes that inactivate nearly all beta-lactam antibiotics (which include penicillins as well as 3rd and 4th generation cephalosporins). There is no doubt that use of antibiotics for treatment and prevention of diseases of dairy cows and other food-producing animals will continue to be scrutinized.

There are two positions on this highly controversial polarizing topic (Turnbridge, 2004). One position is that bacterial resistance to antimicrobials used in human medicine does result from agricultural use of antibiotics, and thus immediate action should be taken to prevent this from happening in the future. The other position is that resistance to antimicrobials used in human

medicine does result from agricultural use of antibiotics; however, evidence of this having a major effect on human health and well-being is minimal or non-existent and therefore no action is required. The real difference between these two positions is whether action should be taken, or should have been taken to effectively deal with bacterial antimicrobial resistance developed in food-producing animals. This on-going debate has led to important changes in perceptions and priorities of federal regulatory and public health agencies throughout the world with regard to antimicrobial usage, in particular use of antimicrobials as growth promoters and as prophylactic agents.

Antibiotic Use in Dairy Cows and Development of Antimicrobial Resistance

The topic of antibiotic use in dairy cows and development of antimicrobial resistance raises some key questions including: (1) are science-based data available to demonstrate antimicrobial resistance in veterinary pathogens that cause disease in dairy cows associated with use of antibiotics in dairy cows?, (2) are science-based data available to demonstrate that antimicrobial resistance in veterinary pathogens that cause disease in dairy cows linked to pathogens that cause disease in humans?, and (3) are strategies on prudent use of antibiotics in the dairy industry being advocated and followed? A National Mastitis Council expert group (Erskine et al., 2004) reviewed research on bovine mastitis pathogens and trends in resistance to antimicrobial drugs and concluded that currently available scientific evidence did not support widespread, emerging resistance among mastitis pathogens to antimicrobial drugs, and evidence has not been published to suggest that this is either an emerging or progressing phenomenon.

In a comprehensive review on the impact of antibiotic use in adult dairy cows on antimicrobial resistance of veterinary and human pathogens in adult dairy cows, Oliver et al. (2011) concluded that scientific evidence does not support widespread, emerging resistance among mastitis pathogens to antibacterial drugs even though many of these antibiotics have been used in the dairy industry for treatment and prevention of disease for several decades. However, it is clear that use of antibiotics in food-producing animals does contribute to increased antimicrobial resistance. Based on the current scientific literature, the clinical consequences of antimicrobial resistance of zoonotic dairy pathogens that could infect humans appear small. Antimicrobial resistance among dairy pathogens, particularly those found in milk, is likely not a human health concern as long as the milk is pasteurized. However, an increasing number of people choose to consume raw milk (Oliver et al., 2009b). Transmission of an antimicrobial resistant mastitis pathogen and/or foodborne pathogen to humans could occur if contaminated unpasteurized milk and/or dairy products made from contaminated raw milk is consumed; which is another very important reason why people should not consume raw milk (Oliver et al., 2005). Likewise, resistant bacteria contaminating meat from dairy cows should not be a significant human health concern if meat is cooked properly. However, mechanisms of antibiotic resistance gene transfer from resistant to susceptible bacteria are not well known and killing resistant pathogens alone may not be good enough to prevent transfer of resistance gene.

Different countries throughout the world have different laws and regulations regarding antibiotic use in food-producing animals. Much of the focus was and continues to be on antibiotics that were/are used in animal feed as growth promoters. Antimicrobial use in animal agriculture, especially at sub-therapeutic levels, has met with considerable controversy and is at the center of

the agriculture antibiotic use debate. A significant concern is that selection pressure from use of antimicrobials in food-producing animals could result in the emergence, maintenance and horizontal transfer of antimicrobial resistant determinants in bacteria. Selection pressure through sustained use of antimicrobials at sub-therapeutic concentrations in animal production systems could result in development of antimicrobial resistance in commensal and pathogenic bacteria. Bacteria exchange antimicrobial resistance genes through several mechanisms including plasmids, bacteriophages, pathogenicity islands and these genes may ultimately enter bacteria pathogenic to humans and/or opportunistic bacterial pathogens.

Sweden was the first country to regulate withdrawal of antibiotics as growth promoters in food-producing animals in 1986 (Cogliani et al., 2011). In 1995, Denmark banned use of antibiotics as growth promoters in food animal production and subsequently established a system for monitoring antibiotic resistance in farm animals referred to as DANMAP. Use of all antibiotics as growth promoters was banned in the European Union in 2006. The ban on 'growth promoters' was intended to limit non-essential uses of antibiotics in animal production and to help safeguard the effectiveness of important human antibiotics. The program was very effective in some countries and resulted in substantial reductions in the amount of antibiotics used in animal agriculture. On the other hand, the ban on use of antibiotics as growth promoters had limited impact in other countries. For example, in some countries, the 'growth promoter' ban did not substantially reduce the overall use of antibiotics in food animal production as was intended; there was a subsequent increase in use of 'therapeutic' antibiotics following the ban. It was noted that withdrawing antibiotics as growth promoters needed to be accompanied by a clear definition of "therapeutic" and "non-therapeutic" use of antibiotics, and other interventions including appropriate monitoring and disease control measures (Cogliani et al., 2011).

In the United States, the U.S. Food and Drug Administration recently (June, 2015) announced the Veterinary Feed Directive (VFD) final rule (www.federalregister.gov/articles/2015/06/03 /2015-13393/veterinary-feed-directive). The VFD final rule requires veterinarians to issue all VFDs within the context of a veterinarian-client-patient relationship (VCPR) and specifies the key elements that define a VCPR. Key elements include that the veterinarian engage the client (i.e., animal producer or caretaker) to assume responsibility for making clinical judgments about animal health, have sufficient knowledge of the animal by conducting examinations and/or visits to the facility where the animal is managed, and provide for any necessary follow-up evaluation or care. The final rule will require veterinarians to follow state-defined VCPR requirements; in states where the FDA determines that no applicable or appropriate state VCPR requirements exist, veterinarians will need to issue VFDs in compliance with federally defined VCPR requirements. All veterinarians will need to adhere to a VCPR that includes the key elements in the final rule.

Use of antibiotics on dairy farms should not be an all-or-none proposition. Strategies employing prudent use of antimicrobials are needed and this clearly illustrates the importance of effective herd disease prevention and control programs. Prudent use of antibiotics in the dairy industry is important, worthwhile and necessary. Use of antibiotics at times when animals are susceptible to new infection is a sound management decision and a prudent use of antibiotics on the farm. Strategies involving prudent use of antibiotics for treatment encompass identification of the pathogen causing the infection, determining the susceptibility/resistance of the pathogen to

assess the most appropriate antibiotic to use for treatment, and a long enough treatment duration to ensure effective concentrations of the antibiotic to eliminate the pathogen (Oliver et al., 2011).

To address the concern of antimicrobial use in dairy cows, the US Food and Drug Administration (FDA) in cooperation with the American Association of Bovine Practitioners (AABP) and other groups have taken pro-active measures through education and outreach programs for veterinarians and developed a document on judicious use of antimicrobials, so that veterinarians can work effectively with their clientele by providing guidelines on this issue. (http://www.fda.gov/downloads/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/JudiciousUseofAntimicrobials/UCM095571.pdf). In this document, there are fifteen general principles on prevention, alternative treatments as well as drug selection and use as follows: 1) Preventive strategies such as appropriate husbandry and hygiene, routine health monitoring, and immunization should be emphasized; 2) Other therapeutic options should be considered prior to antimicrobial drugs; 3) Judicious use of antimicrobials, when under the direction of a veterinarian, should meet all requirements of a valid veterinarian-client-patient relationship; 4) Prescription, veterinary feed directives, and extra-label use of antimicrobials should meet all the requirements of a valid veterinarian-client-patient relationship; 5) Extra-label antimicrobial therapy must be prescribed only in accordance with the Animal Medical Drug Use Clarification Act amendments for Food, Drug, and Cosmetics Act and its regulations; 6) Veterinarians should work with those responsible for the care of animals to use antimicrobials judiciously regardless of the distribution system through which the antimicrobial was obtained; 7) Regimens for therapeutic antimicrobial use should be optimized using current pharmacological information and principles; 8) Antimicrobials considered important in treating refractory infections in humans or veterinary medicine should be used in animals only after careful review and reasonable justification. Consider other antimicrobials for initial therapy; 9) Use narrow spectrum antimicrobials whenever appropriate; 10) Utilize culture and susceptibility results to aid in the selection of antimicrobials when clinically relevant; 11) Therapeutic antimicrobial use should be confined to appropriate clinical indications. Inappropriate uses such as for uncomplicated viral infections should be avoided; 12) Therapeutic exposure to antimicrobial should be minimized by treating only for as long as needed for the desired clinical response; 13) Limit therapeutic antimicrobial treatment to ill or at risk animals, treating the fewest animals indicated; 14) Minimize environmental contamination with antimicrobials whenever possible, and 15) Accurate records and outcome should be used to evaluate therapeutic regimens.

All these principles are focused on the proper way to use antibiotics. In spite of this, prudent use of antimicrobials in food-producing animal industries is complicated due to issues such as: 1) access and availability of antimicrobials, 2) need for prescription, 3) policies that dictate the sale and use of antimicrobials, and 4) how individuals who administer antimicrobials come into play in a given country or region. For example, in the US, antibiotics can be obtained from sources other than veterinarians. Expert reviews and committees in many countries have highlighted the need for better control of licensing of antibiotics, and codes for prudent use of antibiotics by veterinary practitioners and farmers (Catanneo et al., 2009). In addition, a survey conducted in PA revealed that only 21% of dairy producers had written protocols for treating sick cows, and only 32% contacted a veterinarian before administering antibiotics (Sawant et al., 2005). Similar results were reported in a survey of 381 dairy producers in Washington State (Raymond et al., 2006). Sawant et al. (2005) indicated that absence of antimicrobial treatment records, lack of

written plans for treating sick animals, failure to consult a veterinarian for treating sick animals, and failure to complete the course of antimicrobial treatment were considered important factors that constituted inappropriate use of antimicrobials, which could lead to emergence of antimicrobial resistant bacteria.

Use of antibiotics by dairy producers with a veterinarian's prescription or under veterinary oversight is generally assumed highly accountable. However, several food animal drugs can be purchased over-the-counter without a veterinary prescription from distributors of livestock feed and other farm supplies, thus accountability is questionable. Alternatively, monitoring and accountability of antimicrobial use is improved when producers: 1) follow dairy industry quality assurance guidelines, and, with veterinary assistance, 2) document incidences of antibiotic use and practices associated with their use, such as specific infections treated, dose of drug, frequency of drug administration, treatment duration, and route of administration. Such information is important because the emergence of resistant strains of microorganisms in animals that are treated with antibiotics is related to drug concentrations to which microbes were exposed and the duration of therapy. However, there are no clear definitions of the duration or the dosage at which resistance develops in a particular species of bacteria for a specified drug.

Alternative Approaches to Antibiotics

Given today's public health and food safety concerns regarding antimicrobial resistance, and antibiotic residues in meat and milk of dairy cows associated with treatment of mastitis and other diseases affecting dairy cows, alternative approaches for disease control has gained considerable attention. Yet, for a variety of reasons, alternative approaches for the prevention and control of dairy cattle diseases have achieved only limited success (Oliver et al., 2011). Even though progress has been made understanding the pathogenesis of many diseases affecting dairy cows, the multiplicity of pathogens capable of causing disease; and lack of knowledge on bovine immunology, bacterial virulence factors, and mechanisms of pathogenesis are factors that have hindered development of effective alternative approaches.

Alternatives to antibiotics for disease prevention currently under investigation include improvements in housing, management practices that reduce the likelihood and effect of infectious diseases, management systems and feed formulation, studies to gain a better understanding of animal behavior, and the development of more vaccines, probiotics and competitive exclusion products (Oliver et al., 2009a, Economou and Gousia, 2015). Established practices to prevent or control infectious diseases of dairy cows include improved husbandry practices, quarantines and other biosecurity measures, vaccinations, use of antiseptics such as teat disinfection to prevent mastitis, vector control, and use of probiotics or other competitive microorganisms to exclude pathogens.

Vaccines as an Alternative to Antibiotics

Current mastitis control measures are based upon good milking time hygiene; use of properly functioning milking machines; maintaining clean, dry, comfortable housing areas; good nutritional programs; segregation and culling of persistently infected animals; dry cow antibiotic therapy; and proper identification and treatment of cows with clinical and subclinical mastitis.

Despite adoption of these measures and subsequent reduction in incidence and prevalence rates of mastitis caused by contagious pathogens in some well-managed dairy farms, mastitis continues to be the most common and costly disease of dairy cattle throughout the world.

The purpose of vaccination is to elicit a potent and effective immune response that prevents/eliminates infection within a short period of time. An enhanced immune response with presence of increased number of somatic cells in milk for extended period of time is not desirable since increased somatic cells in milk is considered as evidence of mastitis and reduced milk quality. Therefore, the ideal mastitis vaccine must be able to induce potent and effective immune response which prevents/reduces clinical severity of infection without stimulating a marked inflammatory response of long duration.

Despite several mastitis vaccine trials conducted against major mastitis pathogens such as *Staphylococcus aureus* (Bradley et al., 2015; Leitner et al., 2003a; Leitner et al., 2003b; Luby and Middleton, 2005; Middleton et al., 2006; Rivas et al., 2002; Schukken et al., 2014; Shkreta et al., 2004; Smith et al., 2006), *Streptococcus uberis* (Calzolari et al., 1997; Finch et al., 1994; Finch et al., 1997; Fontaine et al., 2002; Giraudo et al., 1997; Leigh et al., 1999) and *Escherichia coli* (Hogan et al., 1992a; Hogan et al., 1992b; Hogan et al., 1995), all field trials have either been unsuccessful or had limited success. Most vaccination strategies for prevention of mastitis have focused on enhancement of humoral immunity. Development of vaccines that induce a protective cellular immune response in the mammary gland have not been well investigated. The ability to induce cellular immunity, especially neutrophil activation and recruitment into the mammary gland, is one of the key strategies in the control of mastitis but the magnitude and duration of increased cellular recruitment into the mammary gland leads to a high number of somatic cells and poor quality milk.

Commercial Mastitis Vaccines

There are commercial vaccines against mastitis caused by *Staphylococcus aureus* and coliform bacteria. However, there are no commercial vaccines available that protect against streptococcal mastitis. The three commercialized *Staph. aureus* vaccines are Somato-Staph®, Lysigin® and Startvac®. All three vaccines are bacterins that are believed to have same components labeled as somatic antigen containing phage types I, II, III, IV with different strains of *Staph. aureus*. The four coliform vaccines are J-5 Bacterin®, Mastiguard®, J Vac® and Endovac-bovi®. Of the four coliform vaccines, J-5 Bacterin® and Mastiguard® are believed to have same component which is J-5 Bacterin. The J Vac® is a different bacterin-toxoid. Endovac-Bovi® contains mutant *Salmonella typhimurium* bacterin toxoid. All coliform mastitis vaccine formulations use gram-negative core antigens to produce non-specific immunity directed against endotoxin (LPS). The efficacy of these vaccines has been demonstrated in both experimental challenge trials and in field trials in commercial dairy herds (Hogan et al., 1992a; Hogan et al., 1992b; Hogan et al., 1995). The principle of these bacterins is based upon their ability to stimulate production of antibodies directed against common core antigens that gram-negative bacteria share. These vaccines are considered efficacious even though the rate of intramammary infection is not significantly reduced in vaccinated animals because they significantly reduce the clinical severity of the infection. Experimental challenge studies have demonstrated that J5 vaccines are able to reduce bacterial counts in milk and result in fewer and less severe clinical symptoms (Hogan et

al., 1995). Vaccinated cows may become infected with gram-negative mastitis pathogens at the same rate as control animals but have a lower rate of development of clinical mastitis(Hogan et al., 1992a), reduced duration of infection (Hogan et al., 1992b), less loss of milk production, culling and death losses (DeGraves and Fetrow, 1991; Allore and Erb, 1998).

Major problems affecting successful development of protective mastitis vaccines are strain variation, the presence of exopolysaccharide (capsule, slime, biofilm) layer in most pathogenic strains of bacteria (*Staph. aureus*, *Strep. uberis*) which does not allow recognition of antibody coated bacteria by phagocytic cells, dilution of immune effectors by milk (Yancey, 1999; Guidry et al., 1994), interaction between milk components and immune effectors (Russell et al., 1977) that reduce their effectiveness, and the ability of most mastitis causing bacteria to attach and internalize into mammary epithelial cells. Furthermore, evaluation of mastitis vaccines is complicated by the absence of uniform challenge study models, and lack of uniform route(s) of vaccination, time of vaccination, adjuvants and challenge dose. There is an increasing need for development of better vaccines that overcome these problems. A better understanding of natural and acquired immunological defenses of the mammary gland coupled with detailed knowledge of the pathogenesis of each mammary pathogen should lead to the development of improved methods of reducing the incidence of mastitis in dairy cows.

Conclusions

Antibiotics are used extensively in food-producing animals to combat disease and to improve animal performance. On dairy farms, antibiotics such as penicillin, cephalosporin, streptomycin, and tetracycline are used for treatment and prevention of diseases affecting dairy cows caused by a variety of Gram-positive and Gram-negative bacteria. Antibiotics are often administered routinely to entire herds to prevent mastitis during the nonlactating period. Use of antibiotics for treatment and prevention of diseases of dairy cows will continue to be scrutinized. It is clear that strategies employing prudent use of antimicrobials are needed. This clearly illustrates the importance of effective herd disease prevention and control programs.

Comprehensive reviews on the topic of antimicrobial resistance associated with the use of antibiotics concluded that antibiotic use in adult dairy cows has not increased antimicrobial resistance of veterinary pathogens to antibiotics used routinely in the dairy industry. Scientific evidence does not support widespread, emerging resistance among mastitis pathogens to antibacterial drugs even though many of these antibiotics have been used in the dairy industry for treatment and prevention of disease for several decades. However, it is clear that use of antibiotics in food-producing animals does contribute to increased antimicrobial resistance. While antimicrobial resistance does occur, we are of the opinion that the advantages of using antibiotics in adult dairy cows far outweigh the disadvantages.

Based on the current scientific literature, the clinical consequences of antimicrobial resistance of dairy pathogens affecting humans appear small. Antimicrobial resistance among dairy pathogens, particularly those found in milk, is likely not a human health concern as long as the milk is pasteurized. However, an increasing number of people choose to consume raw milk. Transmission of an antimicrobial resistant mastitis pathogen and/or foodborne pathogen to humans could occur if contaminated unpasteurized milk and/or dairy products made from

contaminated raw milk is consumed; which is another very important reason why people should not consume raw milk. Likewise, resistant bacteria contaminating meat from dairy cows should not be a significant human health concern if the meat is cooked properly.

We emphasize and advocate prudent use of antibiotics in the dairy industry; it is important, worthwhile and necessary. Use of antibiotics at times when animals are susceptible to new infection is a sound management decision and a prudent use of antibiotics on the farm. Strategies involving prudent use of antibiotics for treatment encompass identification of the pathogen causing the infection, determining the susceptibility/resistance pattern of the pathogen to assess the most appropriate antibiotic to use for treatment, and a long enough treatment duration to ensure effective concentrations of the antibiotic to eliminate the pathogen. Alternatives to use of antibiotics for maintaining animal health and productivity based on preventative measures, such as vaccination, improved nutrition, environmental sanitation, use of teat sealants, and disease resistance genetic traits together with advances in more rapid pathogen detection and characterization systems will undoubtedly play an integral role in strategies aimed at prudent use of antibiotics.

Lastly, as the debate on use of antibiotics in food-producing animals continues, we need to consider the consequences of "What would happen if antibiotics are banned from use in the dairy industry and in other food-producing animal industries?" The implications of this question are far reaching and include such aspects as animal welfare, health and well-being; and impacts on food quantity, quality, and food costs. This question should be an important aspect in this ongoing and controversial debate!

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OUTCOMES OF MILK RESIDUE TESTING AND THE CHANGING STRUCTURE OF MILK RESIDUE TESTING IN THE FUTURE

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Introduction

The current milk residue-testing program established within the Pasteurized Milk Ordinance (PMO) has been in place since enactment following the 1991 biennial meeting of the National Conference on Interstate Milk Shipments (NCIMS). Since the implementation of the current program, the percentage of milk residue tests that are found to be violative has been decreasing almost yearly, to a current historically low level of 0.014% in 2014 (Figure 1) (NMRD, 2015). As a result of this and other surveillance testing that has been done by the US Food and Drug Administration (FDA), proposals have been passed through the NCIMS conference to amend the drug testing protocols into a more comprehensive program in the future.

History

Procedures for the production and processing of Grade A milk production are established within the NCIMS, which is a federal/state cooperative program participated in by state milk control agencies from all fifty states, the District of Columbia, and US Trust Territories. These procedures are published in the PMO on a biennial basis following the biennial conferences in which proposals for changing the PMO are considered. Prior to 1991, Appendix G of the PMO contained the milk drug residue testing guidelines. Under Appendix G, milk was tested using the Bacillus stearothermophilus Disc Assay (BDSA), with a 16 mm zone of inhibition accepted as the standard for a violative result. While a positive result did proof that an inhibitor was present in the milk, it did not provide the identity of the inhibitory compound or the quantity of the inhibitor present in the milk. The BDSA kit had been shown to detect residues of penicillin, ampicillin, cephapirin, and amoxicillin at or below safe levels established for each drug. It also detected ceftiofur at a level slightly above the safe level (US FDA, 1996).

Following a series of press reports in the late 1980's, questioning the safety of the milk supply in regards to antibiotics, talks to improve the program began to occur. At the 1991 NCIMS biennial meeting, it was proposed and accepted to amend the PMO, which led to inclusion of Appendix N into PMO. Appendix N testing requires that every bulk milk pick-up tanker truck be tested for beta-lactam violative residues prior to be processed. The proposal requires that approved test kits to be used for Appendix N testing be able to detect four of the six beta-lactam antibiotics commonly used in dairy cattle at or below their established tolerance. These six antibiotics are penicillin, ampicillin, amoxicillin, cloxacillin, cephapirin, and ceftiofur. In addition, each farm will have their bulk tank milk checked individually four out of six months each year. Through the years, this program has resulted in over 3 million tests conducted on an annual basis. As a result of better management over the years, there has been a tremendous reduction in the

percentage of confirmed violative samples. For the last two years, the level of violative samples has been 0.014% (Figure 1).

Beginning in 2007, Appendix N began to consider the future of milk residue testing beyond beta-lactams. At that time, they asked FDA to provide a risk-ranking framework to guide future testing.

Today and the Future

Over the last two years, the Appendix N subcommittee of the PMO has been working closely with the FDA on the future of milk testing. In the spring of 2015, FDA released the results of two studies that are being utilized for the future of drug residue testing in milk. The first was the Milk Drug Residue Sampling Survey (FDA, 2015a). This program utilized a multi-component liquid chromatography analysis to simultaneously test for thirty-one milk drug residues at or below the legal tolerances. The FDA initiated the program several years ago to determine if there was a difference in drug residues in milk from farms that had had a violative residue detected in a slaughter animal compared with farms that had not had a history of a violative residues. The results of the testing program found eleven positive samples, representing twelve positive residues (one milk sample had two residues present) from 953 samples in the target group. The drug residues found included florfenicol (6), tulathromycin (2), and one each for ciprofloxacin, sulfamethazine, tilmicosin, and gentamicin. In the non-target group, there were four positive samples from 959 analyzed samples. The drug residues found in the non-target group were all florfenicol. Overall, this test showed that the milk sample is very safe, but there was a small level of violative residues found, with an overall violative rate of 0.78%.

In April 2015, FDA released the first version of the Multicriteria-based Ranking Model for Risk Management of Animal Drug Residues in Milk and Milk Products (FDA, 2015b). This was the report the Appendix N subcommittee asked FDA to provide starting in 2007. This document provided a list for drug families that potentially pose the most risk of causing milk violative drug residues in milk based on several criteria. The top eight drug families identified included beta-lactams, avermectins, macrolides, aminoglycosides, NSAIDs (flunixin), sulfonamides, tetracyclines, and amphenicols (florfenicol).

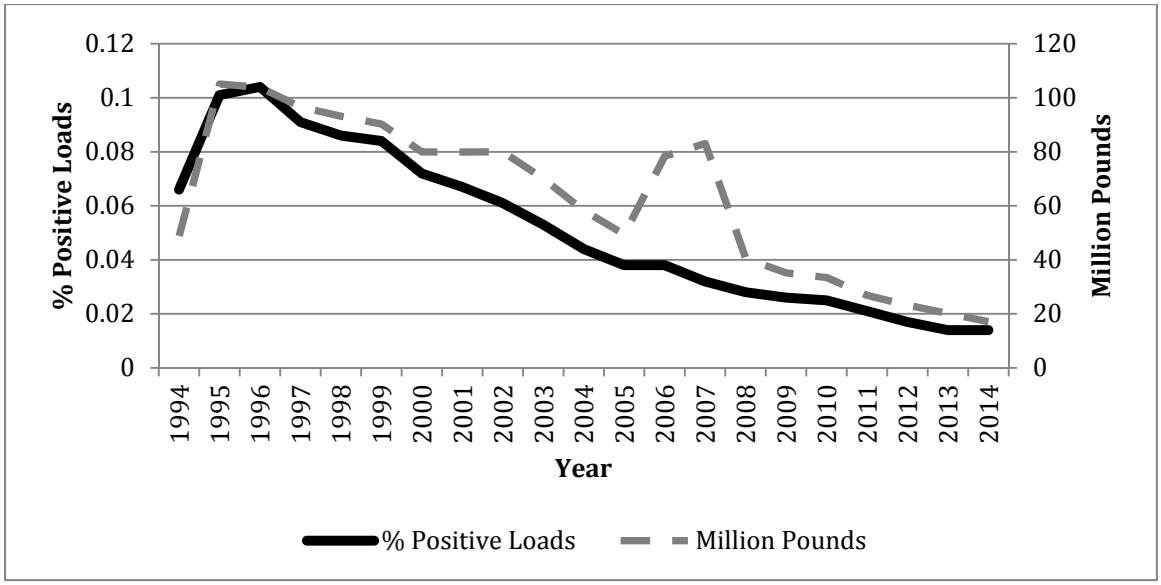
As a result of these two documents and the work done by the Appendix N subcommittee, several proposals related to milk residue testing were introduced at the 2015 NCIMS biennial conference. From this conference, proposal 211 was approved by the conference, which stated that the Appendix N subcommittee shall develop a regulatory framework for a more comprehensive milk drug residue-testing program outside of the beta-lactam testing program. The sub-committee is expected to utilize the information provided the multicriteria risk ranking model (FDA, 2015c). One of the major determinants of the timeline for implementation of an expanded residue testing program is the requirement within proposal 211 is that there are two approved residue detection test kits that can be used by processors. At this time, there are no drug families in the first version of the FDA's multicriteria risk ranking model that have two test kits approved. Based on this and the logical timeline for implementation of new processes within the dairy processing industry, it seems likely that new testing requirements will not be initiated until late 2016 at the earliest. The current proposal for the expanded drug-testing program will

reduce the number of samples tested for new drugs. The frequency will likely fall between 1 in 7 to 1 in 15 tanker loads of milk, depending on the drug being screened.

Conclusion

A closing statement made in the FDA's sampling survey was "The FDA remains confident in the overall safety of the U.S. milk supply." Going forward, the FDA has made it very clear that they expect the Appendix N committee to continue expand the residue testing program so the industry has a comprehensive residue detection program for raw milk. As time progresses and more data becomes available, the multicriteria risk ranking model may be re-run to which could shift the focus of drug testing protocols.

Figure 1. Milk disposition due presence of violative drug residues



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JUDICIOUS USE OF ANTIMICROBIALS: A NEW ZEALAND PERSPECTIVE

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The increasing concern with antimicrobial resistance has resulted in increasing scrutiny of antimicrobial usage in the animal industries. In New Zealand this has resulted in a leadership role being taken by the New Zealand Veterinary Association (NZVA) and increasing activity by regulators, veterinarians, animal health companies and industry bodies.

This paper briefly outlines the approach to antimicrobial usage (AMU) and antimicrobial resistance (AMR) in New Zealand, with particular focus on the dairy industry and use of antimicrobials in treatment and control of mastitis.

Regulation of Antimicrobials in New Zealand

The Ministry for Primary Industries (MPI) has a regulatory role in the registration and use of antimicrobials. Under the Agricultural Compounds and Veterinary Medicines Act (1997) they have a responsibility to ensure that when new antimicrobials are being registered that there is appropriate assessment and labelling. During the registration process the Ministry of Health assesses the importance of the antimicrobial to human health. The World Health Organization classification is used and those antimicrobials critically important in human medicine have label restrictions on use. So for example, some third and fourth generation cephalosporins are registered in New Zealand, but particularly for the fourth generation compounds, there are restrictions on use such that they should only be prescribed for specific indication where culture results indicate that no other compounds are likely efficacious.

MPI also undertakes monitoring of drug sales and registrants are required to provide data of sales. These sales data are circulated for industry comment before general publication. MPI also undertakes strategic reviews of antimicrobial resistance and releases guidance information for prescribers. Audits of veterinary prescribing and on-farm usage of antimicrobials are also undertaken by MPI.

Prescribing Antimicrobials

By law veterinarians are the only individuals with the right to prescribe antimicrobials. The majority of antimicrobials are both prescribed and provided by veterinarians; however a mechanism is available by which prescriptions may be filled by approved third parties.

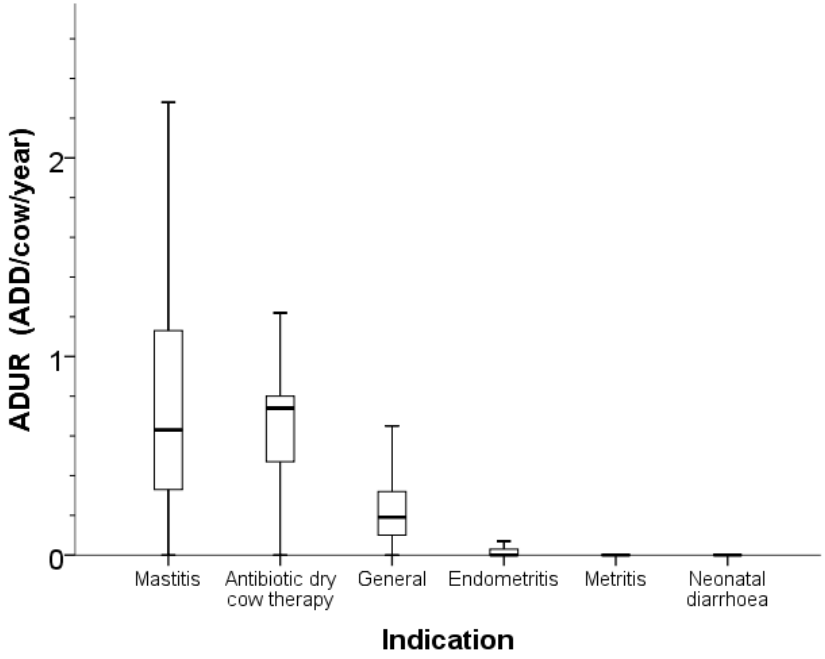
The NZVA provides prescribing guidelines similar to those produced by many veterinary associations around the world. The key points of these guidelines include evidence of a bacterial infection being present, and understanding of the likely sensitivity of the pathogen, the pharmacokinetic/pharmacodynamics of the antimicrobial, immune status of the animal and likelihood of compliance. There is also an emphasis on disease control as an alternative or

adjunct to antimicrobial usage. The NZVA has taken a position that by 2030 antimicrobials will not be used for maintenance of animal health and welfare. This does not mean that those animals with bacterial disease can't be treated, but rather that antimicrobials use will not be required in a preventative way, due to improved animal management and alternative control strategies.
Prescription can only occur to bone fide clients and supply of antimicrobials is reviewed six monthly. In the context of mastitis, annual milk quality consultations are undertaken at which the epidemiology, microbiology, control strategies and antimicrobial use are reviewed for each farm by the veterinarian and scripting undertaken as required. Antimicrobials can be held on farm for emergency use, but the volume and range of antimicrobials is restricted. Veterinary businesses monitor antimicrobial sales to producers. Recently our business has started providing producers data on average daily dose (ADD) used per annum for all classes of antimicrobials and for specific indications. This is being done to alert producers to abnormally high usage to ensure that the prescribing veterinarians understand the variation in usage and disease incidence amongst farms.

Antimicrobial Use in the New Zealand Dairy Industry

National sales figures for antimicrobials are known, but as some antimicrobials are on label across animal species and indications, specific use patterns are not always clear. Recently we have calculated farm level, annual ADD based on sales data within a single large veterinary business. The average per cow per annum ADD was approximately 2, with the majority (85%) of usage being for treatment and control of mastitis (Figure 1). While this level of usage appears to be lower than from other dairy industries around the world, differences in assumptions and calculations may result in calculations from different studies not being directly comparable.

Figure 1. Calculated average daily dose (ADD) per cow per year of antimicrobials by indication from 1,251 herd-seasons from one veterinary business in New Zealand (Data from Compton and McDougall 2014).

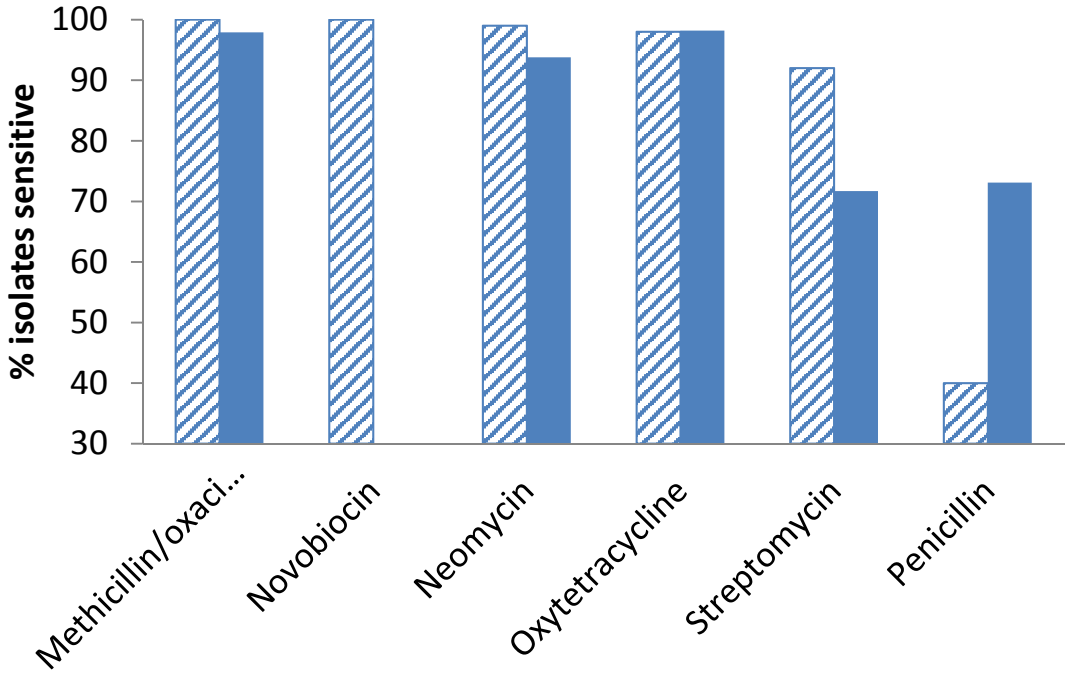


Antimicrobial Resistance in Bacteria of Bovine Origin

Sensitivity of enteric and environmental pathogens obtained from carcass rinse sates of young cattle have demonstrated that a proportion of *Escherichia coli* isolates are resistant to ampicillin, neomycin, spectinomycin, streptomycin, and sulfamethoxazole. Some *Enterococcus faecium* and *Enterococcus faecalis* isolates were resistant to ciprofloxacin, and tetracycline; however, relatively few salmonella isolates were resistant (Heffernan et al 2011). The conclusion of that study were that the prevalence of resistance in these isolates was lower than in human isolates from New Zealand and lower than that reported from Denmark (Heffernan et al 2011).

A number of retrospective analyses of sensitivity patterns of bovine mastitis isolates submitted to commercial veterinary laboratories have been undertaken over the last 30 years in New Zealand. Broadly these studies have demonstrated low levels of resistance to the commonly used antimicrobials other than penicillin, and that over time the proportion of penicillin sensitive isolates may in fact have increased (Belton 1991; Petrovski et al 2011; Figure 2).

Figure 2. Proportion of *Staphylococcus aureus* bovine mastitis isolates sensitive to a range of antimicrobials (data from Belton 1991 [diagonal bars]; Petrovski et al 2011 [solid bars]).



Some care is required in interpreting this data as the samples submitted are not a random sample of the population (i.e. there is a potential bias towards recurrent mastitis cases and/or isolates from problem herds). Additionally, no herd- or cow-level demographic or epidemiological data is available for these isolates. It has been demonstrated that the distributions of minimum inhibitory concentrations (MIC) for a population of mastitis isolates may be affected by the source; that is, differences in the MIC distribution may occur where isolates are drawn from controlled studies when compared with isolates submitted to veterinary laboratories (McDougall et al 2014).

Producer and Veterinary Attitudes toward Antimicrobial Use

Surveys of veterinary prescribing have identified that technical factors such as likely bacterial species present, antimicrobial susceptibility testing results, and on label drug use are the primary drivers of prescribing behavior (De Briyne et al 2013; Gibbons et al 2013). Non-clinical factors do affect veterinary prescriber's behavior. Factors increasing the probability that cattle veterinarians in Ireland would prescribe antimicrobials included farmers' demand for an antimicrobial, a perception that if antimicrobials were later found to be required the vet would be blamed if not prescribing antimicrobials in the first instance, farmer expectation that antimicrobials will be used, perception that if the animal doesn't improve then the farmer will call the veterinarian again and lack of confidence in the primary diagnosis (Gibbons et al 2013).
To understand producer and veterinary knowledge, attitudes, skills and aspirations (KASA) around antimicrobial usage three producer focus groups, two veterinary focus groups and one veterinary online survey were undertaken (McDougall et al 2015).

Producers valued veterinary advice and stated that this was their primary source of information as to which antimicrobial to use. However, producers' personal experience with perceived efficacy was a strong driver of day-to-day choice of antimicrobial. When semi quantitative analysis was undertaken, producers experience was in fact the most highly ranked factor in choice of antimicrobials. Producers did not value culture and generally believed that apparent clinical failure was due to incorrect antimicrobial choice, rather than any bacterial or host factors. Nearly 80% of producers believe antimicrobial resistance of bovine pathogens is real, but only 47% agreed or strongly agreed that antimicrobial use on their farm could affect prevalence of resistance, only 11% agreed that antimicrobial use on their farm could affect prevalence of resistance on other farms, and only 26% agreed that antimicrobial usage on their farm could potentially result in resistance in human pathogens.

Veterinarian's choice of antimicrobials was related to drug, bacteria and host factors. Prescribing was also influenced by producer feedback on apparent efficacy, the veterinarian's experience of perceived efficacy on the farm, cost/benefit analyses and on practice policy. However, only 30% of veterinarians reported having a practice policy for prescribing. A survey of over 200 practicing dairy veterinarians found that the median clinician was neutral on statements including that antibiotics are a diminishing resource, that antimicrobial risk on farm is genuine, and that antimicrobial resistance is a risk to farm staff. However, the majority of veterinarians strongly agreed with statements around importance of management of withdrawal periods, managing the risk around off label usage, and responsible prescribing. There were differences in scores for some responses by gender, by years of experience, and by role within the business (i.e. owners versus employees).

Strategies to Manage Risks of Antimicrobial Resistance

There has been increased communication around prudent usage of antimicrobials and managing the risk of antimicrobial resistance to the veterinary profession in recent years. As outlined above, the NZVA has taken a strong position on this, supported by emails and articles in veterinary professional journals and magazines.

Formularies are being updated for all animal species, which will be circulated to all veterinarians.

On-farm culture of mastitis cases is not widely practiced at present in New Zealand. Currently a multicenter, multi-herd study is under way assessing the effect of introduction of on-farm culture on antimicrobial usage. The study design is a controlled randomized intervention study whereby cows are randomly assigned within sequential pairs of clinical mastitis cases within farm to be treated as per standard farm protocol or only to be treated following assessment of an on-farm selective media culture (checkup, Farmedix, Auckland, New Zealand). In consultation with the herd veterinarian, farm staff have been trained in use of the culture system and have been provided with a decision tree. The selective culture media provides speciation to the level of *S. aureus*, various Streptococcal species, CNS, *E. coli*, and Klebsiella spp. amongst others. Therapy is based on the decision tree with no therapy for 'no growths' or Gram negative isolates, extended duration of therapy for *S. aureus* and a short course of intramammary narrow spectrum penicillin for the Streptococci. The on-farm culture and following the decision trees is

moderately complex and compliance has been variable amongst herds. High levels of support for producers have been required in some cases to ensure use of the technology.

A decision support app has been developed to allow producers and veterinarians to assess the likelihood of bacteriological cure of clinical mastitis cases given the inputs of the age of the cow, stage of lactation, position of the gland (front vs. rear) and if known, the bacterial species. The output is given as a percentage which is color coded as green, amber or red. This app is freely available for download to android or apple platforms.

Alternatives to antimicrobial use are also being explored. There is increasing use of internal teat sealants alone in dairy heifers pre-partum and in cows with a low risk of intramammary infection at drying off (for example with low somatic cell count at each DHIA throughout lactation and no history of clinical mastitis).

Recently a mastitis vaccine has been registered in New Zealand (StartVac, Hippra, Spain) as has an immune restorative bovine granulocyte colony stimulating factor product (Imrestor, Elanco). While currently not widely used, efficacy data is being generated to potentially support usage of these products more broadly.

Conclusions

While the incidence and prevalence of antimicrobial resistance in bovine isolates has not been determined at a national level, research and retrospective analyses of laboratory submissions suggest prevalence is not high. However, given the concerns of consumers, politicians and the medical profession efforts, are being undertaken to improve prescribing practices, improve on-farm diagnosis and treatment decisions, and to look at alternatives to antimicrobial usage for management and control of common bacterial infections such as mastitis.

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ADOPTING AND IMPLEMENTING ON-FARM CULTURING

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Five critical aspects to succeeding with on-farm culturing:

1. Management must commit the resources and the time
2. Establish a protocol with responsibility and accountability
3. Establish a recording system that is meaningful to the dairy
4. Training and continue evaluation of personnel and protocol
5. Act/Adjust as situations and circumstances change

Although not all inclusive, we found through our experiences that these functions will lay the foundation for the opportunity to succeed and maintain a sustainable on-farm culturing program that yields actionable management information.

Commit the Resources and the Time

Like many things, we failed before we succeeded to implement on-farm culturing at Green Valley Dairy. Through trial and error, it became apparent devoting the proper resources and time would drive our success. Resources and time go hand in hand as necessary ingredients for success.

To accomplish this, we dedicated a locked-down location in our office area as our “lab”. We installed water, a sink, cabinets, counter tops and refrigeration. We established access, an expectation of cleanliness and assigned responsibility and accountability. Once complete, we fully furnished the lab with equipment that would allow the level of culturing we required as well as other diagnostic functions we wished to accomplish now and in the future.

What resulted was a clean and sanitary place for us to conduct our work that was close to our parlor and provided for direct supervision. This investment showed management’s commitment and value in the work and the results that would follow.

Time may be the most precious resource that we have. Recognizing that we hoped our lab would play a critical role in our future success, as well as reduced antibiotic use, it was important that we dedicated the appropriate time to this job. As a result, we created a “Lab Technician” position. Given our systems in place and our job responsibilities, we combined two, part- time positions and created a full time position. Our lab technician also feeds new born calves for us.

This position is primarily responsible for all of our lab functions. It allows for reduced procedural drift, accuracy as well as consistency in reporting and reading results and also streamlined our training needs. Furthermore, it has allowed us to continue to expand our capabilities and implement quality control measures on the dairy.

Our lab technician has many responsibilities that go beyond simple milk culturing. We also do mycoplasma cultures, general bacterial cultures or quality control checks on: parlor towels, calf tubers, maternity milk buckets, calf bottles, pasteurized milk samples; calf IGG's, residue tests, SCC tests, bedding samples, and other miscellaneous tests.

Establish a Protocol

Protocols are a cornerstone of the management philosophy at Green Valley Dairy. Protocols allow standardization of work to minimize variation within the task so that the procedure and the people can be fairly monitored and evaluated. Management implemented written Standard Operating Procedures (SOP's); and just like any other process or task on the dairy; we placed a high level of importance on the job believing that we would be better for it. It was also important to ensure that buy-in was achieved cross functionally as the lab could not be successful without proper sample collection and cooperation with the parlor leads. Cooperation and alignment throughout the organization is required to establish a successful lab.

Protocols that needed to be established for milk culturing:

Mastitis Identification
Collecting Milk Samples
Lab Sanitation
Mastitis Culturing
Identification
Recording and Reporting
Equipment Care and Inspection

Establish a Record System

A lab produces data. At Green Valley Dairy, we believe to be successful we must turn data into information, but more importantly, information must be turned into management action. As a commercial dairy, the collection of data or information that cannot be turned into management action, although interesting, has little value and is resourced accordingly. Two different recording systems needed to be established within our herd management record system. The first was the designation of a system for recording our culture results. For that we utilized the "Minnesota Easy Culture System II" from the Laboratory for Udder Health, University of Minnesota. The second was to establish a consistent definition for mastitis as well as culture-based treatment protocols for mastitis. We utilized Valley Ag's DC 305 as a tool to help us organize and analyze the information.

Recording was developed for managerial monitoring vs a more academic or benchmarking mindset. The questions we wanted to answer that could lead to management action were:

1. If a cow entered the hospital pen how long was she there?
2. If a cow left the hospital pen and then re-entered, what was that time frame?
3. What percent of the cows treated for mastitis required extended therapy?
4. Based of culture results, does the pattern to the above questions change?
5. Is there a change or seasonal pattern to mastitis pathogens?

Training and Evaluation

We began our process with the "Minnesota Easy Culture System II" from the Laboratory for Udder Health, University of Minnesota. Our next step was off site hands on training from Dr. Monty Belmer and Kari Slager at Waupun Veterinary Services Milk Quality Lab. This has been a continuous process with an annual visit.

I took part in the initial phase of this training. I felt it necessary to understand the details so I could to help ensure accurate results. Then we passed on this knowledge and trained our lab tech. The training consisted of large amounts of on-site work followed by tests, visits and calls with Waupun Veterinary Services. We were able to utilize their expertise, expand our capabilities and implement some of their standard operating procedures.

Our training is continuous as we utilize Waupun for quality control and accuracy checks. We also send them samples that we are unsure of the results.

Act/Adjust on the Information

Information and technology are wonderful things. But, too much information can overwhelm the process and be difficult to utilize or organize.

Knowing the questions we were trying to answer and establishing base lines, trends and changes in our results became easy to diagnose and analyze with this system. This information allows us to get into management action. When you record accurate information and utilize it to make decisions, you truly learn to value what the lab can do for you.

The recorded results allow us to run on-farm tests with different treatment protocols and analyze the results. We are focused on what the numbers tell us and not what we feel. We utilize the information derived from the lab in our prevention of mastitis, milking order, culling decisions and vaccinations. The lab results have further aided us in reduced use of antibiotics.

The quality control checks that we run allow us to monitor and verify procedural drift from protocols in many areas as well as provide us with valuable information when diagnosing a problem that may be occurring in those particular areas of the dairy.

The work can seem tedious and many times things are not changing, but the effort associated with this process will pay dividends if you have the fortuitousness to stay with it. The monetary benefits are there, but there are intrinsic things that are very beneficial with on-farm culturing. We have been growing this process for seven years and learn new things all the time. Sometimes the best information comes from the places you never thought to look.

MILK COMES FROM COWS, QUALITY COMES FROM PEOPLE: WHAT VALUE COMES FROM YOU?

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Throughout the entire dairy industry, there are a lot of specialists within every facet of a modern dairy operation. When it comes to employee management and communication, there's no shortage of consultants who provide their theories, principles, and advice for how to be a better manager, leader, and communicator.

For the most part, many of these advisers offer valuable, effective advice for managing and leading people. But at the same time, much of this advice tends to be complicated and even impractical. When it comes to leadership and employee management, the most useful, effective advice isn't just technical, academic theory. The best guidance is usually simple, commonsense advice that can be implemented down in the trenches, where the "real work" is done.

As dairy businesses continue to grow, they will continue to be more reliant on their team of advisors and employees to help keep their cattle healthy and their businesses profitable. While most team members provide value to the dairy with their labor, others bring value by offering technical guidance. Together, everyone on the dairy's team is responsible for making an impact on the overall success of the business.

The challenge for all dairy professionals is simple yet difficult. Every day, we must work together. We must work together and communicate effectively. We must work together towards reaching our shared goals and delivering results. Just as we strive to help each animal reach its genetic potential, we must work together to help dairy teams create healthy habits that help them reach their potential.

At the foundation of helping dairy teams reach their potential and obtain better results are the following three core principles: Clarity, Accountability, and Discipline.

These three principles apply to, and come from, everyone who's part of the dairy's team. They start at the top with owners and their management team. From there, these principles extend out to include the dairy's outside advisors such as veterinarians, nutritionists, and equipment specialists. And finally, they make their way to the dedicated people who do the real work down in the trenches.

How well are you helping the dairies you work with when it comes to these three foundational areas?

Clarity

Clarity exists when the people on your dairy team know and understand what is expected of them. No guessing, no confusion, no gray area – just clear expectations.

How effectively and clearly do you communicate with dairy owners, managers, and laborers? Do you help create Standard Operating Procedures that everyone can follow and understand? It's critical that everyone knows what to do, how to do it, and why it's important. How well do you simplify and clarify complex information so everyone can understand it?

The easiest way to clearly communicate and explain what's needed for each task is by creating and implementing simple, step-by-step protocols in writing. Unfortunately, most people don't read directions before doing a task. So how can you ensure that managers and laborers will actually follow the protocols you create? The solution is to make SOP's easier to follow. One way to do make them easier to follow is to convert a numerical list into an interactive flow chart. Another solution is to organize protocols in a linear path that include tools that are easy to use and conveniently located.

Ultimately, providing clear expectations and instructions will help everyone on the team strive toward reaching the results the dairy needs to succeed.

Another important principle at the foundation of helping dairy teams reach their goal is Accountability.

Accountability

Accountability has two parts. It starts with each person doing their own job according to the dairy's clear expectations. Once these standards are established, everyone should know what they're expected to do. What truly matters however is that they actually do it. Towards that end, the second part of accountability involves holding each person responsible for what they do and what they don't.

How and where can you start improving the accountability of the dairy teams you work with? It starts with you and the entire management team setting the example for everyone else on the team. From there, it continues when you and the dairy's management team overcomes the discomfort of addressing and dealing with the people who aren't pulling their weight.

Why is it important you have these difficult conversations? The short and simple answer is that the cows and the rest of the team are counting on everyone to do their work. They are counting on the team's leaders to hold people accountable.

Unfortunately, when people aren't held accountable for doing their work, many choose not to do it. And when someone doesn't do their job… conflicts begin, communication suffers, and teamwork ends. However, when people are accountable to themselves and to the people on their team, they become more committed to doing their work and working together. Ultimately, accountability builds trust and strengthens teams.

Finally, the third important principle at the foundation of helping dairy teams reach their goals is Discipline.

Discipline

Discipline is all about following through and doing what you say you're going to do – even if, especially if – you'd rather not do it. Discipline is about being consistent day after day and forming good habits. It requires a strong will and a commitment of time to show people that you're serious about everyone following your protocols, adhering to your values, and achieving your shared goals.

What happens when a milker is undisciplined when following the milking routine? What about a herdsperson who lacks the discipline to follow the repro program? Just like everyone on the dairy's team, managers and advisers need to be disciplined when implementing and following up on the protocols they implement. Without a realistic action plan and a steadfast discipline for following up, dairy leaders fail to execute. In the end, their words lose their impact.

When leaders act in a consistently disciplined way with even the smallest of details, their team will realize just how serious they are about everyone performing their job correctly.

Summary

No, this isn't profound advice. In fact, many people would say that it's just commonsense. They're probably right.

Maintaining the principles of Clarity, Accountability, and Discipline at the foundation of every dairy's day-to-day operations will make everyone's job easier, help people communicate and work together more effectively, and help everybody reach their potential.

MOTIVATING ON-FARM CHANGE WITH PEER LEARNING

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Introduction

For generations, researchers have thoroughly investigated the on-farm risk factors associated with common cow- and herd-level diseases. This work has resulted in a wealth of knowledge surrounding the pathogenesis, epidemiology and economic impacts associated with a number of important production-limiting pathogens. This in turn has led to great strides in pinpointing the critical control points on the farm that must be addressed to effectively prevent and control disease. However, despite a rich understanding of how to combat on-farm disease, we often observe a wide variety of management practices being implemented across farms, and generally a mixed level of uptake of 'best practices' by farmers. A common assumption to explain this is that producers are simply unaware or uninformed about the science of what is recommended, and that this lack of awareness or understanding results in a lack of adoption of the recommended behavior(s). A traditional response to this has then been to develop and implement a series of educational campaigns to fill this 'gap' in knowledge. However, upon evaluation, many of these initiatives fall short in terms of influencing on-farm change. This challenge often stems from the fact that we tend to fail to understand the most important animal on the farm – the farmer. While knowledge is an important influencer of behavior, it is only one of a series of personal and interpersonal factors that influence a producer's behavior. In this paper, I discuss some of these factors, how theoretical frameworks can be used to package these factors to better understand producer behavior, and how my colleagues and I at the University of Guelph have used this understanding in the context of Johne's Disease (JD) control to design and implement more effective interventions, using peer learning techniques, to influence producer behavior.

Producer Behavior

Social psychologists have long studied the drivers of human behavior. Much of this body of work suggests that a person's behavior, and subsequent decision to adhere with recommendations to change their behavior, is influenced by numerous personal factors (e.g. attitude, perception, knowledge, opinion, beliefs, skills) and interpersonal factors (e.g. veterinarian-producer communication, agricultural extension efforts, industry outreach) (Leeuwis and van den Ban, 2004; Pratt and Bowman, 2008). Therefore, when it comes to designing initiatives to influence producer behavior, it is essential that we first understand the true perceptions, attitudes, and opinions influencing dairy producers hold with respect to a given issue. We can then use this understanding to tailor educational interventions and other extension approaches to effectively influence producer behavior.

I believe it is particularly important to first consider the differences between knowledge and attitudes, the role that each plays in influencing producer behavior towards making an on-farm change.

Knowledge

An individual's knowledge with respect to a given topic or issue, provides the foundation for their behaviors relating to that topic or issue. Therefore, ensuring that producers have sufficient technical knowledge about mastitis and its control is an important component to influencing their behavior towards adoption of recommended on-farm management practices.

Certainly, increasing one's understanding of a given issue will be useful in facilitating changes in behavior. However, assuming that increases in knowledge alone will result in behavior change relies on the assumption that people make behavioral decisions purely based on logic and rational thinking (Petty and Cacioppo, 1986). This notion can quickly be dispelled when reviewing your own personal behaviors related to shopping, for example, where emotional impulse and other factors may drive your own behavioral decisions. Numerous studies have investigated the impact of knowledge of disease and biosecurity measures on adoption of control practices and have concluded that, while knowledge is certainly necessary, it is far from sufficient for behavior change (Kuiper et al., 2005; Jansen, 2010; Kristensen and Jakobsen, 2011; Lam et al., 2011; Garforth, 2011; Garforth et al., 2013).

Similar conclusions were made in a study conducted by my colleagues and I at the University of Guelph (Roche et al., 2015), where we evaluated the level of knowledge two groups of Ontario dairy producers possessed about JD and JD control. One group of dairy producers were intimately involved in an agricultural extension process (called Focus Farms (FF) – *discussed in more detail below*) designed to educate them and influence their on-farm behaviors relating to JD control, while the other group was a control group who were exposed to basic industry extension efforts. A review of the results of a pre- and post-intervention knowledge assessment (i.e. quiz) showed that the knowledge score of FF respondents significantly increased during the study period, while the knowledge score of control respondents did not. However, both FF and control respondents displayed a moderate to good knowledge score prior to any intervention. The results suggest that the majority of respondents possessed sufficient knowledge, as measured by the knowledge assessment, with respect to JD and JD control prior to the intervention. Therefore, content knowledge likely had very little do with the behavioral change observed among FF respondents in our study. Therefore, while an understanding of control measures is important for producers, knowledge alone is likely insufficient to influence behavior.

Attitudes

Research on the factors that influence an individual to change their behavior often highlights the importance of attitudes and perceptions (Leeuwis and van den Ban, 2004; Garforth, 2011). While an individual's behavior is influenced by a unique and complex set of attitudes and perceptions, researchers have created models and frameworks to help explain the key factors, their relationships and interconnections, and their roles in influencing an individual's behavior (Leeuwis and van den Ban, 2004). Leeuwis and van den Ban (2004) provide a particularly useful model that describes the basic variables relevant to understanding a producer's behavior, which are: evaluative frame of reference, perceived environmental effectiveness, perceived self-

efficacy, and social relationships and perceived social pressure. These factors are described in the context of mastitis prevention and control below:

The evaluative frame of reference corresponds to the factors that a producer considers when rationalizing a behavioral change. In particular, producers will consider their perception of the consequences of the management practices they are asked to implement (e.g. labour, time investment, impact, required inputs, etc.). They will also consider their perceptions of the risk of mastitis to their farm and livelihood, and the likelihood that changing their behavior will positively impact the incidence of mastitis. Importantly, these perceptions will be formed based on each producer's personal and professional goals and aspirations, their physical resources (i.e. time, money, infrastructure), their personal values, and what they believe are the social norms with respect to the practice.

A producer's perception of environmental effectiveness refers to whether or not they believe that their existing socio-economic environment can support the behavior(s) they are being asked to undertake. For example, a producer considering on-farm changes for mastitis will evaluate: the availability of support from their veterinarian, employees, and fellow farmers, the availability and reliability of physical and organizational resources (e.g. milking equipment), and market prices (e.g. treatment cost, cow replacement cost). Essentially, the availability of resources, which can facilitate the adoption of these behaviors, is a key consideration for adopting a given behavior.

Perceived self-efficacy refers to a person's confidence in his or her own ability to perform a given behavior. More specifically, producers will consider their ability to obtain and mobilize resources (i.e. money and labour), their own personal skills and competence, and their ability to control or manage the risks that may arise from adopting the behavior.

Lastly, producers will consider their social relationships and perception about the social pressures being put on them to perform a given behavior. More specifically, they will consider what the expectations are of them from other sources (e.g. friends, family, peers, organizations, etc.), and the resources, penalties, and incentives that exist to persuade them to make the change. Individuals are then likely to place a value on these perceptions that will be weighted based on their personal feelings, relationships, and experiences with these sources. Therefore, for mastitis prevention and control, a producer is likely to consider what their employees, family, fellow producers, veterinarians, industry organizations, and extension specialists expect of them with respect to disease prevention and control. The value they place on these perceptions will then ultimately determine how they respond.

It is important to note that there are a host of other factors (e.g. values, morals, ethics, learning styles, emotions, etc.) that will also impact on an individual's decision to change his or her behavior. Influencing producer behavior is thus a complicated endeavour, which requires knowledge of how to effectively inform, educate, and influence, as well as an understanding of how and why producers behave in the way that they do.

Relevant Theories of Behavioral Change

Over the years, social psychologists have developed numerous health behavior theories and frameworks (NIH, 2005), which describe, assess, and predict changes in behavior based on an individual's perceptions, attitudes, and opinions. Central to many of these theories are three key assumptions: (1) behavior is mediated by what people know and think, (2) knowledge is necessary for, but not sufficient to produce, most behavior changes, and (3) perceptions, motivations, skills, and social environment are key influences on behavior. Two prominent theories, the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB), are particularly relevant for application to the adoption of on-farm management practices to prevent and control the spread of disease.

Health Belief Model

The HBM identifies six main constructs that are believed to influence an individual's decision to make a behavioral change (Rosenstock, 1974). The following are the constructs of the HBM in the context of mastitis prevention: (1) perceived susceptibility (e.g. 'Is my herd susceptible to mastitis?'), (2) perceived severity (e.g. 'Does mastitis have serious consequences?'), (3) perceived benefits (e.g. 'Will making management changes to prevent mastitis reduce my susceptibility or its severity?'), (4) perceived barriers (e.g. 'Are the costs of preventing mastitis outweighed by the benefits?'), (5) cues to action (e.g. 'What is being communicated to me about mastitis prevention?'), and (6) self-efficacy (e.g. 'Am I confident that I can make management changes to prevent mastitis?') (Glanz et al., 2008).

Theory of Planned Behavior

The TPB identifies three constructs that influence behavioral intentions (e.g. intent to perform the behavior) and actual behavior (Ajzen, 1991). Each construct can be split up into 'behavioral beliefs', which are comprised of two separate components. The first TPB construct is 'attitudes toward the behavior' (e.g. 'Is mastitis control good, bad or neutral?'), which is shaped by inputs needed to perform the behavior (e.g. time, money, etc.) and the expected outcomes of the behavior. The second construct is 'subjective norms', or the perceived social pressure to perform the behavior (e.g. 'Do people I trust agree or disagree with making changes to control mastitis?'), which is shaped by their perception about the social pressure they receive from individuals they perceive as important, and the strength of motivation to change their behavior resulting from each source of social pressure. The final TPB construct is 'perceived behavioral control', or the perceived ability to perform the behavior (e.g. 'Is making management changes to control mastitis within my control?'), which is shaped by the individual's perception of how difficult the behavior is and their perception of how much is within their control (Ajzen, 1991).

These theoretical frameworks are particularly valuable for understanding the factors that influence behaviour and how these factors interrelate. Importantly, these factors or constructs can be measured using questionnaire-based instruments and used to inform the creation and evaluation of agricultural extension initiatives aimed at influencing dairy producer behavior.

A Theory-based Intervention for Johne's Disease Control

Beginning in 2010, the provincial dairy industry in Ontario, Canada implemented a three-year, voluntary JD control program, called the Ontario Johne's Education and Management Assistance Program (OJEMAP) (OJEMAP, 2009). The program was comprised of an education component, a veterinarian administered on-farm risk assessment (called a Risk Assessment and Management Assistant Plan (RAMP)) and voluntary, whole-herd testing. The education component of OJEMAP focused on the development of an extension model to improve the adoption of on-farm management practices to control JD.

As part of my doctoral research at University of Guelph, I set out to design, implement and evaluate a participatory and self-directed agricultural extension model for on-farm JD education with Ontario dairy producers. The resulting approach, called Ontario Focus Farms (FF), is a learner-centered process that uses peer-to-peer learning and embraces four key principles, which are a product of learning and behavior change theories: (1) participatory, self-directed and collaborative, based on group-identified priorities, (2) honest communication and trust, (3) planning, action and implementation, and (4) reflection. These principles are designed to ensure the process creates an effective learning environment and addresses the social factors influencing producer behaviour (Roche, 2014).

Conceptually, FF is a peer learning process, where dairy producers engage in group-learning activities in a highly participatory and collaborative environment. The process revolves around producers, and through goal setting, prioritization, and discussion, each group self-directs their learning. This approach offers producers the ability to pursue their own learning agenda to acquire knowledge about a specific issue, rather than one that is imposed upon them. Furthermore, it generates pragmatic and contextually meaningful solutions by using producers' pre-existing knowledge and experiences.

Focus Farms embraces the steps of the Kolb Cycle for experiential learning (concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), active experimentation (AE)) (Kolb, 1984). Producers engage in learning activities (e.g. farm walk/tour, risk assessment), CE; review each experience from various perspectives, *RO*; further discuss their observations, *AC*; and finally, explore potential applications on their own farms, *AE*. Overall, producers engage in the active implementation of learned concepts/information, and learn from one another's experiences and observations.

Each group, comprised of 8 to 12 producers, commits to meeting a minimum of 4 times in one year. A professional facilitator facilitates every group and is responsible for creating a comfortable, supportive, and trusting learning environment. Facilitators ensure meetings were self-directed by participants, meaning that that each group controlled the content discussed and learning activities used, through goal setting, prioritization, and discussion. Each meeting is a combination of a half-day of on-farm tours and activities, and a half-day of round-table discussions and indoor activities.

Evaluating Focus Farms

Roche et al. (2015) provides a thorough breakdown of the evaluation of the FF process. The primary goals of this study were to (1) assess the impact of FF on participating dairy producers' knowledge, attitudes, and behavior with regard to JD control, (2) compare changes in these factors among FF participants to changes among a group of non-participating dairy producers.

Pre- and post-FF intervention questionnaires were used to collect data on respondents' knowledge, attitudes, behavior, herd production and demographic information, and pre- and post-JD risk assessments (RAMPs), performed by each respondent's herd veterinarian, were used to assess respondents' on-farm risk of JD transmission.

Overall, 176 dairy producers participated in the FF process; 39.8% (70/176) of FF and 14.6% (52/357) of control participants responded to both the pre- and post-intervention questionnaires. Upon comparison, FF respondents were more likely to be younger, have larger herds, and have higher management scores. Eighty-one percent (57/70) of respondents reported implementing at least one on-farm management change to address JD as a result of FF. Upon comparison, significantly fewer ($p < 0.01$) control respondents made on-farms changes; 38.5% (20/52) reported implementing at least one on-farm management change. The most commonly reported change by both FF (n = 23) and control respondents (n = 11) was the removal of calves from the maternity pen within three hours after birth.

As previously discussed above, comparisons between pre- and post-JD knowledge assessments showed that FF respondents' knowledge significantly increased, while control respondents' knowledge did not significantly change. Most importantly, both groups of producers exhibited a moderate to good level of knowledge prior to any intervention, suggesting that knowledge was likely not a significant driver of behavioral change observed among FF respondents in this study.

A series of questions based on the TPB constructs were used to evaluate the social factors that may have contributed to behavioral changes. Each of the three main constructs of the TPB (attitude towards the behavior (i.e. JD control)), subjective norms, and perceived behavioral control) were quantified using a series of Likert scale questions pertaining to each given construct. These were then tallied and means were generated and plotted on a negative-positive axis, where negative values indicate a negative perception and positive values indicate positive perceptions (Figure 1).

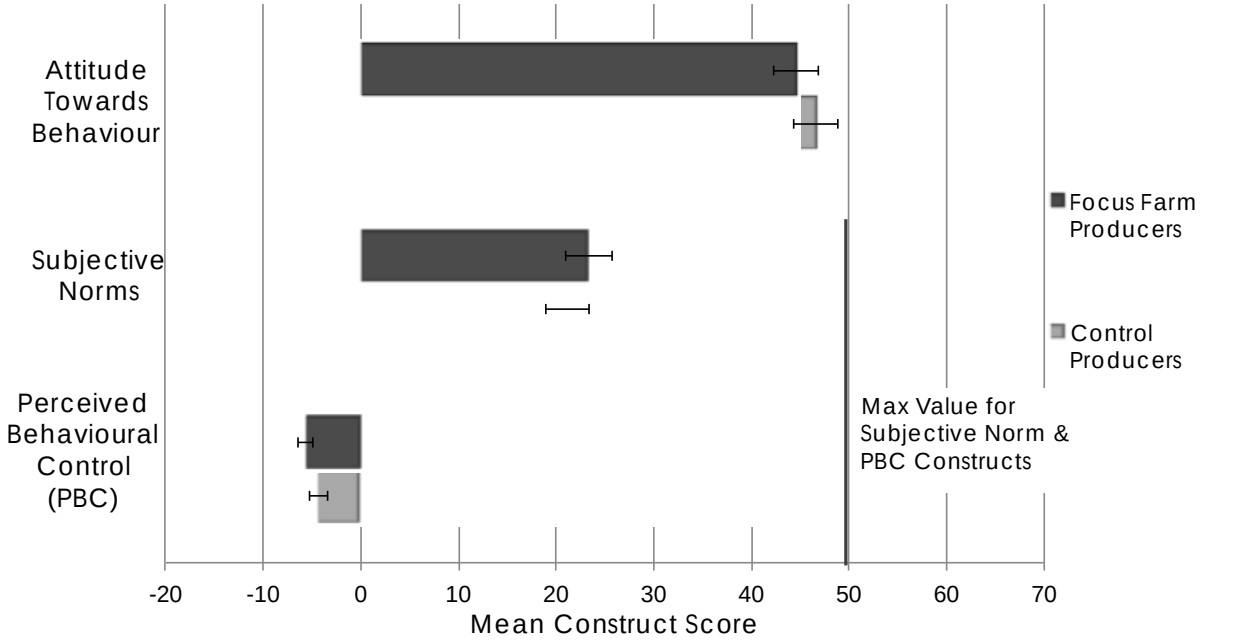

Figure 1. Comparisons between the mean construct score for the three major Theory of Planned Behavior (TPB) constructs (Attitude (-70 to +70 scale), Subjective Norms (-50 to +50 scale), Perceived Behavioral Control (-50 to +50 scale) among 65 Ontario Focus Farm (FF) respondents and 52 Control respondents.

Both FF and control respondents held strong positive attitudes towards JD control and felt a moderate amount of social pressure from veterinarians and industry organizations to make on-farm changes. However, they questioned their ability to effectively control JD on the farm. Drilling down further, our results showed that the poor accuracy of JD tests seemed to negatively impact the producers' perceived ability to control JD. Additionally, the chronic nature of JD and a prolonged sub-clinical phase appeared to impact on this perception as well. This negative perception could stem from the fact that the effects of management changes on JD prevalence will generally not be realized for several years, due to the chronic nature and long incubation period of JD. This delayed impact may result in producers questioning whether the changes have had, or will have, a positive impact. Given these results we concluded that the practicality and efficacy of on-farm management practices for JD control must be consistently communicated to producers to improve their perception that they can get control of JD on their farm. It is thus important that all communication efforts emphasize that JD control requires that producers be vigilant and 'stay the course' in order to effectively combat this chronic disease.

The use of a TPB-instrument here was useful to gain insights into the factors that influence producer's to make changes on-farm for JD control. This tool thus becomes useful to inform future initiatives and over time, evaluate the impact of these initiatives on these factors, which are posited to influence producer behaviour.

Conclusions

Overall, the disciplines of sociology, psychology and social psychology offer invaluable tools, methods and frameworks that enable the creation of effective agricultural extension programs.

Future initiatives will benefit from a multi-disciplinary approach to influencing producer behavior, where not just scientific content is carefully considered and evaluated, but the approaches with which this content is delivered and shared.

The results of the FF evaluation suggest that this producer-centered, peer learning approach was indeed effective. Importantly, we observed significant increases in the adoption of on-farm management practices among FF respondents, as compared to control respondents and positive changes in content knowledge and other key attitudinal factors. Pratt and Bowman (2008) suggest that actual behavioral change occurs when the cognitive, social, psychological, and emotional dimensions of the behavior are addressed. The increases in adoption among FF respondents we observed may be attributed to the fact that FF addressed, and in many cases significantly changed, some of these key factors (i.e. knowledge, perceptions and attitudes). Pratt and Bowman (2008) also suggest that if behavior change is the goal, then extension programs must include personally relevant, problem-focused, experiential, active learning practices focused on skill building. Given this recommendation, and the demonstrated improvement in the adoption evidenced in our studies, the participatory, collaborative learning methods, which FF employs, appear to be effective in facilitating on-farm changes for producers.

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IT HAPPENS THROUGH PEOPLE…WHY RELATIONSHIPS MATTER

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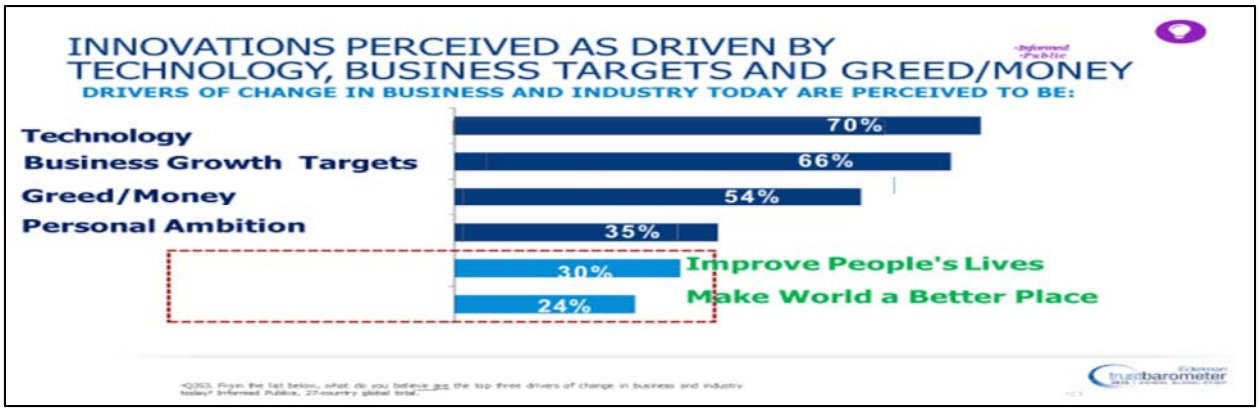
Sales, teaching, leadership, innovation, service, motivation and conflict resolution all happen through people. Even as technology increases the amount of information available and the pace at which we innovate accelerates, people remain at the heart of success and failure.

The Evaporation of Trust

The 2015 Edelman Trust Barometer conducted by Edelman Public Relations documented developments that are instructive for each of us, at all levels of the dairy industry.

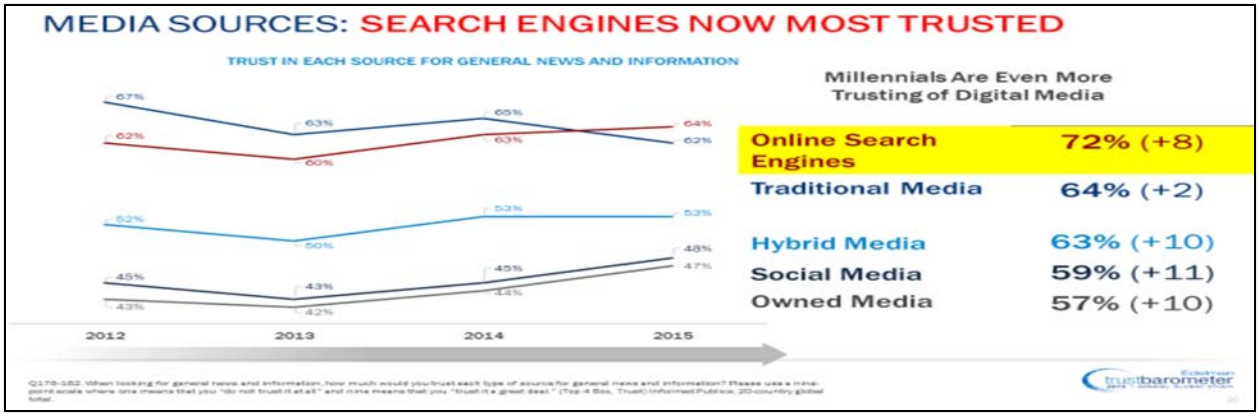
1. 2015 saw the evaporation of trust in Business, NGO's and Media
2. Over ½ the respondents felt the pace of Innovation was too fast
3. Over ½ felt innovation was driven by the wrong priorities

The majority of respondents felt business innovation was driven by technology, business growth targets, greed and money and personal ambition. Consumers asserted it was important for them to know how business innovations would improve their lives or make the world a better place. When innovation moved too rapidly and did not address consumer's societal and emotional needs, 51% of respondents looked to Government to provide protection and regulate business.



Most Trusted Sources for News and General Information

The 2015 Trust Barometer also documented that Search Engines are now the most trusted source of news and information. Among Millennials that trust is even higher. In other words, "the University of Google" is where society now gets its news. What does that mean as we work to inform, motivate and empower change among our owners, managers, peers, employees and consumers?



People Don't Buy What We Do – They Buy WHY We Do It

Author and speaker Simon Sinek looked across many leading organizations and discovered what separated the great organizations from all the others. He calls it the "Golden Circle" which he described in his book and TED Talk, or *Starting with Why*. He makes the point that all business know what they do, many know how but few can articulate the why or the purpose. Profitability is not a purpose – it is a result.

How Does Sineks' Principle Apply to Dairy?

What is your businesses' purpose and reason for being? How does what you do enrich people's lives or make the World a better place? That's the why today's consumer wants to emotionally connect with and that most businesses are missing. Help your owners, employees, peers and consumers discover, understand and communicate the why and you will be better able to inspire cooperation, trust and change. Simon Sinek: How great leaders inspire action | TED Talk ...
▸ 18:04 https://www.ted.com/.../

Tough Questions

√ Is trust in dairy, food or agriculture increasing or decreasing?
√ Whose job is it to communicate to consumers about what we do?
√ Who do consumers want to hear from?
√ How often do *you* communicate with consumers?
√ How large is your consumer audience and voice? What are you doing to grow it?
√ What's at risk if you don't? Who or what are you waiting for?

Societal and Technological Change Help Drive Dairy/Consumer Disconnects

We like to talk about how consumers are disconnected from dairy but I've discovered we are also disconnected from consumers? This is exacerbated when you understand we live during a period of some of the most profound demographic changes since the 1890's.

√ 55+ Population will increase 45% by 2020
√ 48% of Food Expenditures Away from Home
√ 53% are less than 30 years old
√ Asian Population +43% since 2000
√ 50% Growth 2000 - 2010 Hispanic
√ Couples with Children Declining

Pace of Technological Change 2003 - 2013

√ Growth of the Web:
2003 - 43.7 million websites
2013 - 785.3 million websites

√ Mobile Users:
2003 - 650 million cell phones
2013 - 1.8 billion cell/smartphone

√ High-speed Internet:
2003 - 63 million global broadband users
2013 - 696 million global broadband users
2003 - 8.8 million mobile broadband users
2013 - 2.1 billion mobile broadband users

Pace of Technology Adoption is Speeding Up
√ It took 30 years for electricity and 25 years for telephones to reach 10% adoption.
√ It took less than five years for tablet devices to achieve the 10% rate.

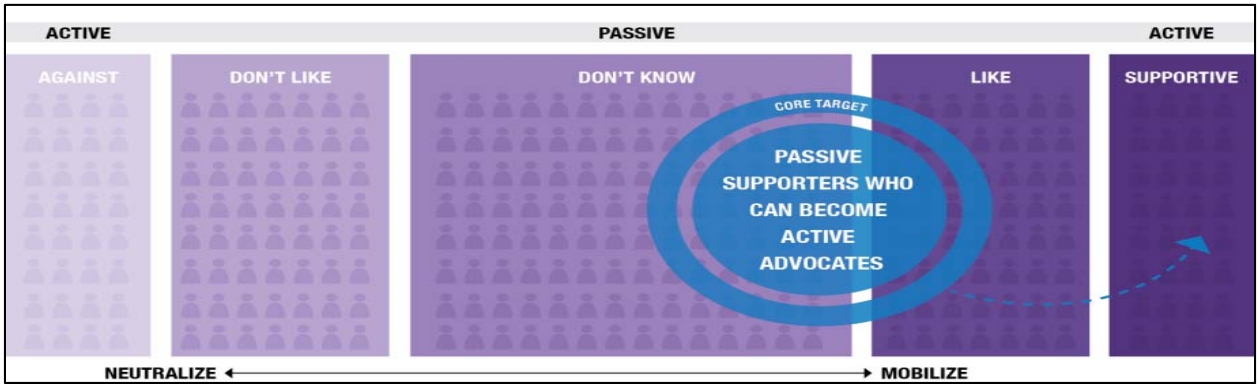
Rapid Change, Information Access, and Social Media Use has Increased Consumer Skepticism

According to Edelman's *Field to Fork* consumer study:

- Only 47% agree with the statement that farming is performed in a responsible way
- Only 40% agree that US farmers take good care of the environment
- Only one-third agree livestock are treated in a humane manner.

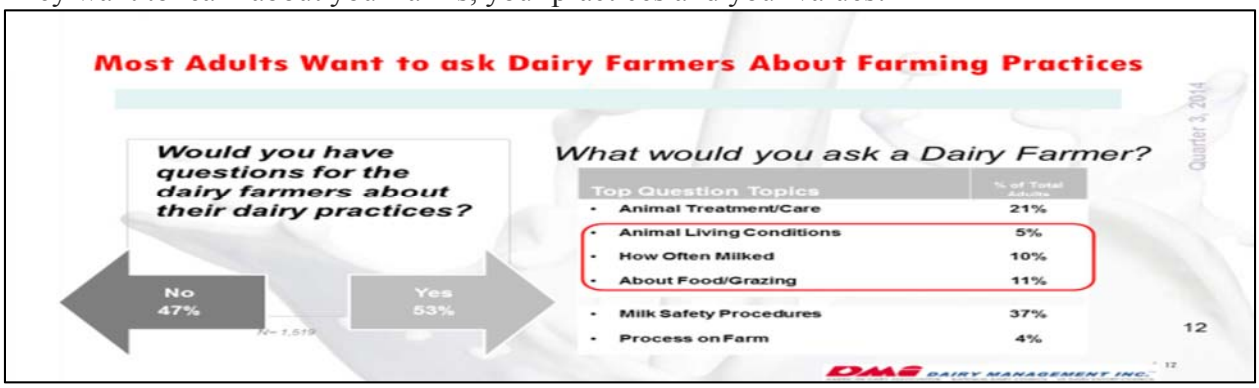
It's important to note a significant group of consumers simply don't know or haven't formed an opinion on these statements as a result of lack of interest, time or information. This group is called the "Moveable Middle" and is the target audience we must engage

Moveable Middle



Consumers Want To Hear From and Ask Farmers Questions.

They want to learn about your farms, your practices and your values!



Consumers Also Want to Hear from Credentialed Experts - Like NMC's Membership!

This is a Huge Opportunity if We Capitalize

In order to be successful we must reprogram our messages and approach. We have to examine where and how we engage consumers including millennials. Why Millennials?

Millennials Purchasing Power is Growing

2014 - $150 Billion	2020 - $290 Billion	
96% Buy Milk	32 Gallons per Household	= 27% of Retail Milk Volume
98% Buy Cheese	34 Pounds per Household	= 28% of Retail Cheese Volume
90% Buy Yogurt	31 Pints per Household	= 28% of Retail Yogurt Volume

How to Use Conversations, Relationships, and Social Media to Reconnect Consumers with Dairy

We've all experienced the positive conversations and discoveries that occur when consumers or a group of thought leaders visit a dairy. We've also experienced and benefitted from the relationships that are formed and trust that is built. This is the ultimate act of transparency. But how do we get 319 Million Americans to visit 45,344 U.S. dairy farms? Before we answer that

question let's explore some key definitions and approaches we must embrace to become successful dairy advocates.

Conversations + Transparency = Relationships and Trust

Relationships = Information, service or support proven reliable over time.

Trust is rejuvenated through relationships

How Do We Build Relationships?

Begin with mutually respectful conversations where common interests and common ground are discovered and you gain permission to stay in touch. You must establish a foundation of mutual care and interest. President Theodore Roosevelt put it this way, "people don't care how much you know…until they know how much you care".

Conversation Defined

I've observed and participated in many conversations about dairy with consumers. The best ones begin with questions - signaling genuine interest that leads to personal and professional discovery. Common ground is identified through questions which demonstrates transparency and a sincere desire to understand. *"Seek first to understand…then to be understood".* – Stephen Covey. Remember, many consumers have seen or read something leading them to believe we have something to hide. Asking questions and making yourself vulnerable to theirs demonstrates otherwise.

What Does Trust And Transparency Mean?

Trust: is a choice to be available, vulnerable and transparent in a relationship, because the person you're trusting has proven worthy of your partnership through consistency in their honesty, information, integrity and dependability."

Transparency: Is a choice to operate in such a way that it is easy for others to see what actions are performed. It has been defined simply as "the perceived quality of intentionally shared information or action."

My Goal Today is to Inform, Motivate, and Equip You as a Dairy Advocate

Following is a list of steps you can take to help you engage friends, family, neighbors, employees and consumers in dairy in conversations about dairy farming, farmers and products. This meetings theme is about motivation and creating behavioral change. Consistent with Meeting Theme I'm going to ask each of you to commit to taking 3 of the following steps in 2016:

1. Become Consumer Focused – Your focus must shift to them! We like to talk about us/me
2. Develop Values Based Messages – to Connect with Consumer's Values and Emotions
    a. See Worksheet in the Addendum

    b. Practice Owning the Messages You Develop – They must be heartfelt not recited
3. Develop Your Core Story – Start with Why.
    a. See Worksheets in the Addendum
4. Build Consumer Relationships by Having More Dairy Conversations
    a. Begin with family, friends & neighbors
5. Quit Talking AT People - Your Mission is to Create Trust not Win Arguments
6. Devote 1 Hour Each week to Dairy Advocacy.
7. Become Engaged in Social Media
    a. If you don't have a Facebook page start one. It's not difficult.
8. Contact me or your State & Regional Dairy Promotion Organization for tools and training
    a. See List in the Addendum
9. Register in the Dairy Hub Amplification Center
    a. Let me know you want to register by e-mailing me at Stan.Erwine@dairy.org
    b. I will see you are sent an invitation to join.

Resources Available to Support You

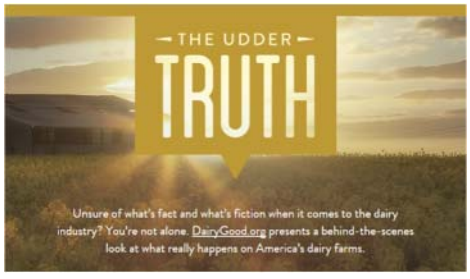
Where Good Comes From – The Dairy Checkoff has created a Consumer Confidence initiative, system and tools everyone in the dairy industry from farmers to veterinarians to processors, agribusiness, students and university leaders can use to tell dairy's story via tours, presentations and particularly via your personal and organization Social Media channels.

Common Voice Network: More than 120 companies' communicators have joined the Common Voice Network to help dairy speak with a common voice using common messages.

The DairyGood Newsroom: Monitors and responds when appropriate to all dairy related news and or misinformation across all communications channels 24/7/365.

DairyGood: Dairy's consumer facing digital platform that operates as a Facebook, Blog and virtual magazine to tell the story of America's dairy farm families and put a face on what we do, how we do it and most importantly WHY we do it and the values we share with consumers.

The Dairy Hub Amplification Center: A secure online resource where you may access professionally developed and infographics, Facebook, Linked In and Instagram posts.
Each is linked to credible research and third party content you can use to support your efforts to proactively engage consumers in dairy conversations.



The Udder Truth: a three-part video series launched in July aimed at busting some of the most common myths about dairy, including cow care, antibiotics, and large farms. Videos featured real farmers telling the truth about what happens on farms, and viewership was driven by an unusual partnership with humor news website *The Onion.*

Acres & Avenues: The momentum created by The Udder Truth has continued through another video webisode series, Acres & Avenues which launched in October 2015 shows that farmers and urban Millennial have things in common. We paired them to spend time in each other's lives – revealing shared values, including sustainability and nutrition. Videos are hosted by online video star and travel and food blogger Jax Austin, and can be found on DairyGood.org and popular millennial sites and social channels via AOL. Another season of Acres & Avenues is on the way. Stay tuned!

Barriers You Must Overcome

I Don't Have Time to Do This - I Don't Have a Facebook - I Don't Want to Become a Target
OK. Maybe you don't, but someone on your team or in your company would be perfect for this. Treat it like improving Milk Quality. Put someone in charge, set goals, implement and evaluate.

Think Bigger Picture

Question - What's at stake if we don't do this?
Answer - Our freedom to operate in the marketplace with minimal restrictions.
If you and our industry fail to engage in some form you are yielding the floor and messages to those whose agenda is to put us out of business.

Tips on Telling an Effective Core Story for Dairy

Sharing Your Core Story:

1) Stay Authentic – Tell your story based on your own experience and expertise, not some canned set of responses, or key messages.
2) Be Values-Based – Say WHY you are passionate about dairy, and what you stand for (e.g., your commitment to delivering a safe, wholesome and nutritious product to people).
3) Be relevant to your audience – While your core story may be solid as stone, use examples that will appeal to the people you are communicating with (example: When communicating animal care, talk about baby calves to young children, cow feeding rations to older children, etc.).
4) Show confidence in your story – Stay positive by sharing stories that come from the heart, and that mean the most to you.

Answering Difficult Questions:

5) Listen first, before forming your response.
6) Ask clarifying questions, to learn what the questioner really wants to know.
7) Make it a conversation, rather than just trying to communicate YOUR ideas.
8) Share your thoughts, instead of trying to educate.

9) "Swim in Your Own Lane"– don't try to give detailed answers on topics you know little about; refer detailed questions to a knowledgeable colleague.
10) Bridge back to your Core Story --to leave a positive final impression.

Tips on Delivering an Effective Core Story for Dairy

1. Identify a target audience as specifically as you can. (e.g., a mom's group; school children; local community leaders, etc.) and establish common ground. .
2. Include a beginning (the challenge), middle (the solution) and an end (result, or benefit to the audience).
3. Make the story personal to yourself, and lead with an emotional connection.
4. Include an opening statement that is succinct, attention-grabbing and memorable.
5. Add elements of dairy's overall core story, as appropriate.
6. When discussing dairy's role in providing the solution to the challenge, establish how your experience and expertise can help your audience.
7. Describe how dairy can benefit their situation. .
8. Add a values statement or personal story.
9. Prove your point with an analogy or a vision of the future.

Sample Outlines of Core Stories for Dairy (add your own Personal Story)
Challenge: People are looking for healthy foods and beverages that fit with how they live today, but are confused about what's good for them.
Solution: Not only are dairy products good-tasting, but dairy's unique nutrition package can also help people get the nutrition they need.

Result/Benefit: Including dairy products in the diet can help people meet their health needs and lead happy, productive lives.

OR

Challenge: Our society must find ways to feed growing populations and address hunger in a sustainable and socially responsible way.

Solution: Dairy farmers provide sufficient, safe, affordable and nutritious food for our nation, and the world. They are dedicated to helping feed a growing population in a safe and sustainable way, using fewer resources.

Result/Benefit: Our nation and world can be fed in the future without an undue burden on our land, air and water resources.

How to Introduce Yourself and Your Dairy Business

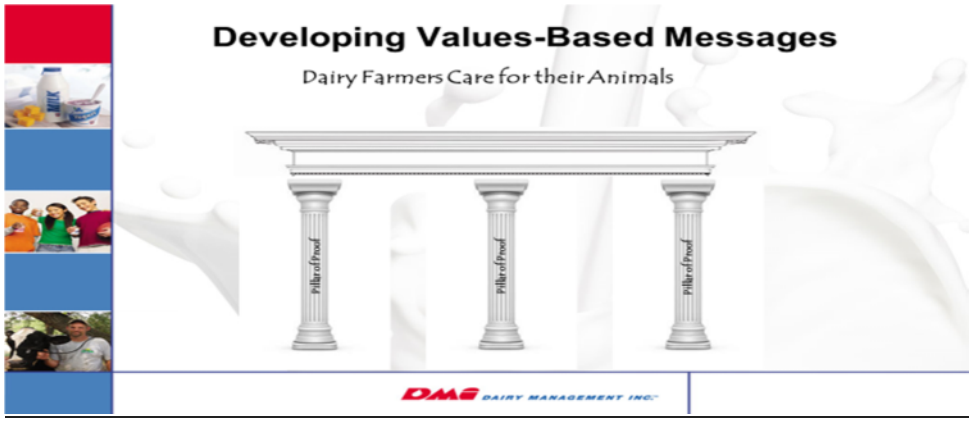
Demonstrate knowledge and confidence by creating a simple, strong introduction that clearly shares elements of the story of your business.

Scenario: an individual interested in doing a blog post on your business. Introduce yourself.

1. Begin with your name and role
2. Describe two ways your business benefits the community, the environment or human health and well-being.
3. Mention your commitment to doing the right thing. This may be a values statement.
    a. "One thing I've learned…"
    b. Or add a belief statement. "I believe my land…"

Write your own introduction.

How to Create Your Own Values=ased Messages

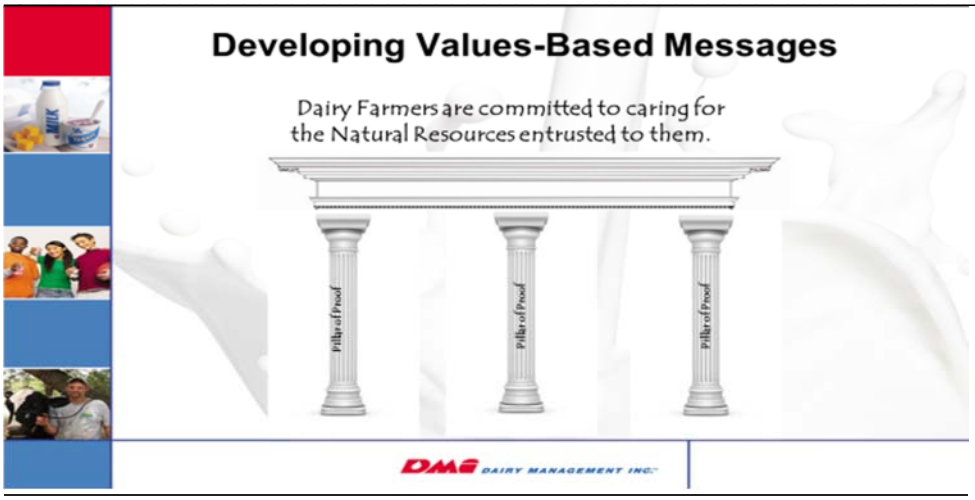


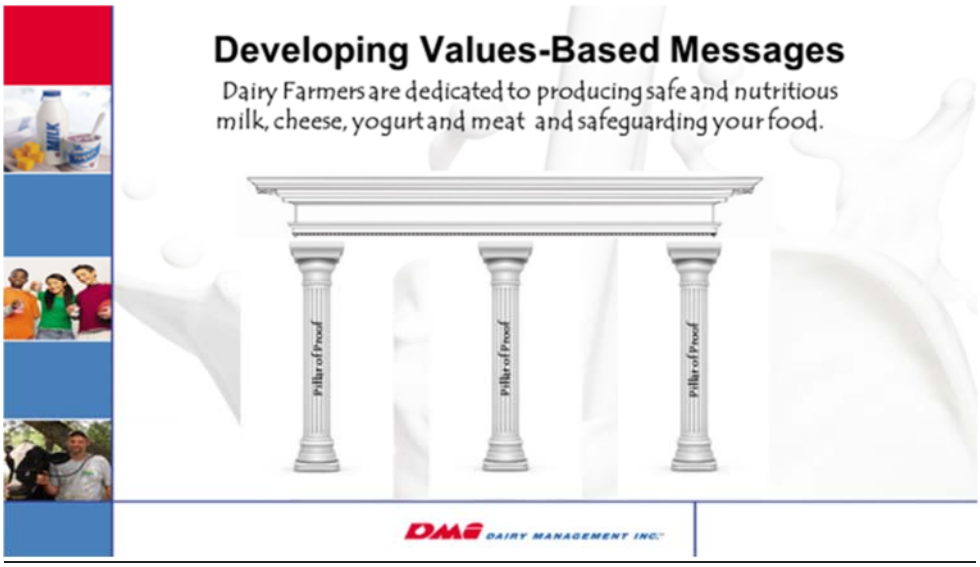
What are the key words or phrases you want to make sure you communicate?

What is your key message?

Your supporting statements (pillars of proof) are:

How will you end your message?





State and Regional Dairy Promotion Organizations

ADA Mideast
5950 Sharon Woods Blvd.
Columbus, OH
Phone: 614-890-1800

American Dairy Association, Indiana, Inc.
9360 Castlegate Dr. Main Indianapolis, IN
Phone: 317-842-3060

American Dairy Association and Dairy Council
Syracuse, NY
Phone: 315-472-9143

Arizona Milk Producers
510 N. 52nd Street Main
Tempe, AZ
Phone: 480-656-7163

California Milk Advisory Board
Modesto, CA
Phone: 650-871-6455

Dairy MAX, Inc.
2214 Paddock Way Dr.
Grand Prairie, TX
Phone: 972-603-4700

Florida Dairy Farmers
66 Lookout Place
Maitland, FL
Phone: 407-647-8899

Maine Dairy Promotion Board
333 Cony Road Main
Augusta, ME
Phone: 207-287-3621

Midwest Dairy Association
2015 Rice Street Main
St. Paul, MN
Phone: 651-488-0261

Mid-Atlantic Dairy Association
Philadelphia, PA

Phone: 215-627-8800

Mountain West Dairy Promotion
1213 East 2100 South
Salt Lake City, UT
Phone: 801-487-9976

New England Dairy Promotion Board
Phone: 617-734-6750

Oregon Dairy Products Commission
10505 SW Barbour Blvd.
Portland, OR
Phone: 503-229-5033

Southeast United Dairy Industry Association, Inc.
5340 W. Fayetteville Rd
Atlanta, GA
Phone: 770-996-6085

United Dairy Industry of Michigan
2163 Jolly Road Main
Okemos, MI
Phone: 517-349-8923

United Dairymen of Idaho
743 North Touchmark Avenue
Meridian, ID
Phone: 208-327-7050

Washington State Dairy Products Commission
4201 198th Street, SW
Lynnwood, WA
Phone: 425-672-0687

Western Dairy Association
12000 North Washington
Thornton, CO
Phone: 303-451-7711

Wisconsin Milk Marketing Board Inc.
8418 Excelsior Drive
Madison, WI
Phone: 608-836-8820

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FACTORS INFLUENCING NEW INTRAMAMMARY INFECTION RATE IN TEAT DIP EFFICACY TRIALS BY META-ANALYSIS

Benjamin D. Enger[1], Robin R. White[1], Stephen C. Nickerson[2], and Lawrence K. Fox[3]
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[2]University of Georgia, Athens, Georgia, USA
[3]Washington State University, Pullman, Washington, USA

Introduction

Teat disinfection before and after milking is an effective tool used to reduce incidence of new intramammary infections (IMI), especially those caused by contagious pathogens. Teat dip efficacy is influenced by many factors, and any new product should be evaluated for effectiveness prior to commercial distribution. To date, many trials have tested teat dip efficacy. The objective of this study was to identify factors associated with teat dip trials, including the active ingredient, that have a significant influence on the new IMI rate. A meta-analysis of teat dip efficacy trial data collected from peer-reviewed journals was used to identify these factors.

Materials and Methods

The National Mastitis Council (NMC) Research Committee's report of teat dip studies published in peer-reviewed journals (NMC, 2015) was used to identify natural exposure studies for meta-analysis. The 24 studies cited were screened and used to construct a dataset of comparable studies for analysis. Sixteen trials were included in the final dataset resulting in 256 observations available for analysis. The new IMI rate was defined as the percentage of new quarter infections (PNQI) per month, which was calculated using the equation $PNQI/mo = (N_i / E_j) / (D_k / mo)$ where N_i = number of new quarter infections during the trial; E_j = number of quarters eligible for infection at start of trial; D_k = trial duration expressed in d; and mo = 28 d. Mixed-effect linear regression was used for model derivation where the new IMI rate was the response variable, data were weighted by quarters eligible for infection, and study was a random effect. All explanatory variables of the dataset were included in the model and removed sequentially due to nonsignificance ($P > 0.1$). Once significant main effects were identified, interactions were tested and previously removed variables were reintroduced to confirm that variables were removed due to nonsignificance rather than model instability. The least square means generated by the final model were contrasted using Tukey Kramer's multiple comparison procedure.

Results and Discussion

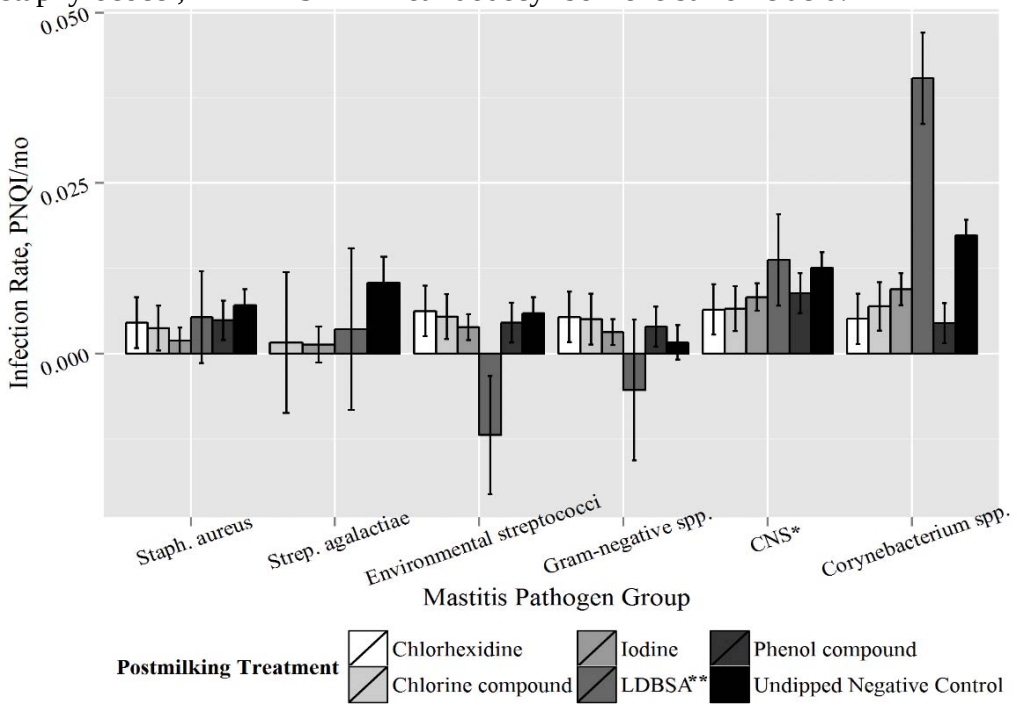
The final model contained the fixed, independent effects of study design (spilt udder or split herd; n = 2), mastitis pathogen group (n = 6), postmilking treatment (n = 6), and the interaction between mastitis pathogen group and postmilking treatment.

The least square means of postmilking treatments within mastitis pathogen groups are illustrated in Figure 1. Overall, *Corynebacterium* spp. had the highest new IMI rate (0.0139 ± 0.0018 PNQI), which differed ($P < 0.05$) from *Staphylococcus aureus* (0.0046 ± 0.0017 PNQI),

environmental streptococci, (0.0023 ± 0.0020 PNQI), and Gram-negative spp. (0.0023 ± 0.0022 PNQI). Coagulase-negative staphylococci had the second highest IMI rate (0.0094 ± 0.0017 PNQI), which differed ($P < 0.05$) from environmental streptococci and Gram-negative spp. *Streptococcus agalactiae* had the third highest IMI rate (0.0054 ± 0.0043 PNQI), which was similar to all other pathogen groups ($P > 0.05$).

Factors such as concentration of a dip's active ingredient, presence of a skin conditioning agent in a postmilking teat dip, and use of a premilking teat dip did not influence new IMI rate ($P > 0.05$). Some dips appeared more efficacious against certain pathogens than others (Figure 1). Studies using a split herd design to test teat dips had a higher IMI rate (0.0089 ± 0.0017 PNQI) than herds using a split udder design (0.0046 ± 0.0017 PNQI; $P = 0.0343$).

Figure 1. New quarter infection rate per month (PNQI/mo) for each postmilking treatment within mastitis pathogen group. Error bars represent the standard error of the mean. *****CNS = coagulase-negative staphylococci; ****** LDBSA = linear dodecyl benzene sulfonic acid.



Conclusions

The new IMI rate of mastitis pathogens differed and was influenced by different postmilking teat dips. Additionally, split herd studies had a greater rate of new IMI relative to split udder designs, suggesting that future teat dip efficacy trials utilize a split udder design to reduce the impact on overall herd udder health.

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National Mastitis Council. 2015. Summary of peer-reviewed publications on efficacy of premilking and postmilking teat disinfections published since 1980. Accessed April 20, 2015. http://www.nmconline.org/docs/teatbibl.pdf.

EVALUATION OF THE COMPOSITE MILK SOMATIC CELL COUNT AT DRY-OFF AND LAST MILK RECORDING BEFORE DRY-OFF AS AN INDICATOR FOR INTRAMAMMARY INFECTIONS AT DRY-OFF

Z. Lipkens, S. Piepers, and S. De Vliegher
M-team and Ghent University
Merelbeke, Belgium

Introduction

Nowadays, the (over)use of antimicrobials along with its contribution to antimicrobial resistance in both humans and animals is a worldwide reason for concern. The majority of antimicrobials used in dairy herds are related to udder health, of which approximately two-thirds as dry cow products. Because of the preventive character of dry cow antimicrobials and the large potential reduction in antimicrobial use, selective dry cow therapy instead of blanket dry cow therapy has been suggested. A first prerequisite for successfully applying selective dry cow therapy is the availability of a relatively cheap, rapid and easy method, to precisely distinguish infected (in particular those with a major pathogen) from non-infected cows at dry-off. Bacteriological culture is still considered as the gold standard for the detection of intramammary infections (IMI), yet is both from a practical and economical point of view less applicable in daily practice. Milk somatic cell count (SCC) is often used as a proxy for IMI (Dufour et al., 2011) and composite milk SCC (cSCC) records are available on a regular basis for both producers and their advisors from Dairy Herd Improvement (DHI) programs.

The objectives of this study were (a) to estimate the IMI status based on bacteriological culture results obtained at dry-off, and (b) to determine the sensitivity (Se), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) for several cSCC-thresholds both at dry-off and at the last milk recording before dry-off for IMI at dry-off.

Material and Methods

In this preliminary study, a total of 412 cows originating from15 herds with a low bulk milk SCC (< 250,000 cells/mL) were enrolled. From all cows, composite milk samples were collected at maximum four days before dry-off for bacteriological culturing and determination of the cSCC at dry-off. Based on the culture results, cows were considered to be non-infected or to be infected with a major mastitis pathogen. Additionally, another composite milk sample was available via the local DHI association for the determination of the cSCC at the last milk recording before dry-off (max. 6 weeks before dry-off). Comparing the cSCC determined at dry-off or at the last milk recording with the IMI status at dry-off (i.e. non-infected versus infected with major pathogens) allowed us to determine the Se, Sp, NPV, and PPV for different cSCC thresholds.

Results

Based on the bacteriological culture results at dry-off, almost 50% of the cows was considered to be non-infected whereas 31% and 11% were considered to be infected with a minor and a major pathogen, respectively. The Se, Sp, PPV and NPV for the different cSCC-thresholds both at dry-

off and the last milk recording before dry-off to differentiate between non-infected and major pathogen infected cows at dry-off are represented in Figure 1.

The lowest risk for the farmers (i.e. the highest NPV) was obtained at a threshold of 150,000 cells/ml. Using the latter threshold for the cSCC at dry-off and the last milk recording before dry-off, only 6.3% and 7.8 % of the cows infected with a major pathogen would have not received long-acting antimicrobials at dry-off. At that threshold, however, still 74% of the non-infected animals would be dried-off with long-acting antimicrobials The highest reduction in antimicrobials (i.e. the highest PPV) would be obtained at a threshold of 250,000 cells/ml, though using this threshold would increase the risk for the farmer to 8.6% and 10.6% when using the cSCC at dry-off and at the last milk recording, respectively.

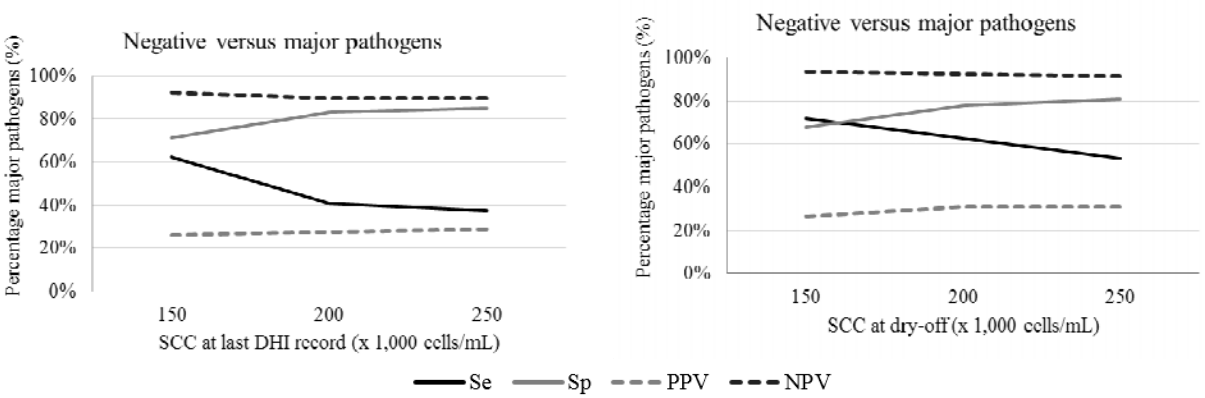

Figure 1. The sensitivity, specificity, positive predictive value, and negative predictive value for the different cSCC-thresholds both at dry-off and the last milk recording before dry-off to differentiate between non-infected and major pathogen infected cows at dry-off.

Discussion and Conclusions

Based on these preliminary results, the difference in NPV and PPV between cSCC determined at the last milk recording before dry-off and at dry-off, respectively, seems to be very limited, indicating that the cSCC determined at the last milk recording might be a good yet not perfect indicator for the IMI-status at dry-off on low bulk milk SCC farms. Still, further research is needed to determine the cSCC-threshold that provides the best compromise between reducing the use of antimicrobials and minimizing the risk of untreated major pathogen IMI at dry-off. Also, the effect of other variables such as parity and herd SCC that might influence the risk of IMI at dry-off will on the test-characteristics of the cSCC values should be investigated. Furthermore, the added value of other parameters including differential cell count in predicting the IMI-status at dry-off should be investigated.

References

Dufour, S., A. Frechette, H.W. Barkema, A. Mussell, and D.T. Soholl. 2011. Invited review: Effect of udder health management practices on herd somatic cell count. J. Dairy Sci. 94:563-579.

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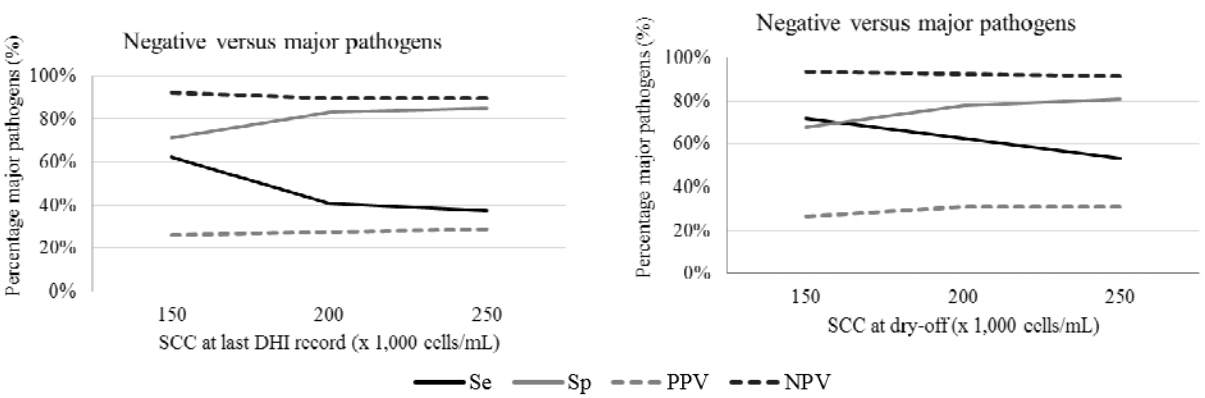

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CLINICAL MASTITIS RECURRENCE IN DAIRY COWS

Hossein Jamali, Herman Barkema, Mario Jacques, François Malouin, Vineet Saini, Henrik Stryhn, and Simon Dufour
Canadian Bovine Mastitis and Milk Quality Research Network
St. Hyacinthe, Quebec, Canada

Clinical mastitis (CM) is one of the most frequent and costly diseases in cows, worldwide. A high proportion of cows that experience a CM event in a lactation will experience repeated CM events during the same lactation. The aim of the current study was: 1) to determine, in a large population of farms, time to CM recurrence following a preceding CM event; and 2) to identify effect of parity, days in milk (DIM) at occurrence of preceding CM event, and clinical severity of preceding CM event on hazard of CM recurrence in the same lactation.

Materials and Methods

Data were extracted from the database of the National Cohort of Dairy Farms, a cohort of 91 Canadian dairies followed between January 2007 and December 2008 (Reyher et al., 2011). For the current study, the 75 herds with validated CM data were used. Data related to all CM events, such as time of occurrence, severity, and pathogens involved were recorded. Clinical severity was reported as 1 (abnormal milk only), 2 (abnormal milk plus swollen quarter), or 3 (abnormal milk, swollen quarter, and sick cow). A CM event occurring less than 14 days after a previous CM event was not considered a new CM case. Only lactations starting after January 2007 and followed until drying-off or culling were included (i.e. complete lactations). In this database, data for 2,186 lactations with ≥ 1 CM case from 1,538 cows was available. Hazard of CM recurrence following preceding CM case was modeled using an Anderson-Gill proportional hazard survival model for recurrent events. For these preliminary analyses, clustering of event by herd was considered using a frailty term, but clustering by quarter and cow were ignored.

Results and Discussion

Median DIM at 1st CM event was 39 d (range: 4-251). Median DIM at 2nd and 3rd CM event was 161 and 179 d, respectively. A total of 23% 1st, 30% 2nd, and 47% ≥3rd parity cows had at least one CM event. Hazard of experiencing CM recurrence varied by parity, with 2nd and ≥3rd parities having respectively a 2.3 (95% CI: 1.4, 3.7) and 2.0 (95% CI: 1.3, 3.2) higher hazard of CM recurrence compared to 1st parity cows. Relationship between parity and probability of CM recurrence following the 1st CM event is illustrated in figure 1. Our findings are in agreement with other studies, whereby parity was significantly associated with hazard of CM recurrence (e.g. Monti and De Jong, 2005). Parity is known as a risk factor for CM event possibly because the intramammary defense mechanisms and anatomy of cows may deteriorate with age (Zadoks et al., 2011). The severity score was recorded for 1,931 CM cases. A total of 45, 36, and 19% of the cows had score 1, 2 and 3, respectively. Severity was not associated with hazard of CM recurrence. Swinkels et al. (2013) also reported that CM recurrence was not associated with the severity of initial CM case. Whenever the preceding CM event occurred ≥14 DIM, the hazard of experiencing a CM recurrence was 2.2 times (95% CI: 1.5, 3.4) higher, but this hazard was not

associated with number of preceding cases in the current lactation. Occurrence of CM in early lactation was attributed to depressed immune system. It is also more often related to infections acquired during the dry period, which may behave differently than lactation-acquired infections.

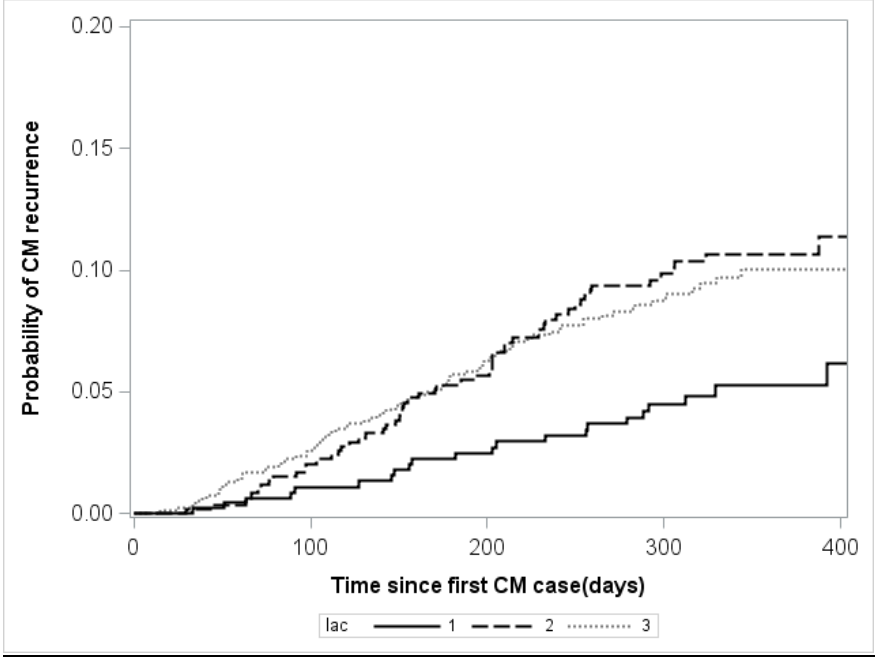

Figure 1. Kaplan-Meier probability of CM recurrence by parity following a 1st CM event.

This study sheds new light on variables associated with CM recurrence, especially the impact of time of occurrence of previous CM case relative to beginning of lactation. Next steps for this research will be to evaluate effect of pathogen involved on preceding CM case and of its phenotypic and genotypic characteristics on risk of recurrence, and to investigate whether these vary according to time of occurrence of previous CM case.

References

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BEDDING SUBSTRATES UTILIZED ON CANADIAN DAIRY FARMS: BACTERIAL CONCENTRATIONS AND THEIR ASSOCIATION WITH COW HYGIENE AND MILK QUALITY

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Regardless of housing type, the lying area of dairy cows should be clean and comfortable. The two primary factors affecting this are the bedding surface and the configuration (dimensions) of the stall components. Cows clearly prefer softer lying surfaces with more bedding; they spend more time lying down in well-bedded, dry stalls (Tucker and Weary, 2004; Fregonesi et al., 2007). However, the lying surface can also affect udder health. Use of organic bedding material can support greater bacterial growth; thus, use of organic bedding materials may increase teat end exposure to environmental mastitis pathogens (Husfeldt et al., 2012). Alternatively, many researchers have shown the advantages to cows of using inorganic bedding (i.e. sand) as a way of reducing the growth of bacteria associated with environmental mastitis.

Given the limited ability of producers to handle and use sand, and high costs of common organic bedding (straw, wood sawdust, or shavings) (Husfeldt et al., 2012), there is interest in evaluating various bedding types. Alternative bedding that has received interest include recycled manure solids (RMS), obtained from anaerobic digesting, raw manure separation, and compost (Husfeldt et al., 2012). Evidence suggests that these bedding types are linked with higher bacterial growth (Husfeldt et al., 2012). Thus, the objective of this study was to determine which bedding options currently being used on dairy farms in Ontario, Canada support the least bacterial growth, and the association of the use of such bedding with cow hygiene and milk quality.

Methods

Seventy-one farms in Ontario, Canada were visited 3 times, 7-d apart, during October-December 2014; January-February 2015. Cows were housed in free-stalls (n=45) or tie-stalls (n=26). At each visit, composite samples of used bedding material were collected for dry matter (DM) determination and bacterial culturing of pathogens (*Streptococcus* spp., all Gram-negatives, *Klebsiella* spp.). Bedding substrates were classified by farm: Sand (n=12), straw and other dry forage (n=33), wood products (shavings, sawdust; n=17), and RMS (compost, digestate; n=9). We assessed the relationship between bedding substrate and cow hygiene score by randomly sampling 25% of the cows in each lactating pen (free stalls) or row of stalls (tie-stalls) in herds with >160 cows, or a minimum of 40 cows per herds with <160 cows. Cows were scored for cleanliness on each of three visits, on a scale of 1 (clean) to 4 (dirty), in each of 3 zones (lower leg, udder, and upper leg and flank). Proportion of cows with poor hygiene (scores 3 and 4) was calculated per farm. Stall dimensions (including stall width, length, and neck rail position) were

recorded. Environmental conditions (temperature and humidity) for a week prior up to each farm visit were obtained. DHI reports from the test closest to the first visit and another test closest to the last visit were obtained. Associations between bedding types and management, stall design, bedding DM %, bacterial concentrations, cow hygiene, and measures of udder health were investigated using multivariable regression models.

Results

Sand was driest (95.2 ± 1.8%), then straw (77.9 ±1.1%) and wood (75.4 ± 1.5 %), while RMS (46.9 ±2.0%) were wettest ($P<0.001$). Higher relative humidity tended ($P=0.07$) to be linked with lower DM %. *Streptococcus* spp. did not vary between used bedding subtypes (16.0 ± 0.4 ln cfu/mL; $P=0.15$). However, *Streptococcus* spp. counts were associated ($P<0.001$) with more days since additional bedding was added. Higher DM content in used bedding was linked ($P<0.01$) with lower *Streptococcus* spp. counts. Counts of Gram-negative bacteria in used bedding were highest in RMS (16.3±0.7 ln cfu/mL), then straw (13.8±0.4 ln cfu/mL) and sand (13.5 ± 0.6 ln cfu/mL) ($P<0.001$), while lower in wood (10.3±0.5 ln cfu/mL). Counts of *Klebsiella* spp. in used bedding were similar for sand (10.8±1.0 cfu/mL), straw (11.7 ±0.6 ln cfu/mL), and RMS (11.4±1.1 ln cfu/mL), while lower in ood (5.9±0.8 ln cfu/mL) ($P<0.001$).

Higher mean SCC was seen in herds with higher DIM ($P=0.03$) and a tendency on farms with narrower stalls ($P=0.09$). A higher % of cows with dirty lower legs and udders were observed in free-stall compared to tie-stall herds ($P<0.001$). Higher % of cows with dirty lower legs was found on farms that scraped stalls less often ($P<0.01$). Increased herd size had lower % of cows with dirty udders ($P<0.001$). Farms with mattress-based stalls had a higher % of cows with dirty udders compared to deep bedding ($P=0.02$). There was a tendency ($P=0.06$) for herds milking 2x/d vs. 3x/d to have higher % of cows with dirty upper legs and flanks. The highest % of cows with dirty upper legs and flanks were in herds milked in automatic milking systems, followed by parlors, and lowest for cows milked in stalls ($P<0.001$). Herds bedded with sand tended ($P=0.1$) to have a lower % of cows with dirty upper legs and flanks, compared to straw, wood, and RMS.

These results suggest that elevated bacterial counts in used bedding, across bedding types, provides evidence that bedding management can have a profound impact on cow hygiene and bacterial concentrations in the bedding substrates, which in turn may affect mastitis risk. The most important factors affecting this relationship include the addition of new bedding, how often the stalls are scraped, housing type, milking system and herd size.

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ASSESSMENT OF CHANGES IN QUARTER MILK YIELD RANKING IN EARLY LACTATION

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Introduction

Quarter milking in robotic milking systems creates an opportunity to analyse variability in quarter milk flow rates, milking time and milk yields which could provide insights into novel milk harvesting strategies to maximise milking system throughput. Results from milking frequency trials have illustrated that milk production is regulated by local factors within each quarter as well as systemic factors (Wall and McFadden., 2011). It is also known that the occurrence of clinical mastitis in a quarter has deleterious effects on udder milk yield by between 2.5-8.4 kg/d depending on the pathogen in first 1-2 weeks post diagnosis (Grohn et al., 2004). The aim of this study was to assess quarter milk yield contribution to udder yield and QMY ranking. The effect of clinical mastitis (CM) on QMY ranking was also assessed.

Materials and Methods

Quarter milking performance data was obtained from 530 cows within a single herd via the robotic milking system herd management software (Dellpro – DeLaval). Both daily and 10 day averages of QMY were calculated in SAS 9.4 (SAS Institute). Potential milk meter inaccuracies of 5% were accounted for in the analysis of rank. These averages were used to rank quarters within cow for contribution to udder yield. Changes in rankings were measured, within cow, on a daily basis and were assessed a) with the full dataset of cows (DIM 10-120) or b) with clinical mastitis cases excluded from the dataset based on the mastitis diagnosis date less 3 days or less 14 days (n=86 CM cows).

Results and Conclusion

Analysis of 10d average QMY rankings show that for approximately 20% of observations one of the rear quarters is not the highest ranked quarter. The percentage contribution to udder MY, regardless of quarter position (left front etc.), of the highest to lowest ranked quarters, is similar from DIM 20- 120 based on 10d average QMY (Table 1).

Table 2 illustrates large volatility in QMY ranking with 69.2% (367/530) of cows having all four quarters change rank at least once in any day between 10-120 DIM. Only 4.2% (22/530) of cows had no change in quarter rank for the same period. It was expected that when the 86 cows with a clinical mastitis case were excluded from analysis this volatility would lessen but it remained essentially unchanged irrespective of the margin allowed between diagnosis date and when the cow data was excluded from analysis (either -3d or -14d from diagnosis date). This might indicate that QMY changes in response to a clinical mastitis episode occur more than 2 weeks prior to diagnosis or that average QMY reduction due to mastitis is not sufficient to change that

quarter ranking. Potentially, this has implications for mastitis detection strategies in robotic milking based on individual QMY reduction algorithms.

Table 1. Mean percentage contribution of ranked quarters to udder milk yield by 20 DIM increments (irrespective of Q position).

DIM	Mean % contrib. rank 1 (SD)	Mean % contrib. rank 2 (SD)	Mean % contrib. rank 3 (SD)	Mean % contrib. rank 4 (SD)
20	29.9 (3.7)	27.2 (2.3)	23.7 (2.4)	21.2 (3.1)
40	29.9 (3.2)	27.3 (2.3)	23.1 (2.5)	20.5 (3.3)
60	30.0 (3.1)	27.4 (2.3)	23.2 (2.3)	20.2 (3.8)
80	30.2 (3.4)	27.5 (2.4)	23.3 (2.4)	19.9 (4.2)
100	30.4 (3.5)	27.5 (2.4)	23.2 (2.4)	19.7 (4.3)
120	30.8 (4.1)	27.6 (2.7)	23.3 (2.6)	19.4 (4.7)

Table 2. Summary of changes in quarter milk yield ranking within cow averaged by day (10-120 DIM).

Change in QMY rank (DIM 10-120)	All cows in dataset	CM cows excluded from 3d prior to treatment	CM cows excluded from 14d prior to treatment
Cows analysed	530	530	530
All 4 Q changed rank	367	366	363
3 Q changed rank	71	70	72
2 Q changed rank	70	72	72
0 Q changed rank	22	22	23

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