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Disease Control on Dairy Farms with a Focus on Johne's disease and Veterinary Communication

by

Caroline Manuela Nancy Ritter

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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ABSTRACT

Motivating dairy farmers to implement disease prevention and control strategies can be challenging. The first objective of this thesis was to assess factors that influence farmers' management decisions. A literature review was conducted focusing on socio-psychological influences and farmers' preferred information sources. Additionally, surveys and qualitative interviews with Alberta dairy farmers contributed to the current knowledge by assessing farmers' attitudes, beliefs, and perceptions in regard to the prevention and control of Johne's disease, an infectious enteritis that is caused by *Mycobacterium avium* subsp. *paratuberculosis* (MAP) and is endemic in Canadian dairy cows. Environmental fecal samples were analyzed for MAP to assess whether farm infection status influenced farmers' decision to enroll in the voluntary Alberta Johne's Disease Initiative (AJDI). Observed herd prevalence of MAP (i.e., 51%) was similar between AJDI participants and nonparticipants. Results further indicated that farmers have to believe in the importance of the disease and in recommended prevention and control strategies to make changes. In Alberta, the reasons why farmers did not participate in the AJDI or implemented recommended measures included skepticism of the threat and negative effects of Johne's disease, critique of test sensitivity, required time, and costs. Farmers used a variety of information channels, but herd veterinarians had a major influence on their management. Veterinarians are in an ideal position to communicate and motivate recommended strategies targeted to each farm, and it is well established that effective communication skills can improve adherence with advice and health outcomes. Therefore, the second objective was to assess veterinary communication patterns. First, the suitability of on-farm video recordings for comprehensive communication analysis using the Roter Interaction

Analysis System was demonstrated. Then, veterinary communication during 70 dairy farm visits was assessed. Veterinarians spent most of their talk on farmer education and relationship building. Demographics such as gender and length of the professional veterinarian-farmer relationship affected the use of some communication variables, whereas the effect of previous communication training was minimal.

Identification of influences on farmers' management decisions and of veterinary communication patterns can reveal opportunities to enhance communication, thus improving the uptake of prevention and control measures.

PREFACE

This thesis consists of 6 manuscripts: 5 have been published and 1 will be submitted in Spring 2018. Permission from the publishers has been obtained.

The following manuscripts are included in this thesis:

Chapter 2

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

Chapter 3

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Chapter 4

Ritter C., R. Wolf, C. L. Adams, D. F. Kelton, C. Pickel, S. Mason, K. Orsel, J. De Buck, and H. W. Barkema. 2015. Herd-level prevalence of *Mycobacterium avium* ssp.

paratuberculosis is not associated with participation in a voluntary Alberta Johne's disease control program. J. Dairy Sci. 99:2157-2160.

Chapter 5

Ritter C., J. Jansen, K. Roth, J. P. Kastelic, C. L. Adams, and H. W. Barkema. 2016. Dairy farmers' perceptions toward the implementation of Johne's disease prevention and control strategies on Alberta dairy farms. J. Dairy Sci. 99:1-12.

Chapter 6

Ritter, C., H. W. Barkema, and C. L. Adams. 2017. Action cameras and the Roter interaction analysis system to assess veterinarian-producer interactions in a dairy setting. Vet. Rec. 182:227.

Chapter 7

Ritter, C., C. L. Adams, D. F. Kelton, and H. W. Barkema. Clinical communication patterns of veterinary practitioners during dairy herd health and production management visits.

Statement of work done

Caroline Ritter synthesized the literature and conducted the narrative review (Chapter 2). Dr. Robert Wolf, Mike Slomp, Jodi Flaig, and Charlotte Pickel helped with questionnaire administration (Chapter 3) and sample collection (Chapter 4). Laboratory analysis (Chapter 4) was done by Uliana Kanavets, and Keliesha Roth helped conducting qualitative interviews (Chapter 5). Drs. Herman Barkema and David Kelton aided in recruiting veterinarians, and RIASworks professionally coded the video material (Chapter 6 and Chapter 7).

All quantitative data were cleaned and analyzed by Caroline Ritter with the aid of Dr. Grace Kwong, (Chapter 3), Dr. Diego Nobrega (Chapter 3 and Chapter 7), and Dr. Herman Barkema when needed. Qualitative recordings were transcribed, coded and analyzed by Caroline Ritter. All manuscripts were drafted by Caroline Ritter. The co-authors provided critical review of the manuscripts before journal submission. Permission has been obtained from all co-authors and the publishing journals to reprint the manuscripts in this thesis.

<u>The following manuscripts that I co-authored while I was a PhD-student at the University of Calgary were not included in this thesis:</u>

Barkema, H.W., K. Orsel, S. S. Nielsen, A. P. Koets, V. P. Rutten, J. P. Bannantine, G. P. Keefe, D. F. Kelton, S. J. Wells, R. J. Whittington, C. G. Mackintosh, E. J. Manning, M. F. Weber1, C. Heuer, T. Forde, C. Ritter, S. Roche, C. Corbett, R. Wolf, J. P. Kastelic, J. De Buck. 2017. Knowledge gaps that hamper prevention and control of *Mycobacterium avium* subsp. *paratuberculosis* infection. Transbound. Emerg Dis., in press.

S. L. B. McKenna, C. Ritter, I. Dohoo, G. P. Keefe, and H. W. Barkema. Comparison of fecal pooling strategies for detection of *Mycobacterium avium* subsp. *paratuberculosis*. J. Dairy Sci., submitted.

Conor G. McAloon, S. Roche, C. Ritter, H. W. Barkema, P. Whytea, S. J. Morea, L. O'Gradya, M. J. Greend, M. L. Doherty. Epidemiology and control of paratuberculosis in dairy herds – A Review. Vet. J., submitted.

Durst, P. T., S. J. Moore, C. Ritter, and H. W. Barkema. Evaluation of dairy farm employee management by employees. J. Dairy Sci., submitted.

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To my parents

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A$	Australian dollar(s)
AJDI	Alberta Johne's Disease Initiative
BIC	Bayesian information criterion
CAN$	Canadian dollar(s)
CD	Crohn's disease
CI	confidence interval
CJDI	Canadian Johne's Disease Initiative
d	day(s)
DHI	Dairy Herd Improvement
ELISA	enzyme-linked immunosorbent assay
GB	gigabyte
GDP	gross domestic product
HBM	Health Belief Model
HH&PM	herd health and production management
ICC	Intra-class correlation coefficient
IQR	interquartile range
JD	Johne's disease
kg	kilogram(s)
KMO	Kaiser-Meyer-Olkin
MAP	*Mycobacterium avium* spp. *paratuberculosis*
mL	milliliter
mo	month(s)
PCR	polymerase chain reaction
qPCR	quantitative polymerase chain reaction
RAMP	risk assessment and management plan
RCC	relationship-centered care
RIAS	Roter Interaction Analysis System
SCC	somatic cell count
SD	standard deviation

SEM	standard error of the mean
spp.	subspecies
TPB	Theory of Planned Behavior
US$	United Stated dollar(s)
WCDS	Western Canadian Dairy Seminar
yr	year(s)

CHAPTER 1: General introduction

1.1. Dairy farming in Canada

With almost 1 million dairy cows and an annual gross domestic product (GDP) contribution of approximately CAN$20 billion, dairy farming is one of the largest agricultural sectors in Canada (DFC, 2018; AIMIS, 2017). To grow to these dimensions, the Canadian dairy industry, similarly to that of many developed and developing countries, has undergone substantial changes in the last decades (Barkema et al., 2015). Farmers who want to remain competitive are required to optimize their management (Barkema et al., 2015). Furthermore, consumers are increasingly interested in health and welfare aspects of dairy cow care, and dairy farmers are, more than ever, obligated to adopt requirements to comply with industry standards (Barkema et al., 2017). Societal concern over food safety and antimicrobial resistance increasingly urges farmers to improve biosecurity, antimicrobial and hormone use (Jones et al., 2015).

These changes in the industry require farmers to shift their management from a reactive approach, which focusses on individual treatment of sick or underperforming cows, to a proactive approach with the goal of problem prevention (Higgins et al., 2013). The Canadian dairy industry attempts to support farmers by providing guidelines on recommended management practices, and by implementing (voluntary) disease prevention and control programs. For example, in Alberta, a voluntary program for Johne's disease, the Alberta Johne's Disease Initiative (AJDI), received substantial industry attention in the last years (Barkema et al., 2018).

1.2. Johne's disease

1.2.1. Transmission and pathogenesis

Johne's disease primarily affects ruminants and is caused by the slow-growing *Mycobacterium avium* ssp. *paratuberculosis* (MAP). The bacterium can survive freely in the environment for up to one year and, if orally ingested, can cause a chronic enteritis in infected cows (Chacon et al., 2004). Although young animals are considered most susceptible, calves of up to 12 months could be successfully infected in controlled trials and infections of even older animals have been reported (Windsor and Whittington, 2010; Mortier et al., 2014). After infection with MAP, the disease often remains latent for several years (Whitlock and Buergelt, 1996). During the silent or subclinical stages of the infection, animals will show no obvious clinical signs of JD but continue to intermittently shed MAP into the environment. In contrast to common beliefs, even young calves can actively shed MAP and infect other calves (Corbett et al., 2017). After progressing to the clinical stage of the disease, cattle display diarrhea, gradual weight loss despite normal appetite, and decreased milk production (Tiwari et al., 2006, Smith et al., 2016). In the absence of an effective treatment, affected animals eventually die or are culled due to poor condition (McKenna et al., 2006).

Besides infecting ruminants, MAP has also been identified in other animals including foxes, stoats, weasels, wood mice and rats (Beard et al., 1999; 2001). Furthermore, an association between MAP and Crohn's disease in humans has been described in several studies (e.g., Roholl et al., 2002, Clancy et al., 2007, Uzoigwe et al., 2007). Although the causality of this association is debated in the scientific community (Naser and Collins, 2005, Behr and Kapur, 2008, Over et al., 2011), the occurrence of viable MAP in milk has raised the concern of a public health hazard (Grant et al., 2005).

1.2.2. Prevalence and diagnostics

Infections with MAP have been reported in many countries with developed livestock industries (Geraghty et al., 2014). In Canada, estimates of cow-level seroprevalence range from 1.3% (Prince Edward Island) to 7% (Alberta; Tiwari et al., 2006). However, due to intermittent shedding of MAP, lack of humoral immune responses in the early stages of infection, and suboptimal test sensitivity, diagnosis of MAP infection is challenging (Coussens, 2004; Nielsen and Toft, 2008; Barkema et al., 2017). It has been estimated that for every clinically infected cow there are at least 15 to 20 cows that are infected but do not display clinical signs and are not necessarily detectable with laboratory tests (Whitlock and Buergeld, 1996; Whitlock et al., 2000). Wolf et al. (2014) accounted for the shortfalls of MAP detection and estimated the true prevalence on dairy farms to be 68% (Alberta) and 76% (Saskatchewan).

1.2.3. Economic impact

Johne's disease has a negative economic impact due to its clinical effects such as reduced milk production or reduced slaughter value. However, the extent of the financial burden of JD on farmers and the dairy industry is difficult to assess and modeling approaches often have to estimate required input parameters, thus increasing uncertainty of the results (Wolf et al., 2014). However, Shephard et al. (2016) concluded that JD leads to an estimated annual loss of profit of approximately A$45 per cow/year on commercial Victorian (Australia) dairy farms without control measures for JD. In Canada, Chi et al. (2002)

estimated the annual losses to be CAN$2,472 for a herd with 50 cows and a mean MAP prevalence of 7%, and Tiwari et al., (2008) concluded that in a herd of 61 cows with 12.7% seroprevalence, the annual loss would account for CAN$2992. In contrast, participation in the AJDI was estimated to lead to a net benefit of CAN$27 per cow over the course of 10 years if the project costs were covered by participating farmers (Wolf et al., 2014).

1.2.4. Prevention and control

Decreased welfare of animals affected by JD, the public health concern over MAP's zoonotic potential, and economic losses have instigated efforts for enhanced JD prevention and control. Attempts have been made to control JD by vigorously testing individual cows for MAP and culling test-positive animals. However, these test-and-cull strategies are largely unsuccessful (Groenedaal et al., 2003; Barkema et al., 2017; Geragthy et al., 2014). In particular, intermittent shedding patterns and lack of test sensitivity require frequent testing, which is not cost-effective (Kudahl et al., 2008). Instead, implementing risk-based control strategies are considered to be more effective (Kudahl et al., 2008; Wolf et al., 2014).

Several studies have investigated the most important risk factors for MAP transmission. Within the herd, suboptimal farm hygiene and manure management has been demonstrated to increase the risk of MAP transmission. For example, poor cleanliness of animals, pens, and equipment were identified as risk factors for MAP infection (Berghaus et al., 2005; Ferrouillet et al., 2009; Wolf et al., 2016). Furthermore, using the maternity pen also as the sick cow pen, feeding young stock left-over cow feed, and using the same equipment for feed and manure are management practices that can spread existing MAP on the farm (Berghaus et al., 2005; Tavornpanich et al., 2008; Ferrouillet et al., 2009). Due to calves' high susceptibility to MAP infection, important risk factors for MAP infection are calves' direct exposure to cow manure, feeding pooled colostrum and milk, allowing the calf to suckle the dam, and extended time until the calf is removed from the dam after birth (Berghaus et al., 2005; Ridge et al., 2005; Ferrouillet et al., 2009; Sorge et al., 2012). Moreover, group maternity pens and proximity of calves to cow housing have been demonstrated to increase the risk of MAP transmission to susceptible calves (Berghaus et al., 2005; Dorshorst et al., 2006; Mee and Richardson, 2008).

If a herd is deemed MAP-negative, especially the introduction of infected animals poses a risk to the herd. Even diagnostic testing of potential new animals for MAP does not guarantee a true negative MAP-status due to lack of laboratory sensitivities (Sorge et al., 2012; Barkema et al., 2017). Dairy farmers who frequently introduced new animals and who were less cautious during purchase were more likely to have MAP infected herds (Nielsen and Toft, 2011; Wolf et al., 2016).

Because of the importance management practices play in the transmission of MAP, many countries worldwide implemented programs that focus on JD prevention and control through encouragement of recommended management practices (Geraghty et al., 2014).

Alberta Johne's Disease Initiative. The Canadian Johne's Disease Initiation (CJDI) was developed by modifying existing national and international programs to create a unique program for the Canadian dairy industry. Whereas the CJDI provided national standards and inter-provincial coordination, the Canadian provinces were responsible for implementing their own JD prevention and control programs (Geraghty et al., 2014; Barkema et al., 2018). In Alberta, farmers could enroll in the voluntary Alberta Johne's

Disease Initiative (AJDI), which was implemented in 2010 and essentially free of charge for the first 4 years of the program. Environmental fecal testing for MAP was an important part of the program to trigger involvement of farmers, aid in identification of herds that needed more intensive assistance to reduce infection rates, and monitor progress over time. Furthermore, to reduce MAP prevalence, the AJDI encouraged participating farmers to implement management practices that reduced the risk of MAP transmission. Upon enrollment, and subsequently on an annual basis, the herd veterinarian conducted an on-farm risk assessment to identify farm-specific management practices that increased the risk of MAP transmission (Wolf et al., 2014). Based on the risk assessment, the veterinarian then provided the farmer with up to three recommendations on how to improve farm management taking into account each recommendations' feasibility, costs and expected benefits.

Although >60% of dairy farmers participated in the AJDI (Barkema et al., 2018), many of them only had one risk assessment done, and most of them ended participation when they had to pay for the veterinary and laboratory services. The reasons for farmers to enroll in the AJDI (or not) were unclear; for example, whether farmers were more likely to enroll if they expected their herd to be infected with MAP. Additionally, there is very limited information on what influences AJDI-participating farmers' uptake of recommended management practices to reduce MAP prevalence on their farm or the risk of MAP introduction onto their farm. To ensure sufficient participation rates and program success, interventions such as the AJDI need to account for farmers' motivators and barriers to enroll and implemented recommended management strategies.

1.3. Dairy farmers' management decisions

For dairy producers in developed countries, their farm is generally the main source of income. Therefore, running the farm as a successful enterprise is crucial and dairy farmers attempt to make the right business decisions (Noordhuizen et al., 2008). However, over the last decades, an increasing body of literature demonstrated that farmers make management choices not only based on economic considerations but that a variety of other factors influence their farm management (Jansen and Lam, 2012; Brennan and Christley, 2013). From an outside perspective, these management decisions might not always appear rational (Edwards-Jones, 2006). Nevertheless, farmers generally have their own reasons to adopt certain practices (or not), and these reasons largely depend on factors unique to each farmer such as individual circumstances, attitudes, perceptions, values, knowledge, skills, and goals (Jansen and Lam, 2012). Because of the influence of these socio-psychological factors, Bigras-Poulin et al. (1985) proposed more than 30 years ago that "attitudes should be measured and considered before proposing management practices to improve farm performance". However, low participation rates in voluntary control programs and suboptimal uptake of recommended management strategies worldwide suggest that current efforts still do not sufficiently account for the socio-psychological dimension of farmers' decision making (Sorge et al., 2010; Barkema et al., 2017). External motivation (e.g., financial bonuses or penalties) might elicit the desired farmer behavior, but without necessarily affecting "hearts and minds" farmers will likely return to old management practices as soon as the external motivator is abolished (Pike, 2008).

1.3.1. Theoretical frameworks of behavioral change

Numerous health behavior theories have been developed that try to explain, and ultimately predict, human behavior (Glanz et al., 2015). These theories can facilitate design of health behavior change interventions by providing a foundation of various socio-psychological factors interventions can build on. In the agricultural context, there are two dominant theories that have been adopted from human health research to assess influences on farmers' decision making, and that try to correlate these influences to observed farmer behavior or farm performance: the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB).

The HBM assumes that peoples' perceived susceptibility to a disease and their belief in serious consequences of the disease (i.e., perceived severity) determine whether they feel threatened and therefore are motivated to commit to prevention and control behavior (Rosenstock, 1974). Furthermore, the model theorizes that people are more amenable to changing their behavior if they are confident in their ability to successfully perform the behavior (i.e., self-efficacy) and if the perceived benefits of taking action outweigh the perceived costs. Lastly, according to the HBM, cues to action (e.g., newsletter articles) might prompt a behavior change.

The TPB assumes that behavioral intention is the most important determinant of behavior (Ajzen, 1991). According to the TPB, a person's attitude toward the proposed behavior, and their belief in their control over the behavior (i.e. perceived behavioral control) influence the intention to change. Furthermore, the belief of whether people or institutions important to the individual approve or disapprove of the behavior (i.e., subjective norm) affects their intention and their actual behavior.

A variety of studies assessed influences on (dairy) farmers' management decisions, often referring to factors included in the HBM and the TPB. A more complete overview of studies investigating farmers' circumstances, contexts and socio-psychological factors affecting farm management is compiled in Chapter 2 of this thesis.

1.4. Role of veterinary practitioners

1.4.1. Veterinarians' influence on farmers' management decisions

Veterinarians are often seen as the most trustworthy source of advice on disease and disease risk management (Ellis-Iversen et al., 2010; Garforth, 2013). Dairy farmers generally have a (very) good relationship with their herd veterinarian, and regard veterinary practitioners as reliable source of information on farm management (Heffernan et al., 2008; Jansen et al., 2010). For example, dairy farmers considered their herd veterinarian as most important source for information on biosecurity, and veterinarians had an important role motivating participation in voluntary cattle disease control programs (Hop et al., 2011; Brennan and Christley, 2013). Despite their important influential role on the farm, dairy practitioners do not always fulfill their advisory tasks to an optimal degree. In Denmark, dairy veterinarians focused too much on financial aspects of farm management, whereas farmers valued teamwork and animal welfare more (Kristensen and Enevoldsen, 2008). Veterinarians in a Dutch study only discussed herd performance goals with the farmer in 24% of the cases often resulting in their inability to identify a dairy producer's main farm goal and contrasting priorities of veterinarian and farmer (Derks et al., 2013). Insufficient communication between veterinary practitioner and farmer likely also results in poor uptake of veterinary advice; for example, regarding the implementation of recommended management practices (Adams and Kutz, 2017). In a voluntary JD prevention and control program in Ontario, veterinarians likely overwhelmed farmers with too many management suggestions, unintentionally discouraging practices uptake (Sorge et al., 2010). Furthermore, veterinarians believed that a lack of uptake was attributable to farmer attitudes, whereas they perceived their suggestions as practical and feasible (Roche, 2014). These examples highlight that veterinary practitioners can only fulfill their role as advisor successfully if they are effective communicators. However, it is apparent that there are communication gaps between veterinary practitioners and farmers.

1.4.2. Communication between veterinary practitioners and dairy farmers

To provide proficient consultancy, competent communication skills are essential tools for practitioners. In human medicine, a large body of studies investigated the effects of clinical communication over the last decades (e.g., Bertakis et al., 1991; Roter, 2000; Silverman et al., 2005). In contrast, communication research conducted in the veterinary context is scarce, and most available studies investigated clinical communication in companion animal settings (e.g., Shaw et al., 2004; Coe et al., 2009; Nogueira Borden et al., 2010; Kanji et al., 2012). These studies from human and companion animal medicine indicate that proficient clinical communication leads to increased satisfaction with the consultancy for practitioners and patients/clients, enhanced adherence with medical advice, and improved health outcomes for patients (reviewed by Silverman et al., 2005; Adams and Kurtz, 2017). Currently, findings from human and companion animal studies are used in the development and implementation of veterinary curricula and continuing education around the world. In contrast, there is a lack of communication research in the large animal setting, potentially due to the challenges of gathering communication data in this environment and analyzing it effectively. For example, studies in the companion animal environment were able to use a stationary camera to obtain recordings of the interaction between client and veterinarian, which was subsequently used for communication analyses (Shaw et al., 2008; Coe et al., 2009). This approach is not feasible in the dairy environment because veterinarian and farmer will move through the barn.

1.5. Thesis rationale

Although an increasing number of studies indicates that socio-psychological factors play an important role in farmers' decision making, there are still research gaps regarding the importance of specific factors, and whether the influence of these factors is comparable across different countries and diseases. In Alberta, little is known about influences on dairy farmers' decisions to participate in the AJDI and to implement JD prevention and control measures.

Because veterinary practitioners are known to have profound influence on dairy farmers' management decisions, they are in the ideal position to motivate recommended management practices through effective communication. However, a limited number of research studies assessed veterinary communication skills, and available research has largely been conducted in the companion animal context. Identification of communication characteristics that are specific to veterinary-farmer interactions are a necessary first step to provide optimal communication education to veterinary students and during post-graduate training events.

1.6. Research objectives

(1) Review relevant literature regarding socio-psychological factors and information tools affecting farmers' disease management decisions. Development of evidence-based strategies that account for these influences; thereby providing an aid for the design of disease prevention and control programs and for motivating adoption of recommended management practices (Chapter 2).

(2) Assess motivators and barriers of Alberta dairy farmers that influence whether they enroll in the AJDI or not (Chapter 3).

(3) Investigate whether on-farm prevalence of MAP prior to AJDI participation influences Alberta dairy farmers' decision to enroll (Chapter 4).

(4) Assess factors influencing whether Alberta dairy farmers participating in the AJDI adopt recommended management strategies for more effective JD prevention and control (Chapter 5).

(5) Introduce an approach to obtain and analyze data on communication patterns used by dairy practitioners (Chapter 6).

(6) Assess veterinary communication patterns during herd health and production management (HH&PM) dairy farm visits (Chapter 7).

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CHAPTER 2: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control

2.1. Abstract

The prevention and control of endemic pathogens within and between farms often depends on the adoption of best management practices. However, farmers regularly do not adopt recommended measures or do not enroll in voluntary disease control programs. This indicates that a more comprehensive understanding of the influences and extension tools that affect farmers' management decisions is necessary. Based on a review of relevant published literature, we developed recommendations to support policy-makers, industry representatives, researchers, veterinarians, and other stakeholders when motivating farmers to adopt best management practices, and to facilitate the development and implementation of voluntary prevention and control programs for livestock diseases. Farmers will make management decisions based on their unique circumstances, agricultural contexts, beliefs, and goals. Providing them with rational but universal arguments might not always be sufficient to motivate on-farm change. Implementation of recommended management practices is more likely if farmers acknowledge the existence of a problem and their responsibility to take action. The perceived feasibility and effectiveness of the recommended management strategy and sufficient technical knowledge further increase the likelihood of adequate adoption. Farmers will also weigh the expected advantages of a proposed change against the expected disadvantages, and these considerations often include internal drivers such as pride or the desire to conform with perceived standards. Extension tools and farmers' social referents (e.g., veterinarians, peers) not only provide

technical information but also influence these standards. Whereas mass media have the potential to deliver information to a broad audience, more personal approaches such as participatory group learning or individual communication with farm advisors can enable the tailoring of recommendations to farmers' situations. Approaches that appeal to farmers' internal motivators or that unconsciously elicit the desired behavior will increase the success of the intervention. Collaboration among stakeholders, assisted by social scientists and communication specialists, is necessary to provide a context that facilitates on-farm change and transfers consistent messages across extension tools in the most effective way.

2.2. Introduction

Livestock farmers worldwide face endemic disease challenges that threaten animal health and welfare. These diseases can have a substantial economic impact on individual enterprises and on the farming industry as a whole (Wierup, 2012). Therefore, although the relevance of specific diseases might vary by country, the prevention and eradication of infectious animal diseases [i.e., diseases that can be spread directly or indirectly between animals (and potentially to humans)] has become an increasing focus for many nations. Despite huge advances in the development of livestock vaccines and treatment options, the implementation of best management practices is still the most effective way to prevent and control many infectious diseases on farms. Farmers are encouraged to implement specific strategies to mitigate the risk of disease transmission, not only for the sake of their animals' health and welfare, but also to protect humans from zoonotic pathogens (OIE Animal Production Food Safety Working Group, 2006). However, poor on-farm adoption of recommendations to enhance general biosecurity practices, or of strategies to decrease transmission of specific diseases, is common (Bell et al., 2009; Brennan and Christley, 2013; Sayers et al., 2013). Furthermore, participation rates in voluntary disease prevention and control programs are often below 30% (Hoe and Ruegg, 2006; Hop et al., 2011; Nielsen, 2011). These experiences suggest that the methods used to motivate participation in control programs and adoption of recommended practices have been suboptimal. Agricultural extension refers to activities and communication channels that facilitate changes in farmer knowledge, attitudes, and behavior by synthesizing, exchanging, and applying information (Black, 2000; Anderson and Feder, 2004). Although agricultural extension differs depending on the context, traditional “top-down” tools such as newsletters or magazines are often the primary routes of knowledge transfer, and they often assume that farmers make decisions based purely on scientific rationale (Roche, 2014). However, it is widely accepted that farmers' decision-making varies, influenced by factors that are not solely based on policy, economic considerations, or rational judgment (Edwards-Jones, 2006; Noordhuizen et al., 2008b). Some variability can be explained by individual farmer traits (e.g., personality, attitudes, beliefs, intentions, values, skills, and knowledge). Remarkably, these socio-psychological variables often explain more variation in farm performance than farmers' measurable management practices (Bigras-Poulin et al., 1985; van den Borne et al., 2014). To account for these factors, different theoretical frameworks have been applied in the agricultural context. Two of the frameworks most commonly used to investigate the effects of socio-psychological variables on farmers' decision-making and better understand farmer behavior, are the Health Belief Model (Janz and Becker, 1984) and the Theory of Planned Behavior (Ajzen, 1991).

In addition to socio-psychological factors, external influences such as input from social referents (e.g., herd veterinarians, colleagues, or family) and agricultural extension conduits (e.g., printed media or discussion groups) can also affect farmers' management decisions (Ritter et al., 2015; Roche et al., 2015).

The objective of this narrative review was to describe the available information on (1) the factors that contribute to farmers' adoption of recommended management strategies; and (2) the influence of social referents and extension tools on farmers' management decisions. Our focus was farmer behavior related to improving animal health, but where applicable, we have included a selection of findings on animal welfare to add relevant information from other contexts. Furthermore, the scope of this review was voluntary management-based prevention and control of endemic infectious livestock diseases (i.e., farmers' decision-making in the absence of compulsive regulations) on commercial farms in economically developed countries.

To meet the second objective, we discussed the main communication channels used to provide information and support farmers in adopting recommended management practices. Based on the evidence as it pertains to the delineated scope, we provide recommendations to policy-makers, industry representatives, researchers, veterinarians, and other stakeholders to facilitate the adoption of on-farm management practices and assist in the development and implementation of voluntary control programs for endemic infectious livestock diseases.

2.3. Socio-psychological influences

Every farmer has their own unique combination of demographic factors (e.g., age, sex, education), personality, previous experiences, routines, and goals, as well as economic, cultural, and family influences (Wilson et al., 2015; Frössling and Nöremark, 2016). These individual characteristics contribute to farmers' views about animal health, prevention and control strategies, and influence their decision-making (Figure 2-1). Not every management decision a farmer makes might appear logical from an outside perspective (Kristensen and Jakobsen, 2011a). An understanding of a farmer's mindset and the specific factors that combine to influence that mindset is crucial for motivating them to change. The socio-psychological influences on farmers' adoption of recommended management practices described in the first part of the review were considered the most relevant and were often derived from constructs described in the Health Belief Model or the Theory of Planned Behavior (Figure 2-1). It is particularly important to consider these factors when formulating voluntary prevention and control programs, and we have provided related recommendations (Tables 2-1 to 2-4). However, interventions to change farmer behavior must acknowledge that farmers are not a homogeneous group and cannot be convinced by relying only on educational arguments (Jansen et al., 2010b,c). Furthermore, farmers' context (e.g., laws and regulations, market prices, or quality programs) can affect decision-making by inhibiting or facilitating the recommended management changes. Because of the influence of farmers' internal logic and context on their decision-making, it is impossible to provide a “one-size-fits-all” solution (Kristensen and Jakobsen, 2011a).

2.3.1. Problem awareness and perception of responsibility

Problem Awareness. People are less willing to change their behavior if they deny the negative (future) effects of their current habits or of their current situation (e.g., the negative effects of smoking or obesity on health; Orji et al., 2012; Mantler, 2013). In this way, informing farmers about the presence of a pathogen or disease on their farm is an important step, but it does not guarantee that they will regard it as an important issue (Leach et al., 2010a; Ritter et al., 2016; Table 2-1). For example, Texas beef and Canadian dairy producers with Johne's disease in their herd often did not consider it a problem (Benjamin et al., 2010; Sorge et al., 2010a), and 90% of dairy farmers in England and Wales did not see lameness as a problem, despite an average prevalence of 36% (Leach et al., 2010a). To change their management practices, farmers need to believe that their current situation poses a problem or increases their risk of future problems, a notion that is described as “perceived threat” in the Health Belief Model (Janz and Becker, 1984; Casal et al., 2007; Benjamin et al., 2010). For example, concern about production losses due to Johne's disease was a main reason why dairy farmers participated in a voluntary Johne's disease control program (Nielsen, 2011).

Farmers also differ in their perception of the threshold at which an issue becomes a problem for their operation (Jansen et al., 2010d; Jansen and Lam, 2012). This so-called “frame of reference” is often influenced by farmers' descriptive norms (e.g., their perception of how other farmers deal with the issue), injunctive norms (i.e., their perception of what is approved by other people), comfort rates, and experiences (Lam et al., 2007; Noordhuizen et al., 2008a; Jansen et al., 2016; Table 2-1). Examples of the influence of farmers' frame of reference include its association with their willingness to decrease mastitis rates, or with variations in mastitis incidence and bulk-milk SCC (Jansen et al., 2009; Jansen and Lam, 2012; Schewe et al., 2015).

A lack of diagnostic test sensitivity or of obvious clinical signs might cause a farmer to overlook an existing problem (Leach et al., 2010a; Wolf et al., 2014). Without necessarily knowing the herd's test status for *Mycobacterium avium* subsp. *paratuberculosis* (MAP), almost 80% of the farmers who thought they had observed clinical cases in their herd considered Johne's disease to be a serious problem, whereas only 10% of farmers who had not observed clinical cases shared that perception (Norton et al., 2009). Therefore, it is more challenging to motivate control strategies for diseases that spread silently or that lack sensitive diagnostic tests (Wassink et al., 2005; Benjamin et al., 2010; Table 2-1), particularly because farmers evaluate any problem not only on an "absolute" scale but also in relation to other issues that demand their attention (Leach et al., 2010a). Ultimately, farmers will spend their resources (e.g., time, money, space) on the issues they think are most urgent, will have the most severe negative impact, and are solvable (Rodrigues and Ruegg, 2005; Elliott et al., 2011; Bruijnis et al., 2013; Horseman et al., 2014). For example, dairy farmers who perceived that they had difficulty finding time to complete all tasks on the farm often gave higher priority to milking cows, limiting the care of calves (e.g., providing colostrum as soon as possible after birth; Santman-Berends et al., 2014).

Reports of estimated negative economic impact are available for the most important diseases that affect cattle (e.g., mastitis, bovine leukosis, bovine viral diarrhea, Johne's disease; Tiwari et al., 2007; Hogeveen et al., 2011). However, it is uncertain whether farmers are aware of these publications. Furthermore, lack of agreement in published estimates might cause confusion among farmers or doubt about the reports' credibility.

Nevertheless, even when estimates of production losses based on bulk-milk SCC were presented to farmers, success in motivating management change was limited when no further incentives were offered (van Asseldonk et al., 2010; Lam et al., 2010).
Farmers who do not have a particular disease on their farm evaluate its threat to their enterprise based on perceived susceptibility (i.e., how likely are animal health problems to occur; Janz and Becker, 1984). The current local disease status appears to play an important role in farmers' perceptions of susceptibility (Table 2-1), although each farmer likely has a different threshold at which they perceive the geographic proximity of disease occurrences to be a threat to their farm. In that sense, farmers are more inclined to take additional precautions if they perceive the risk of pathogen introduction onto their farm to be high: for example, if transmission risks are elevated because of disease occurrences in the area (Ekboir, 1999; Garforth et al., 2013; Toma et al., 2013; Toma et al., 2015).

Perception of responsibility. To take action, farmers need to believe that they are responsible for implementing the management strategies being advocated (Blackstock et al., 2007; Wauters and Rojo Gimeno, 2014; Table 2-1). For example, cattle farmers' perception of responsibility for Escherichia coli 0157 control was positively associated with their willingness to spend time or money on this issue (Toma et al., 2015). For the majority of farmers enrolled in voluntary Johne's disease programs, concerns about consumer health or consumer perceptions of a link to Crohn's disease were key factors for participation (Sorge et al., 2010a; Nielsen, 2011). Other studies, however, have revealed that farmers' considerations of their own farm's performance were often more important to them than responsibility for consumer health or awareness of the industry sector (Kovich et al., 2006; Hop et al., 2011; Ritter et al., 2015). This notion was supported by Jones et al. (2015), who reported that farmers' primary reason for reducing antibiotic use was not concern about resistance in cows and humans, but an attempt to decrease medicine costs. Similarly, helping the dairy sector as a whole to meet its goals was not a strong incentive for farmers to improve mastitis management (Valeeva et al., 2007).

Farmers often mention that government, food retailers, or auxiliary industries need to assume more responsibility for biosecurity (Gunn et al., 2008; Garforth et al., 2013). For example, 44% of cattle farmers from England and Wales stated that the government should contribute financially to controlling zoonotic diseases (Ellis-Iversen et al., 2010; Table 2-1), and 33% of cattle farmers in the United Kingdom felt that control of *E. coli* O157 should be the government's responsibility, at least in part (Toma et al., 2015). In contrast, the reluctance of cattle and sheep farmers to take responsibility for biosecurity in the United Kingom did not revolve around the government, but was instead due to a lack of trust within the farming community (Heffernan et al., 2008). In that regard, farmers' investment in preventive measures is most effective if others are doing the same. Farmers may be more inclined to assume responsibility as part of a joint effort rather than herd by herd (Hovi et al., 2005; Lindberg et al., 2006; Gunn et al., 2008; Heffernan et al., 2008; Brennan and Christley, 2013; Table 2-1).

2.3.2. Effectiveness of recommended strategies

Even farmers who recognize the importance of disease prevention and control and feel responsible for taking action may be reluctant to make on-farm changes if they do not believe that the proposed strategies are effective in preventing pathogen introduction, reducing pathogen prevalence, or mitigating clinical cases (Janz and Becker, 1984; Jansen et al., 2010b; Roche, 2014; Ritter et al., 2016; Table 2-2). Unfortunately, farmers are often uncertain about the effectiveness of recommended measures, or express doubt about the efficacy of a control program (Garforth et al., 2013; Alarcon et al., 2014). This perception is likely strengthened if farmers are not sufficiently informed about a strategy's success or if, due to the complex or chronic nature of some diseases, recommendations are based largely on epidemiological principles and biological plausibility rather than on evidence from clinical trials or field studies (Table 2-2). In particular, multifactorial chronic conditions that require a substantial amount of effort—and for which immediate and accurate assessment of the effect of adopted management changes is limited or unavailable—might reinforce farmers' perceptions that management strategies are ineffective (Raizman et al., 2006; Jansen and Lam, 2012; Table 2-2).

Producers motivated to increase their management efforts were often frustrated or discouraged when they perceived available strategies as ineffective (Ritter et al., 2016). Similarly, Australian cattle farmers believing they could succeed in temporarily eradicating cattle ticks from their farm considered re-infestation from neighboring properties as a major limiting factor in their attempts (Jonsson and Matschoss, 1998). Free-range poultry producers even regarded biosecurity measures directed at reducing disease transmission between buildings as futile and a “waste of time” (Garforth, 2011), and instead focused on practices they perceived more worthwhile, such as separating new animals on arrival or cleaning buildings between batches.

For swine farmers, strategy efficacy was the strongest driver to adopt recommended disease prevention and control measures for endemic and epidemic diseases (Valeeva et al., 2011). For dairy farmers, a positive perception about the effectiveness of proposed measures was not only linked to their adoption intent, but was also strongly associated with mastitis incidence (Jansen et al., 2009). Similarly, the most commonly stated reason for adoption of a protocol for digital dermatitis in cattle was its perceived effectiveness by farmers (Relun et al., 2013). However, the diversity of prevention and treatment protocols for foot health likely enhances farmers' insecurity about best practices and emphasizes the need for standardized recommendations based on credible research (Solano et al., 2017; Table 2-2).

2.3.3. Farmers' (perceived) ability to implement recommended management practices

Perceived behavioral control. Farmers' positive belief in their ability to successfully implement a recommendation is a necessary step toward improved disease control (Ellis-Iversen et al., 2010). This belief in the ability to succeed is called "perceived behavioral control" in the Theory of Planned Behavior (Ajzen, 1991). A similar concept in the Health Belief Model is "self-efficacy" (Janz and Becker, 1984). Perceived behavioral control and self-efficacy are influenced by a person's belief that they have sufficient knowledge to accomplish the task, that they can overcome habitual behavior, and the perceived feasibility of the recommendation (Garforth, 2015; Frössling and Nöremark, 2016).

In human health research, health care workers felt disempowered to correct poor compliance with hygiene measures if they perceived a lack of organizational commitment from the hospital (Smiddy et al., 2015). Similarly, farmers are part of a larger context and can only alter their behavior if their context allows for change. Farmers need organizational and institutional support that facilitates recommended changes (e.g., financial lenders that support investment in biosecurity measures; Kristensen and Jakobsen, 2011b; Table 2-3).

The limited work in the veterinary environment suggests that positive perceived behavioral control does promote farmers' adoption of management strategies. For example, perceived behavioral control was positively associated with farmers' intention to improve dairy cow foot health (Bruijnis et al., 2013) or to improve sustainable practices in gastrointestinal nematode control with diagnostic methods (Vande Velde et al., 2015). Farmers' perceived self-efficacy appeared to be a key influence affecting mastitis control strategies on Dutch dairy farms (Jansen and Lam, 2012), and successfully solving previous mastitis outbreaks probably enhanced farmers' feeling of control. Similarly, calf managers' experience solving calf mortality problems appeared to strongly affect their belief in their ability to minimize mortality rates, and likely influenced whether they were able to prevent a crisis from becoming permanent (Vaarst and Sørensen, 2009). Demonstrations of successfully implemented management strategies on producers' farms can positively influence farmers' attitudes and their belief in their ability to make a change (Roche et al., 2015; Table 2-3). Studies in the human sector are abundant and suggest that perceived behavioral control and self-efficacy play important roles in patient adherence to medical treatment, physical activity or healthy nutrition (e.g., Fransen et al., 2009; Kreausukon et al., 2012; Parschau et al., 2013) but these factors are not well studied in veterinary medicine, and more research is needed to form conclusions about their effect on farmers' management decisions.

Knowledge. To make effective changes farmers need to have sufficient knowledge about disease and management strategies to reduce transmission (Lam et al., 2007; Brightling et al., 2009; Ellis-Iversen et al., 2010; Racicot et al., 2012b; Table 2-3). Farmers' knowledge about Johne's disease and its control was positively associated with their attitudes about participating in a voluntary control program (Benjamin et al., 2010; Ritter et al., 2015; Table 2-2). Also, knowledge about dairy foot-health management likely enhanced farmers' intention to take action (Bruijnis et al., 2013), and the prevalence of lameness in dairy cows in England was negatively associated with farmers' awareness, knowledge, and level of training (Mill and Ward, 1994).

Some farmers believe that they have a good understanding of appropriate measures to optimize dairy cow foot health, mastitis incidence, or calf-rearing practices (Kuiper et al., 2005; Bruijnis et al., 2013; Santman-Berends et al., 2014). This perceived knowledge is often acquired from their experience as farmers and less from formal training (Garforth et al., 2013). However, veterinary practitioners did not always agree that farmers had sufficient knowledge to provide the best care for their animals (Santman-Berends et al., 2014). Farmers' lack of knowledge and understanding was the reason most frequently stated by cattle veterinarians for why their clients did not adopt many biosecurity measures (Pritchard et al., 2015).

Testing actual knowledge revealed that farmers were often unaware of the associated risks and transmission pathways to animals or humans of pathogens such as *Staphylococcus aureus*, *Salmonella*, *E. coli*, or *bovine viral diarrhea virus* (Kuiper et al., 2005; Young et al., 2010a; Lanyon et al., 2015; Toma et al., 2015). Benjamin et al. (2010) reported that 75% of beef cattle farmers who agreed that Johne's disease was a problem on their farm stated that they were unsure of how to prevent and control it (Table 2-3). Furthermore, dairy farmers who were familiar with Johne's disease applied management strategies that were similar to those applied by farmers who were unfamiliar with the disease (Wells and Wagner, 2000).

Farmers' reasons for not acquiring sufficient knowledge range from lack of time to uncertainty about which sources to consult for clear and relevant information (Hop et al., 2011; Alarcon et al., 2014; Lanyon et al., 2015). Farmers who have little experience with Johne's disease on their own farm often lacked management capabilities and knowledge (Hop et al., 2011). In contrast, farmers who had experienced mastitis problems or had a relatively high bulk-tank SCC when they were interviewed, often felt they had insufficient knowledge about mastitis prevention, which could have led to a loss of confidence in their own knowledge (Kuiper et al., 2005). Especially for novel or emerging diseases, sufficient information might not be available for farmers to make informed decisions (Alarcon et al., 2014).

Feasibility and practicality. Disease prevention and control measures will be implemented only if farmers perceive them to be feasible and practical (Garforth et al., 2013; Toma et al., 2015; Table 2-3). For example, dairy cow hoof mats soaked in trademarked chemical solutions were often abandoned because of difficulty manipulating and cleaning them, or because cows were reluctant to walk over them (Relun et al., 2013).
According to farmers, one of the main barriers to implementing new or different management practices was a lack of time to perform them (Garforth, 2011). For example, uptake of recommended Johne's disease control strategies and lameness control activities in sheep and cattle was influenced by time availability (Wassink et al., 2005; Leach et al., 2010a; Sorge et al., 2010a; Roche, 2014; Ritter at al., 2015). However, whereas the expected time requirement was an important barrier to participating in regular herd health management, it was not a key factor in decisions to quit participating (Derks et al., 2012).

Furthermore, participants in a Johne's disease control program believed that several management changes actually saved time (Sorge et al., 2010a; Table 2-3).

The requirement for extra labor can also be an impediment to making on-farm changes, and the cost and availability of skilled labor might impede farmers' implementation of recommended changes (Wassink et al., 2005; Benjamin et al., 2010; Sorge et al., 2010a; Relun et al., 2013; Alarcon et al., 2014; Horseman et al., 2014). After insufficient time, lack of labor was the second most important barrier to lameness control in dairy cattle, with almost half of farmers considering it "extremely important" or "very important" (Leach et al., 2010b).

The impracticality of recommended changes, for instance due to inadequate structural layout of the farm, can be another barrier. Examples include lack of available land and facilities, or inappropriate layout of buildings (Jonsson and Matschoss, 1998; Benjamin et al., 2010; Sorge et al., 2010a; Garforth, 2011; Garforth et al., 2013; Alarcon et al., 2014). Facility restructuring might represent a substantial financial burden, and might not be instantly achievable, but motivated farmers indicated their willingness to make changes as soon as their situation permitted (Ritter et al., 2016). Until they can implement permanent structural changes, some farmers use innovative solutions to decrease the risk of pathogen transmission (e.g., placing a newborn calf in a clean feed or silage cart, which allows the cow to interact with the calf but prevents nursing and limits the calf's contact with cow manure; Godkin and Jansen, 2010; Table 2-3).

Farmers also take into account the financial situation of their farm when considering change (Gunn et al., 2008; Benjamin et al., 2010; Garforth et al., 2013; Ritter et al., 2015); more capital allows the farmer to hire more labor, build facilities, or acquire recommended tools. For producers, it was important that improved foot health could be achieved by affordable measures, and cost-effectiveness was positively associated with the number of indented foot-health strategies (Bruijnis et al., 2013).

2.3.4. Perceived benefits and perceived disadvantages

Economic factors. Farmers' assessment of the expected outcome of a management change and the individually evaluated tradeoff between its perceived benefits and barriers ultimately influence farmers' adoption. One important driver for farmers is perceived cost-effectiveness: strategies are more likely to be implemented if the returns seem to justify them (Fraser et al., 2010; Garforth et al., 2013; Alarcon et al., 2014; Table 2-4). For example, in the case of bovine viral diarrhea, over 70% of interviewed South Australian cattle farmers said they would be willing to pay a small cost to participate in a control program if it could be shown that the long-term benefits exceeded the fees (Lanyon et al., 2015).

Most farmers (75%) interviewed in northwest England believed that having biosecurity measures in place was more cost-effective than treating a disease on-farm (Brennan and Christley, 2013). Similarly, farmers in Great Britain mentioned improved profitability as a key motivator for implementing biosecurity strategies (Gunn et al., 2008). Many dairy farmers that have MAP-positive herds participated in voluntary Johne's disease control programs to avoid production losses. For cattle farms that test negative for MAP, farmers often believed that participating in a certification program results in enhanced marketability of their cattle and that the economic advantages outweigh associated costs (Kovich et al., 2006; Benjamin et al., 2009; Nielsen, 2011; Table 2-4). However, many cattle producers that purchase animals do not consider the infection status of replacement animals for pathogens such as MAP or bovine leukemia virus (Benjamin et al., 2010; Young et al., 2010b; Ritter et al., 2016). This highlights the importance of farmers' context: the farming industry can determine whether it is worthwhile for farmers to participate in certification programs. In an even broader context, consumer demand can also be a driver for farmers to strive for a certain standard (e.g., retailers might not purchase animal products that do not meet a standard). Information about how much farmers are prepared to pay for the purchase of low-risk replacements instead of animals with unknown or high-risk status is not available. However, studies using “willingness to pay” approaches, as applied in marketing research, could yield new insights (Breidert, 2006; Nayga et al., 2006; Benjamin et al., 2010).

As a way of motivating farmers to take steps toward improved disease detection, prevention, and control, recent control programs have offered financial support, for example by reimbursing farmers for Johne's disease testing or for culling high-titer, MAP-positive cows (Kelton et al., 2014; Table 2-4). Penalties for not achieving predetermined thresholds have also been suggested, and in the case of bulk-milk SCC, financial penalties have been more effective than financial premiums (Valeeva et al., 2007; Fraser et al., 2010; Table 2-4). However, relying on these external motivators might cause farmers to participate only as long as the motivators are in place, as observed when industry funding for MAP herd-level testing in the Alberta Johne's Disease Initiative was terminated (unpublished data).

Non-economic factors Besides financial drivers, non-economic motivators are equally—potentially even more—important for many farmers when weighing the advantages and disadvantages of proposed management measures (Garforth and Rehman, 2006; Swinkels et al., 2015; Table 2-4). For example, Gramig et al. (2010) estimated that 41% of dairy farmers would adopt dehorning practices that minimized the risk of bovine leukemia virus transmission to uninfected animals, even if adoption of these practices would not avoid financial losses due to this virus. The authors did not assess other factors that might have played a role in that decision. However, studies suggest that enhancing cattle welfare is an important consideration for improving lameness and mastitis management, as well as for controlling zoonotic pathogens (Valeeva et al., 2007; Ellis-Iversen et al., 2010; Leach et al., 2010b; Relun et al., 2013).

One goal of on-farm disease control measures is to enhance animal health. Although 39% of dairy producers thought their calf and herd health improved after they had implemented at least one strategy for Johne's disease control, some felt that particular recommendations (e.g., immediate removal of the calf from the dam) would compromise animal health and welfare (Sorge et al., 2010a; Table 2-4). A Swedish study reported that some dairy farmers believed regular exposure to infections could be beneficial to animal health (Frössling and Nöremark, 2016), whereas a justified concern mentioned by cattle farmers in Australia was that reincursion of ticks after eradication would jeopardize their animals' health because of increased risk of tick fever (Jonsson and Matschoss, 1998).

Having a good reputation and taking pride in being a good farm manager with a clean barn, healthy animals, and good husbandry can be motivators for executing best management practices (Hovi et al., 2005; Gunn et al., 2008; Leach et al., 2010b; Nielsen, 2011, Alarcon et al., 2014; Roche, 2014; Table 2-4). Some farmers go so far as to claim that endemic disease problems are the individual farmer's fault and that “good” farmers do not have these issues (Heffernan et al., 2008). In addition to job satisfaction, which is often regarded as an important motivator in improving dairy cow mastitis, Johne's disease, or lameness (Valeeva et al., 2007; Hop et al., 2011; Bruijnis et al., 2013), internal incentives mentioned for farmers' adoption of strategies included environmental, family, lifestyle, and stewardship motives (Bergevoet et al., 2004; Garforth and Rehman, 2006; Leach et al., 2010b; Table 2-4). Whereas Valeeva et al. (2007) reported that dairy product quality and image, as well as recognition for a job well done, were the least important motivators for improving mastitis management, Swinkels et al. (2015) concluded that dairy farmers were sensitive to other farmers' social norms and even extended antimicrobial mastitis treatment past the treatment duration recommended by the veterinarian to be a “good farmer.” The importance of each of these internal drivers remains uncertain. To gain a more comprehensive understanding of these social factors and their influence on farmer behavior, qualitative methods (as well as traditional quantitative methods) should be applied.

2.3.5. Summary: socio-psychological influences

Awareness of the presence of a pathogen or disease is not sufficient to motivate management change. Farmers also need to acknowledge that the situation poses a problem that requires action (Wauters and Rojo Gimeno, 2014). Similarly, although sufficient knowledge contributes to farmers' perceived behavioral control and is necessary to adequately implement suggested management practices, we cannot assume that educating farmers about a pathogen and recommended strategies for control is enough to elicit on-farm change. Instead, the perceived effectiveness and feasibility/practicality of a recommended management strategy are key considerations for farmers. Furthermore, they will weigh the perceived advantages of a change against the perceived disadvantages; these considerations involve not only economic factors but also internal drivers such as pride in good farm management, although these drivers have not been extensively studied. The role of farmers' perceived responsibility in their prevention and control efforts varies among studies, but farmers are probably more likely to take on responsibility in the form of a joint effort and if they feel sufficiently supported at an organizational or institutional level. In that sense, farmers are not only influenced by their unique circumstances and individual mindsets, but also by external influences such as other farmers, the industry, or government.

2.4. Extension and communication

Motivating farmers to improve disease prevention and control requires an understanding of the factors that influence farmers' decision-making and a firm knowledge of which information sources pertaining to farm management are most effective at reaching farmers, and at providing effective support to facilitate on-farm changes (Garforth et al., 2004). Importantly, these information sources and social referents not only provide farmers with technical knowledge, they also create an expected standard or norm that might cause farmers to experience social pressure, and motivate them to adopt recommended management strategies (Öhlmér et al., 1998; Lindberg et al., 2006; Lam et al., 2007; Rehman et al., 2007).

The amount of information and the information sources available to farmers are extensive and continually increasing (Alarcon et al., 2014). However, more than half of dairy farmers surveyed in Ireland reported that a lack of information might prevent improvements in biosecurity measures (Sayers et al., 2013), and less than half of South Australian cattle farmers knew where to find clear information about bovine viral diarrhea prevention or control (Lanyon et al., 2015). These examples show that farmers' information-seeking behaviors do not align with existing dissemination pathways.

The accessibility of sources is a necessary precursor to obtaining information, but the credibility of the information source is also an important consideration for farmers (Garforth, 2015). Understanding the extension media at farmers' disposal, their individual preferences, and their context can help to determine the best way to communicate with producers. In this second part of the review, we discuss the main communication tools and approaches used in agricultural extension, as well as the challenges of within-farm communication and the provision of research results and advice to farmers. To capture a wider understanding of the methods, tools, and approaches used to motivate on-farm change, we reviewed any literature outlining agricultural extension approaches, and did not restrict the review to research on agricultural extension related to the prevention and control of infectious animal diseases. We have also provided recommendations for optimizing agricultural extension (Tables 2-5 and 2-6).

2.4.1. Extension and communication tools

Mass media. Information that is widely accessible and often distributed nationally or regionally has the advantage of reaching a broad range of producers (Table 2-5 and Figure 2-2). Printed media and literature are among the preferred information sources for dairy farmers in the Netherlands (Derks et al., 2013a) and the United States (Russell and Bewley, 2011), and information from the farming press is often regarded as up-to-date and relevant (Garforth et al., 2013). Similarly, 77% of cattle producers in England regarded research papers and journals among their preferred sources of biosecurity information, and 38% of those stated that they were most likely to take advice from these sources (Brennan and Christley, 2013). Conversely, television shows and the radio, although used by some, are generally not among farmers' preferred information sources (Heffernan et al., 2008; Brennan and Christley, 2013; Frössling and Nöremark, 2016). Similarly, Internet sources such as social media (i.e., Twitter or Facebook), blogs, podcasts, and webinars are often less preferred, although 40% of Swedish farmers appreciated the websites of animal health organizations and associations (Brennan and Christley, 2013; Frössling and Nöremark, 2016). However, with the growing use of the Internet for personal and professional purposes, we can expect that it will gain popularity. In 2014, 89% of Canadian dairy producers accessed the Internet for dairy information, mostly through search engines (Canadian National Dairy Survey 2014, unpublished data). Additionally, the success of computer- and web-based programs has been demonstrated in human health and agricultural contexts (e.g., Krebs et al., 2010; Merkel and Gipson, 2011; Peels et al., 2014). In particular, the potential for reaching large audiences while customizing messages to individuals' attitudes, goals, motivators, and barriers ("tailoring"), an approach used for health behavior interventions, could be useful in the farming context (Noar et al., 2007). Some farmers perceive information access via mass media as overwhelming, and often regard the advice provided as impractical and irrelevant for their own farm (Ellis-Iversen et al., 2010; Garforth et al., 2013). This perception could lead farmers to ignore advice from central sources, or could reinforce negative attitudes about the information provided (Garforth, 2015). Research on livestock farmers' attitudes about government-derived information is scarce in countries other than the United Kingdom, but farmers often do not see information from this source as important, useful, or credible (Gunn et al., 2008; Heffernan et al., 2008; Hernández-Jover et al., 2012). They commonly consider government information to be relevant only for notifiable diseases and national disease emergencies (Garforth et al., 2013; Alarcon et al., 2014). More research is needed on the perceived trustworthiness of information delivered via mass media. Furthermore, the effectiveness of Internet-based interventions should be further assessed in the agricultural context.

Seminars and conferences. Many studies assessing farmers' use of and preferences for information sources do not include farmers' perceptions of events where information is delivered to a large farmer audience (i.e., large-scale seminars and conferences; Kuiper et al., 2005; Heffernan et al., 2008; Derks et al., 2013a). Other studies report that these events are often less preferred, and may be less frequently used (Brennan and Christley, 2013; Ritter et al., 2015). Seminars and conferences offer a chance for producers to interact with each other and obtain subject matter from a variety of experts, and some producers highly appreciate them, but location, cost, and time away from the farm are barriers to attendance (Chase et al., 2006; Table 2-5 and Figure 2-2). This might explain why 28% of all interviewed dairy farmers in Kentucky indicated that they never attended meetings, but that 56% of those farmers rated local or regional meetings as one of their preferred information delivery methods (Russell and Bewley, 2011).

Participatory group learning. Collective learning approaches allow farmers to share ideas and experiences, and often include on-farm learning through workshops, field days, or farm tours (Black, 2000; Andreata, 2001; Figure 2-2). In Ontario, Canada, “Focus Farms” aimed at improving Johne's disease management by implementing an experiential learning process that used veterinarian-facilitated meetings involving table discussions, farm tours, and specific learning activities/games (Roche et al., 2015). Participating farmers improved their knowledge about Johne's disease, and 81% reported implementing at least one on-farm change, compared with only 38% of farmers who did not participate (Roche et al., 2015). Obtaining tailored information and advice from their peers—who are perceived to be “equal” and to understand farming realities—is likely one of the reasons for increased implementation rates with this method of learning.

Farmer discussion groups are a flexible way to allow groups to explore a variety of issues with the goals of creating a sense of ownership and bridging the gap between scientific information and on-farm practices (Ivemeyer et al., 2015; Table 2-5). Farmers who participate in discussion groups or health schemes/clubs highly value these extension tools and list them among their most preferred and useful communication methods for disease issues (Jonsson and Matschoss, 1998; Vaarst et al., 2007; Alarcon et al., 2014). For example, farmer discussion groups have been proposed to decrease mastitis and lameness in dairy cows, or to discuss sow group housing (Leach et al., 2010b; Lam et al., 2011; de Lauwere et al., 2012). After 6 mo attending discussion groups for dairy farmers in the Netherlands, 72% of study group participants used a standard treatment schedule to improve udder health, compared with only 58% of nonparticipants (Lam et al., 2007).

“Demonstration farms” provide sites for agricultural extension and training, and can be used to showcase specific management techniques and practices. “Monitor farms” also give farmers the option of becoming involved in decision-making for these farms when aiming to improve productivity, profitability, and sustainability. Along the way, farmers can compare their own farm performance, share experiences, and learn from examples (Campbell et al., 2006; Scottish Monitor Farms Programme, 2014). Similarly, "demonstration projects" can be used to assess the outcomes of corresponding methods or processes applied to several farms (Piepers et al., 2011; Erskine et al., 2015) Numerous variations of these 3 approaches exist, but they are generally underpinned by participatory learning or participatory action research.

Although participatory group learning has the advantage of drawing from collective knowledge, it requires farmers to openly share their opinions and experiences, and this might be difficult to achieve (Black, 2000; Alarcon et al., 2014). Furthermore, the potentially large number of opinions and choices presented to farmers during interactive learning might result in high levels of uncertainty, and inhibit farmers' intentions to change management (Hansson and Ferguson, 2011). A person familiar with farming (e.g., a veterinary practitioner or production advisor) who has received facilitation training should therefore moderate discussions (Vaarst et al., 2007; Lam et al., 2011; Roche et al., 2015).

Individual communication. Farmers are more inclined to act in response to information that is tailored to their individual circumstances (Garforth, 2015). One-on-one communication between the farmer and their social referents allows for the personalization of information and advice to fit each farmer's approach (Kristensen and Jakobsen, 2011a; Santman-Berends et al., 2014; Table 2-5 and Figure 2-2). Referents, and farmers' preferences for their advice vary for each producer, but include veterinary practitioners, colleagues, nutritionists, hoof trimmers, DHI personnel, feed representatives, milk equipment advisors, product salespeople, inseminators, researchers, contractors, farm staff, family, friends, and neighbors (Jansen et al., 2010c; Leach et al., 2010a; Relun et al., 2013; Lindahl et al., 2015; Ritter et al., 2015; Wilson et al., 2015; Frössling and Nöremark, 2016). The majority of studies recognize that peers affect farmers' decision-making (Lindberg et al., 2006; Lam et al., 2007; Elliot et al., 2011; Hansson and Ferguson, 2011; Swinkels et al., 2015), but a United Kingdom study reported that what others were saying or doing had little influence on farmers' prevention and control efforts (Garforth et al., 2013).

Further research is needed into the effect of farmers' social network on their management decisions (Burton, 2004; Hansson and Ferguson, 2011), but it is well established that veterinary practitioners often have a profound influence on farmers' decision-making due to their generally good relationship with the farmer and the farmer's trust in their advice (e.g., Jansen et al., 2010c; Young et al., 2010a; Derks et al., 2013a; Sayers et al., 2013; Alarcon et al., 2014). Regular interactions between a farmer and a herd veterinarian increase familiarity with each other's beliefs, values, and aspirations, and enhance trust (Jansen and Lam, 2012; Table 2-5). Even when farmers receive information or advice from other sources, they commonly follow up or check with their local practitioner (Garforth, 2011; Garforth et al., 2013). In one study, if the herd veterinarian thought a mastitis treatment schedule was important, farmers generally agreed (Lam et al., 2007). In others, the veterinarian's advice has been instrumental in decreasing antibiotic usage in cattle (Jones et al., 2015), and in farmers' decisions about whether or not to enroll in a voluntary Johne's disease control program (Hop et al., 2011; Ritter et al., 2015). The majority of farmers stated that they would most likely adopt biosecurity strategies or implement a control program if it was recommended by their herd veterinarian (Ellis-Iversen et al, 2010;

Brennan and Christley, 2013). These high levels of trust and confidence mean that farmers (self-reportedly) take up their veterinarians' advice in more than 80% of cases (Derks et al., 2013a; Table 2-5).

Although many farmers believe that their herd veterinarian works for and with them, negative perceptions mentioned by farmers include a lack of specialized veterinary knowledge or insufficient provision of information by their veterinarian (Kaler and Green, 2013; Alarcon et al., 2014; Table 2-5). Furthermore, more than 30% of sheep and cattle veterinarians believed that uptake of on-farm biosecurity measures was inadequate due to a lack of veterinary time, interest in, or knowledge of farm-level biosecurity measures (Gunn et al., 2008). These perceptions could explain why many cattle and sheep farmers in the United Kingdom interact with their herd veterinarian only “occasionally” or “as needed,” and only 12% of Australian cattle farmers regarded veterinary practitioners as the most useful method of communication (Jonsson and Matschoss, 1998; Heffernan et al., 2008).

Even if the farmer-veterinarian relationship is good and veterinarians have excellent technical knowledge, their success at motivating farm changes will depend on their skills to effectively communicate advice (Mee, 2007; Noordhuizen et al., 2008a,b; Atkinson, 2010b; Adams and Kurtz, 2017; Table 2-5). Unfortunately, the communication skills of veterinary practitioners appear to be less than optimal (Kristensen and Enevoldsen, 2008; Jansen et al., 2010a; Derks et al., 2013b; Cipolla and Zecconi, 2015). This may lead to inadequate uptake of advice, because the farmers are not sufficiently guided in their decision or because veterinarian and farmer have different perceptions of the feasibility of proposed management changes (Sorge et al., 2010a; Roche, 2014).

Peripheral extension tools. The effect of central routes of communication (i.e., routes that assume farmers make rational decisions when approached by the right advisors and presented with the right arguments) will be limited for farmers who are not motivated enough to adopt suggested changes (Jansen et al., 2010b; de Lauwere et al., 2012). For these farmers, a peripheral approach, as extensively studied in social science and often used in marketing, sales, or advertising, can be very effective. Peripheral routes of communication use cues, heuristics, or “nudges” instead of comprehensive science-based argumentation to unconsciously elicit the desired behavior (Cialdini, 2001). The peripheral approach is especially suitable for altering single management practices. For example, a Dutch national mastitis campaign provided farmers with free glove samples, sent humorous postcards reminding farmers to wear gloves during milking, and gave discounts on gloves from the campaign website (Jansen et al., 2010b). During the campaign, the use of milking gloves increased substantially and farmers' attitudes about their use became more positive, which could explain why they continued to use gloves a year after the start of the campaign. It might be worthwhile to consider cooperation with commercial companies (e.g., glove manufacturers) that want to sell their products and have expertise in marketing (Jansen and Lam, 2012; Table 2-5).

2.4.2. Within-farm communication

Management decisions on the farm are often not the responsibility of only one person. Family members or an employed farm manager might have an important influence and should be involved in decision-making (Barkema et al., 2013). However, even after decisions have been made, management is often carried out by others (e.g., farm workers not involved in the decision-making; Blackstock et al., 2007). A lack of communication between decision-makers and workers is likely associated with a lack of on-farm biosecurity uptake, especially if the personnel are unaware of decisions made, of disease transmission pathways, and of the reasons for measure implementation (Vaillancourt and Carver, 1998; Racicot et al., 2012b; Table 2-5).

The implementation of standard operating procedures and engagement of employees are important aspects of farm management to ensure consistent herd performance and prevent disease (Reneau, 2001; Cavazos, 2003; Barkema et al., 2018; Schewe et al., 2015). For example, dairy cows' udder health could be improved by implementing communication strategies for milkers (delivered by veterinarians and consultants on mastitis control), as well as by strictly enforcing protocols and (financial) penalties if bulk-tank SCC increased (Izak et al., 2011; Schewe et al., 2015).

The education and engagement of foreign farm personnel can be a major challenge because of different languages and cultural backgrounds (Atkinson, 2010a; Barkema et al., 2013; Table 2-5). Latino employees from 12 Michigan dairy farms were 3 times less likely to believe they had learned milk protocols from herd owners or managers (as opposed to learning from other employees or being self-taught) and 4 times less likely to know the SCC goals of the dairy farm than English-speaking employees (Erskine et al., 2015). Whereas simple visible cues (e.g., signs, cameras) have been proven to increase compliance with recommended procedures for hand hygiene in hospitals and with biosecurity strategies on poultry farms, it is doubtful whether these cues have a lasting effect, and more sustainable strategies need to be developed (Racicot et al., 2012a; Smiddy et al., 2015). We can assume that farm employees' reasons to perform recommended biosecurity measures (or not) are as diverse as their employers' reasons, and more research into the knowledge, attitudes, and compliance of farm employees relating to recommended practices will help improve adherence to farmers' management strategies (Delabbio, 2006).

2.4.3. Dissemination of research results and advice to farmers

Research is important for generating new knowledge and providing farmers with best management recommendations. The presentation of research findings about disease control programs can also increase farmers' awareness of available programs (Tsui et al., 2006). Furthermore, for any herd health intervention program, the accurate detection and characterization of the current situation is essential for estimating changes and providing feedback on the success of the intervention (Bell et al., 2006; Huijps et al., 2009). Allowing farmers and stakeholders timely access to updated and accurate information about disease status for their own herd, as well as at a national/provincial level, enables them to compare their performance (i.e., benchmarking), make informed decisions, and may motivate on-farm changes (Lindberg et al., 2006; Østerås and Sølverød, 2009; Table 2-6).

Although farmers generally appreciate research and have faith in its credibility (Sorge et al., 2010a; Garforth et al., 2013), they are often unaware of current studies being done by universities and criticize the lack of communication of relevant research findings (Alarcon et al., 2014; Table 2-6). Furthermore, some farmers disapprove of how findings are translated to recommended management strategies and question the relevance of the research being conducted (Garforth et al., 2013; Alarcon et al., 2014; Table 2-6). A comparison of educational materials on the Internet revealed that recommendations about biosecurity measures for different species and classes of livestock contained substantial variations by source, as well as within and among commodity groups (Moore et al., 2008). Furthermore, the biosecurity-related opinions and practices of dairy service providers (i.e., veterinary practitioners and dairy advisors) were often inconsistent, and communication across these groups was poor (Sayers et al., 2014; Table 2-6). These discrepancies could lead to confusion among farmers and farm advisors, and may serve as justification to avoid implementing management changes or to select only a few recommendations that are insufficient to effectively reduce disease transmission (Moore et al., 2008; Wilson et al., 2015). In particular, if farm management recommendations are developed by different sources, inconsistencies in terminology use and interpretation can lead to confusion that inhibits desired uptake (Moore et al., 2008; Brightling et al., 2009).

2.4.4. Summary: extension and communication

Farmers differ in their preferences for receiving information about farm management and disease prevention and control. A range of extension tools should be used in conjunction to deliver status updates and consistent management recommendations that are relevant and practical for the farmer (Jansen et al., 2010c; Ritter et al., 2015). Whereas mass media can be used to easily distribute information to a broad audience, more personal approaches such as discussion groups or one-on-one communication are likely to have a greater effect on motivating on-farm change. Still, further research is needed to investigate the extent and character of discussions about disease prevention and control between farmers and their advisors, and whether communication training for farm advisors (or prospective farm advisors) can positively influence farmer behavior (Derks et al., 2013a; Pritchard et al., 2015). Peripheral routes of communication can reach farmers who are not motivated by external or internal drivers. In this area, veterinary medicine can learn from social science and should further confirm the applicability of peripheral communication for the livestock sector.

Motivating on-farm decision-makers to adopt recommended management practices is important, but adequate implementation of management strategies by farm personnel is also necessary to decrease risk of pathogen transmission. Agricultural communication should, therefore, also include farm personnel.

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Table 2-1. Recommendations to enhance farmers' problem awareness and sense of responsibility

• Confirm and communicate the importance of the disease to farmers.[1]
• To alter farmers' frame of reference, provide guidelines of what is considered "normal" or what is the targeted goal (consider using case studies/stories to convey "normal"). Use benchmark tools to compare individual farm performances against a standard or other farmers' performances.[2]
• Educate farmers that even if they do not see the disease, they still may have subclinically infected (infectious) animals causing substantial losses.[3]
• If diagnostic tests lack sensitivity, communicate to farmers that the issue might be bigger than results suggest and, if possible, provide estimates of the true incidence and/or prevalence.[4]
• Educate farmers that introduction of disease increases without proper preventive measures and is possible, even if they perceive the risk as low.[1]
• Clarify and justify farmers' responsibilities for disease control while encouraging them through collective action to take on this responsibility.[5]

[1]Lam et al., 2013

[2]Kleen et al., 2011; Barkema et al., 2013

[3]Wassink et al., 2005

[4]Wolf et al., 2014

[5]Heffernan et al., 2008

Table 2-2. Recommendations to enhance farmers' belief in the effectiveness of proposed strategies

• Promote solid, ideally evidence-based, management recommendations, taking most current knowledge into account and provide information on effectiveness of various strategies customized for this specific farm.[1]
• If possible, report on the success of the implemented management strategies and/or comparable prevention and control programs.[2]
• Prepare farmers that it might take time to observe positive effects of preventive measures and set realistic goals for the decrease in disease incidence and prevalence.[3]
• Use demonstration herds or case studies/examples that support strategy effectiveness.[4]

[1]Brightling et al., 2009

[2]Ritter et al., 2015

[3]Lam et al., 2013

[4]Ivemeyer et al., 2015; Roche et al., 2015

Table 2-3. Recommendations to enhance farmers' (perceived) ability to implement recommended changes

- Create a context that facilitates on-farm changes (e.g., by supporting the implementation of biosecurity measures financially).[1]
- Share "success stories" of successfully implemented management changes or offer practical demonstrations on producers' farms of options for management adoption to improve farmers' attitudes, intentions and uptake of recommended measures.[2]
- Disseminate sufficient information to educate farmers about the issue, proposed control strategies and the control program, including expected time and financial commitments to avoid insecurities and misconceptions that prevent enrollment.[3]
- Provide farmers with customized recommendations for on-farm improvements that are feasible and practical for their operation.[4]
- Consider using structured risk assessments and management plans to facilitate discussion about (perceived) constraints and to break the complexities of targeted disease control into parts, which can be managed easier.[5]

[1]Weber and Lam, 2012

[2]Ivemeyer et al., 2015; Roche et al., 2015

[3]Brightling et al., 2009

[4]Ritter et al., 2015; Roche et al., 2015; Toma et al., 2015

[5]Wilson et al., 2015; Wolf et al., 2015

Table 2-4. Recommendations to enhance (perceived) benefits of disease prevention and control

• Prioritize management suggestions that require low investments but are still expected to have a positive effect on risk reduction.[1]
• Raise farmers' awareness of (non-)economic benefits that can be expected when successfully implementing changes.[2]
• Encourage farmers to participate in certification programs and / or purchase animals only from farms that are certified.[3]
• Consider supporting farmers financially (e.g., for testing, herd visits of veterinary practitioners or implementation of strategies).
• Consider using (financial) incentives or penalties to motivate achieving predetermined goals.[4]
• Assess producers' views on perceived negative effects of disease control and work toward solutions that take these concerns into account.
• Address internal drivers such as farmers' pride or job satisfaction when motivating best management practices.[5]

[1]Barkema et al., 2013

[2]Simon-Grife et al., 2013

[3]Kovich et al., 2006

[4]Valeeva et al., 2007; Lam et al., 2010

[5]Leach et al., 2010b

Table 2-5. Recommendations to enhance success of extension tools

- Offer a wide variety of information sources to farmers to account for different information-seeking behavior.[1]
- Motivate regular interactions between veterinary practitioners and farmers (for example, through regular herd health visits).[2]
- Prepare farm advisors to educate on disease control and clarify their role in the disease control program. Provide them with free-of-charge educational materials.[3]
- Train veterinary practitioners (and other farm advisors) in effective communication skills.[4]
- Consider using peripheral extension tools, potentially in cooperation with commercial companies.[5]
- Provide educational materials and training programs for farmers and employees that enhance farm personnel compliance (if applicable, account for different languages and cultural backgrounds).[6]
- Maintain consistent messaging across sources.[7]
- Where possible, tailor extension methods used with personal preferences.[8]

[1]Garforth, 2013; Jansen and Lam, 2012

[2]Jansen and Lam, 2012

[3]Sorge et al., 2010b; Ellis-Iversen et al., 2010

[4]Adams and Kurtz, 2017

[5]Jansen et al., 2010b

[6]Izak et al., 2011; Schewe et al., 2015

[7]Moore et al., 2008

[8]Roche, 2014; Ritter et al., 2015

Table 2-6. Recommendations to enhance links between research and agricultural extension

- Provide farmers and stakeholders with relevant data from their own farm or farms in their region.[1]
- Record the pre-intervention status on herd- and national level and monitor changes of recorded parameters (e.g., disease incidence / prevalence 'baseline', adoption of relevant management practices). Where feasible, routine data collection procedures might facilitate this progress and offer benchmarking tools.[2]
- Publish and translate relevant research findings into applicable management solutions that are SMART (i.e. specific, measurable, achievable, realistic/relevant and time bound).[3]
- Publish and translate relevant research findings into easy to understand text and video messages for farm journals and social media.
- Deliver consistent messages that are applicable without modification across the whole industry. Perhaps develop a central independent body working with producer input to devise these messages.[4]
- Include stakeholders, social scientists and communication specialists during the development and delivery of a prevention and control program.[5]

[1]Lindberg et al., 2006

[2]Bell et al., 2006; Raizman et al., 2006

[3]Mee et al., 2007

[4]Brightling et al., 2009; Wilson et al., 2015, Moore et al., 2008

[5]Jansen and Lam, 2012; Klerkx et al., 2012; Wilson et al., 2015

Figure 2-1. Socio-psychological factors influencing adoption of on-farm management strategies for improved infectious disease prevention and control

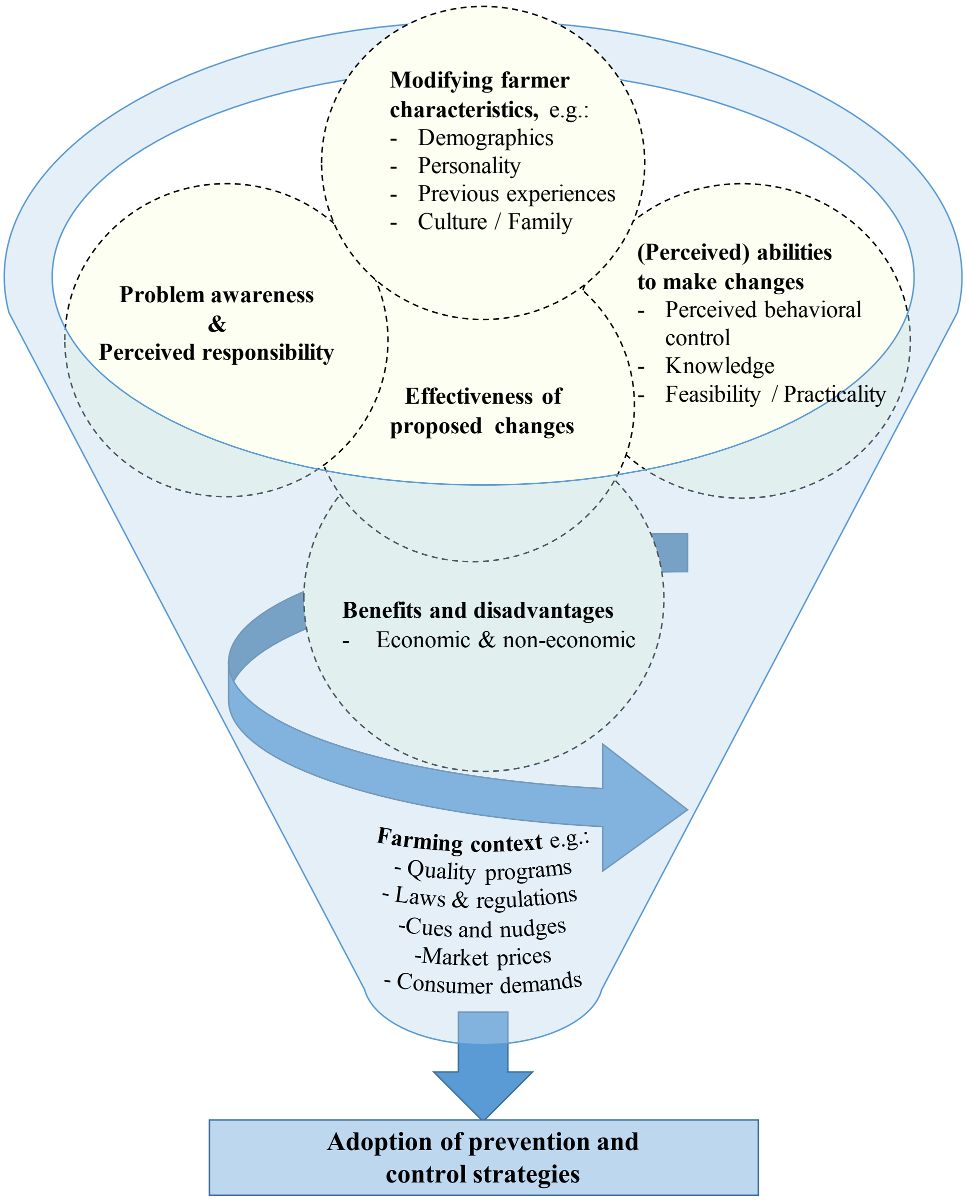
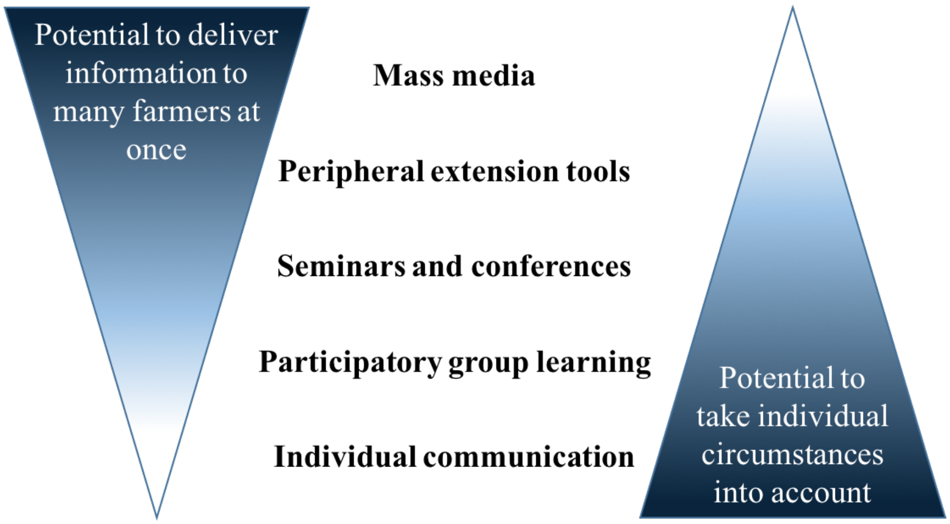


Figure 2-2. Potential of various agricultural extension tools to deliver information simultaneously to many farmers and tailor communication according to individual circumstances



CHAPTER 3: Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program

3.1. Abstract

The Alberta Johne's Disease Initiative (AJDI) is a voluntary, management-based prevention and control program for Johne's disease (JD), a wasting disease in ruminants that causes substantial economic losses to the cattle industry. Despite extensive communication about the program's benefits and low cost to participating producers, approximately 35% of Alberta dairy farmers have not enrolled in the AJDI. Therefore, the objective was to identify differences between AJDI nonparticipants and participants that may influence enrollment. Standardized questionnaires were conducted in person on 163 farms not participating and 61 farms participating in the AJDI. Data collected included demographic characteristics, internal factors (e.g., attitudes and beliefs of the farmer toward JD and the AJDI), external factors (e.g., farmers' JD knowledge and on-farm goals and constraints), as well as farmers' use and influence of various information sources. Nonparticipants and participants differed in at least some aspects of all studied categories. Based on logistic regression, participating farms had larger herds, higher self-assessed knowledge of JD, better understanding of AJDI details before participation, and used their veterinarian more often to get information about new management practices and technologies when compared with nonparticipants. In contrast, nonparticipants indicated that time was a major on-farm constraint and that participation in the AJDI would take too much time. They also indicated that they preferred to wait and see how the program worked on other farms before they participated.

3.2. Introduction

Johne's disease (JD) is an infectious chronic enteritis caused by *Mycobacterium avium* ssp. *paratuberculosis* (MAP). Clinical signs in dairy cattle include intermittent diarrhea, loss of body condition, and reduced milk production (Tiwari et al., 2006). In the absence of an effective cure, affected animals eventually die or are culled due to poor condition. With approximately 70% of Alberta dairy herds being infected with MAP (Wolf et al., 2014a), JD leads to substantial economic losses for individual farmers and the Canadian dairy industry (Wolf et al., 2014b). Furthermore, JD may also be associated with Crohn's disease in humans (Barkema et al., 2011). A causal link between JD and Crohn's disease, or even the perception that MAP is a health risk to humans, could have a considerable negative effect on the dairy industry (Groenendaal and Zagmutt, 2008; Barkema et al., 2011). Preventing disease introduction into a herd, reducing infections of calves, and not using contaminated equipment are currently the best practices to decrease transmission of MAP (Sweeney et al., 2012; Barkema et al., 2014); however, implementation of these control measures requires behavioral changes by producers. To increase uptake of control strategies for JD and to provide province-wide standards, the Alberta Johne's Disease Initiative (AJDI) was launched in 2010 (Wolf et al., 2014b). The AJDI is a voluntary, management-based control program; its primary purposes are to make farmers more aware of JD and to decrease disease prevalence. As part of the AJDI, MAP status of participating farms is assessed annually, based on environmental fecal samples. Prior to program enrollment, dairy farmers are generally unaware of their status because private testing for MAP is uncommon. On-farm risk assessments are another important aspect of the program;

veterinarians trained for AJDI administration identify critical management practices and develop a herd-specific management plan to reduce the risk of MAP transmission. Despite comprehensive extension efforts and the low cost of the program to participants, 35% of Alberta's approximately 580 dairy farms were not enrolled in the AJDI at study initiation in 2012 (Wolf et al., 2014a).

Why some farmers do not implement suggested management practices to improve animal health, although it would be apparently beneficial, has become an important area of research (Ellis-Iversen et al., 2010; Jansen and Lam, 2012). In recent years, several theories have been developed to understand and predict human behavior (Coleman and Pasternak, 2012). Two of the most widely used frameworks in health behavior research are the health belief model (Janz and Becker, 1984) and the theory of planned behavior (Ajzen, 1991). The former concludes that attitudes toward a disease (e.g., does the farmer perceive the disease as a problem), as well as the perceived effectiveness of the proposed strategy to overcome the disease, are key factors for behavioral change (Jansen and Lam, 2012), whereas the latter regards attitudes toward the behavior, subjective norms, and perceived self-efficacy as important influences on intentions to change behavior (Ajzen, 1991). Since their development, both models have been adapted numerous times, according to specific research questions. One example of a framework that draws from previous theories is the social ecology model (Panter-Brick et al., 2006) that was modified and used for the purpose of this study (Figure 3-1). This model has previously been validated by Ellis-Iversen et al. (2010) to identify and explain motivational factors for implementation of disease control programs on cattle farms. According to the model, farmers' decision-making process depends on intrinsic and extrinsic factors (Ellis-Iversen et al., 2010).

Intrinsic factors consist of farmers' attitudes, beliefs, and norms. For this study, intrinsic factors relate to farmers' evaluation of JD and the proposed approach to overcome it. Extrinsic circumstances include resources that the farmer has available to make changes. Herein, extrinsic factors include farmers' knowledge about JD, their skills and abilities, but also disabling factors such as limited time or economic constraints. If farmers' intrinsic or extrinsic factors are not favorable toward JD or the AJDI, these factors constitute barriers hampering enrollment and hence uptake of risk-reducing behavior (Ellis-Iversen et al., 2010).

Because preferred sources of information varied among farmers (Russell and Bewley, 2011; Garforth, 2012; Brennan and Christley, 2013), another potential impediment for enrollment is that external stimuli such as applied extension strategies have been ineffective in reaching and educating some farmers about the AJDI and advantages of participation. The objectives of the study were, therefore, to compare AJDI participants and nonparticipants with regard to (1) general demographics, (2) intrinsic characteristics toward JD and JD control, (3) extrinsic factors, and (4) external stimuli.

3.3. Materials and methods

3.3.1. Herds and questionnaire

Alberta dairy farmers living within 350 km of Calgary, Alberta, Canada, were eligible for the study (i.e., 179 (86%) of all nonparticipating farms and 353 (94%) of all participating farms). Between September 2012 and April 2014, all eligible nonparticipants and, due to time and budget considerations, a randomly selected sample of 69 participants were contacted by telephone. One hundred sixty-three (91%) of the contacted nonparticipants as well as 61 (88%) of the contacted participants agreed to be surveyed. Reasons for refusal were time constraints, illness, travel, or lack of interest. A farm visit was scheduled with each farmer to be interviewed; those interviewed were responsible for herd management and decision making on their farms.

A questionnaire to be used in the interviews was designed, taking into account current knowledge regarding JD and factors influencing farmers' mindset and uptake of preventive measures. A team of extension specialists, veterinary epidemiologists, and veterinary practitioners developed a pilot questionnaire, based on their expertise and relevant literature, which was tested on 13 participating and 10 nonparticipating farms. Feedback was received with regard to content and clarity. Farmers that provided feedback were afterward excluded from the study, and pilot surveys were not included in the analysis. After adjustment, the final questionnaire, containing 38 questions, addressed the following topics: (1) general demographics, (2) intrinsic factors toward JD and the AJDI (i.e., farmers' attitudes, beliefs, and norms), (3) extrinsic factors (i.e., main on-farm goals and constraints, as well as farmers' self-assessed knowledge of JD), and (4) external stimuli (i.e., use and influence of information sources; see Appendix 1a-c. Possible answers to the questions consisted of order rankings, factual assessments, yes/no replies, and 5-point Likert items (Likert and Hayes, 1961). Face-to-face interviews were conducted by 4 trained interviewers on the producers' farms. The farmer received a hard copy of the survey to read, while the interviewer read the questions aloud and documented the farmer's answer. To minimize variability, interviewers were trained to conduct the surveys in a neutral manner. On average, 30 min was required to complete the questionnaire.

3.3.2. Statistical analyses

Each of the 4 themes of the questionnaire (i.e., general demographics, intrinsic factors, extrinsic factors, and external stimuli) was first investigated separately for associations between various predictors and the outcome. Thereafter, a final logistic regression model, which consisted of variables from the 4 themes, was developed.

For analysis of the 4 primary themes, levels of a variable were combined if the number of participants or nonparticipants was <5 (to avoid unstable parameter estimates). Before entering variables in multivariable regression analyses, collinearity between variables within a theme was assessed using Pearson correlation coefficient for continuous variables and Kendall's tau-b for ordinal variables. If 2 variables were highly correlated ($|rho| \geq 0.7$ in continuous case or $|tau\text{-}b| \geq 0.3$ in ordinal case), only 1 was retained, based on interpretability, missing data, and correlation with other variables.

List-wise deletion within models was used (i.e., observations of a farmer were only deleted for a particular model in case of missing data relevant to that model, although the farmer could still provide information for another model).

Distribution of the number of responses for each variable level was assessed, and the level on either end of the scale (e.g., 1 or 5) with the higher frequency in responses was selected as reference level for regression model analyses. Variables for individual multivariable regression models were selected based on univariable association with participation at $P < 0.20$. Variables for the final model were selected based on $P < 0.02$ in the Wald test of the respective model. Interaction terms were included in the final model and collinearity between variables was assessed, applying the same criteria as mentioned above. Manual backward elimination was used to identify the most significant predictors of participation in each multivariable regression model. In detail, the variable with the highest P-value in the Wald test (Stata command: test) was excluded from the model, given that $P > 0.05$ in every level of that particular variable. Additionally, the remaining variables were assessed for confounding (i.e., a 30% change in the estimate) by the removed variable. If confounding was present, the variable remained in the model. This procedure was continued until (1) no predictor had $P > 0.05$ in the Wald test; (2) no level of a variable was $P > 0.05$; or (3) the likelihood ratio test comparing the full model with the reduced model was $P < 0.05$ (in this case, the last removed variable was inserted back into the regression model). Demographic variables with $P < 0.20$ were considered as confounders in every multivariable logistic regression model.

A probability level of $P < 0.05$ was considered significant. Principal component analysis was performed in SPSS (IBM Statistics, Version 22 for MacOSX, Armonk, NY), and all other statistical analyses were done in Stata 12.1 (Stata Corp., College Station, TX).

General demographics. Number of lactating cows, current average bulk tank SCC, and daily production per cow were deemed continuous variables (subsequent natural logarithmic transformation ensured a normal distribution). Categorical classification of age of producer (cut points: ≤ 30, 31–40, 41–50, > 50 yr), years of experience as dairy producer (cut points: ≤ 10, 11–20, 21–30, > 30 yr), years until retirement (<3, within 3–5, within 5–10, > 10 yr), and education (cut points: ≤ 12 yr, college diploma, university degree) were used for analysis.

Intrinsic factors. Data on beliefs, norms, and attitudes toward JD and AJDI were collected using statements that farmers rated on 5-point Likert items (Likert and Hayes, 1961). For example, AJDI participants and nonparticipants were asked to express their agreement to statements such as “Reducing JD prevalence may help protect the Canadian dairy industry,” or their concern about JD “How much does JD worry you”? A total of 28 Likert items were included to explore intrinsic factors in the questionnaire.

Data analysis for intrinsic factors was based on 3 steps: (1) principal component analysis (PCA) was used to reduce the number of variables in the data set and to reduce multicollinearity among variables; (2) univariable logistic regression analyses was performed to assess associations between the reduced data set and participation status; and (3) multivariable logistic regression was carried out to include variables with $P < 0.20$ from univariable analyses.

First, a correlation matrix was generated and variables with high singularity were excluded. Multicollinearity among the remaining variables was assessed based on the determinant of variance, with a threshold of >0.0001 to ensure suitability of the data set for PCA (Field, 2005). Adequacy of the data set was further examined by assessing the overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and individual KMO values based on a threshold of 0.5, as well as Bartlett’s test of sphericity (Field, 2005). Extracted components were selected based on inspection of the scree plot, the total amount of variance explained, and eigenvalues >1 (Kaiser, 1960; Dohoo et al., 1997). Because correlation between components could not be excluded, direct oblimin rotation was applied to facilitate interpretability (Field, 2005). Component loadings >|0.35| were used in interpretation of extracted components. A test for reliability using Cronbach’s $\alpha > 0.7$ as the threshold value (Field, 2005) was done to assess internal consistency of each extracted component.

Second, univariable logistic analysis was performed to identify predictor variables that were associated ($P < 0.20$) with participation in the AJDI. Predictor variables tested in univariable analysis included components extracted through PCA and independent discrete intrinsic variables that were not compromised in any component.

Third, all intrinsic factors identified in step 2 were included in the multivariable logistic regression analysis and a stepwise logistic regression (with backward elimination) was done to identify differences between nonparticipants and participants.

Extrinsic factors. Producers were asked to identify their largest on-farm goals and constraints by selecting the 3 choices most relevant to them (from 8 or 9 possibilities, respectively), and rank their answers. Data for these rank order questions were analyzed by assigning 3 points to the first-choice item, 2 points to the second-choice item, and 1 point to the third-choice item. Dummy variables were created for on-farm goals and constraints, and rankings 1 to 3 were compared with the baseline of not being among the top 3 items. Variables with a $P < 0.20$ from the Mann-Whitney U test or from the univariable logistic regression analysis were included in the extrinsic multivariable logistic regression model. To evaluate self-assessment of JD knowledge, farmers were asked to respond to several statements regarding JD (e.g., “I know the clinical signs of JD” or “I know the general transmission of the disease”) by answering yes or no. Differences between participants and nonparticipants with regard to each statement were tested using chi-squared or Fisher’s exact tests on contingency tables. Knowledge was then included in the logistic regression model as a summary measure by summing positive responses (i.e., yes) for every farmer.

External Stimuli. How often farmers used various information sources to obtain information about new management practices and technologies was assessed on 5-point Likert items. Scores of 1, 3, and 5 indicated that the farmer never, sometimes, and always used the particular source, respectively. Similarly, 5-point Likert items were used to assess what information sources influenced AJDI participation. A score of 1 meant a particular source influenced AJDI enrollment very negatively, whereas a score of 5 meant a particular source had a very positive influence on AJDI enrollment. Here, the farmer also had the option to choose not applicable if no information was received from a particular source (as opposed to a score of 3 where information was received from the source, but did not have any influence on AJDI participation). Logistic regression was used to assess whether use or influence of various information sources was associated with participation in the AJDI.

Final model. To select the most relevant variables for the final model, all covariates with a significant association with participation in any of the previous multivariable logistic regression models were considered. To limit the number of variables in the final model, only variables with $P < 0.02$ in the Wald test were included. Interaction terms were generated and backward elimination was done.

3.4. Results

3.4.1. General demographics

The AJDI participants had more lactating cows compared with nonparticipants (median of 90 and 120, respectively; Table 3-1). Nonparticipants intended to retire earlier compared with participants; in that regard, 20 (12%) of the nonparticipants and 2 (3%) of the participants intended to retire within the next 5 yr. Age of the farmer was highly correlated with years until expected retirement and years as a dairy producer (tau-b = −0.52 and 0.74, respectively). Similarly, years until expected retirement was highly correlated with years as a dairy producer (tau-b = −0.48). Based on the small P-value and plausibility, years until retirement stratified into 2 groups was selected for multivariable regression analysis.

3.4.2. Intrinsic factors

Using PCA was supported by the absence of extreme multicollinearity (determinant of variance = 0.02) and individual KMO values in the anti-correlation matrix of > 0.65. Also, an overall KMO of 0.793 resulted in a significant Bartlett's test of sphericity (chi-squared = 713, df = 78, $P < 0.001$). Selection of components based on eigenvalues >1 and inspection of the scree plot initially resulted in 4 multi-item measures. However, the fourth component failed the test for reliability (Cronbach's $\alpha = 0.62$), and was therefore excluded from further PCA analysis. The 3 remaining components explained 55% of the variance and represented distinct aspects of intrinsic factors that were associated with AJDI participation (Table 3-2). Component 1 represented farmers' general perception of the consequences of JD for the dairy industry. Component 2 was highly correlated with the importance of minimal cost and time investments for AJDI participation. Component 3 represented farmers' concern and worry about JD.

Univariable regression analyses resulted in associations ($P < 0.20$) with AJDI participation of components 1 and 3, as well as 14 additional discrete intrinsic variables not included in any of the components (Appendix 2).

Results from the multivariable logistic regression model consisted of 7 intrinsic variables that were associated with participation (Table 3-3). The most central findings when comparing AJDI nonparticipants and participants (who were asked to answer retrospectively before they participated) were that nonparticipants agreed more strongly that new management practices would take too much time, the costs of the AJDI would outweigh the benefits, and control of other diseases was more important to them. Compared with participants before enrollment, nonparticipants more often did not know if they expected their herd to be infected with MAP. Nonparticipants more often neither agreed nor disagreed with the statement that they understood AJDI details well, whereas participants, answering retrospectively, more often strongly disagreed. Also, nonparticipants agreed more strongly with the statement that animal trade and export will be unaffected by JD, and it was more important to them to know that the AJDI "has worked" on other farms.

3.4.3. Extrinsic factors

Nonparticipants and participants in the AJDI most often ranked "improve herd health," "increase herd longevity," and "increase net profit" among their top 3 goals on their farms (Table 3-4). Time, financial resources, and facilities were the most common constraints selected in both groups. Participants perceived their knowledge of JD overall as better compared with nonparticipants (Table 3-5), although both groups stated that they generally know that JD exists. Furthermore, > 50% of producers in both groups were familiar with the clinical signs of JD, some issues with controlling JD, the general transmission of the disease, and ages of greatest susceptibility. Besides the difference in self-assessed knowledge, multivariable logistic regression revealed that improved herd health was more often a main goal for AJDI participants compared with nonparticipants (Table 3-6), and "time" as well as "capability of labour" were more often main constraints for nonparticipants compared with participants.

3.4.4. External stimuli

The herd veterinarian was used most often as the source to obtain general information about new management strategies or technologies in both AJDI participants as well as nonparticipants, whereas the annual Western Canadian Dairy Seminar and communication by e-mail were least often used (Figure 3-2). Generally, few farmers stated that a particular source had a negative influence on their enrollment in the AJDI (Figure 3-3), with <3% of the farmers (exclusively nonparticipants) stating that the veterinarian or mastitis management workshops influenced them negatively and a maximum of 10% of farmers indicated that the breed association had a negative influence on their participation. For both groups, the herd veterinarian had the most positive influence to motivate enrollment. However, many of the information sources farmers used did not provide information on AJDI participation. In particular, more than one-third of producers were not reached by the AJDI website, mastitis management workshops, breed associations, producer workshops, or DHI staff (65, 48, 40, 36, and 34%, respectively).

Multivariable logistic regression analysis revealed that AJDI nonparticipants used the telephone more often to get information about new management strategies or technologies compared with AJDI participants (Table 3-7). In contrast, participants used their veterinarian and workshops or seminars more often compared with nonparticipants. Participants scored AJDI mail-outs more often as strong positive influence on AJDI enrollment (compared with nonparticipants who more often rated AJDI mail outs as noninfluential). Nonparticipants more often stated that they did not receive any information on AJDI participation from DHI than participants.

3.4.5. Final logistic regression model

The major differences between AJDI nonparticipants and participants (based on the final logistic regression model) were that participating farmers had larger herds, a higher self-assessed knowledge of JD, a better understanding of AJDI details before participation, and used their herd veterinarian more often compared with nonparticipants (Table 3-8). In contrast, nonparticipants perceived time as a greater on-farm constraint and it was more important in their consideration about AJDI participation that the program has worked on other farms. No interaction terms remained in the final multivariable logistic regression model.

3.5. Discussion

Control of JD is an example of targeted biosecurity on dairy farms to prevent disease introduction into the herd and transmission of the disease within the herd. In previous studies, larger livestock enterprises were more likely to have implemented higher biosecurity measures, due to better recognition of disease risk (Nöremark et al., 2010; Valeeva et al., 2011; Garforth et al., 2013). Similarly, AJDI participants had larger herds than nonparticipants.

Notwithstanding, AJDI participants were not more concerned about JD and evaluated its effects on the dairy industry similar to AJDI nonparticipants. Instead, individual on-farm considerations appeared to be the key factor for enrollment. Similarly, Hop et al. (2011) argued that factors related to individual farm performance were more important motivators than concern for consumer health and performance of the dairy sector. Therefore, it was not surprising that extrinsic factors such as financial and time considerations were noted as important impediments to enrolling in voluntary infectious disease control programs, and to improving biosecurity measures (Hop et al., 2011; Garforth et al., 2013). In the present study, nonparticipants did not consider finances a greater on-farm constraint compared with AJDI participants. However, they often strongly agreed with the statement that AJDI costs outweighed the benefits. Considering the producers did not have to pay for environmental testing and risk assessment when enrolled in the AJDI (Wolf et al., 2014b), this perception of nonparticipants could either arise from their lack of knowledge of AJDI details, or from their expectations that the recommended management changes would be too costly. Also, nonparticipants believed that management practices associated with the AJDI would take too much time; furthermore, they regarded time available for on-farm duties as a greater constraint. Although some recommended JD control strategies might require considerable time, cost, or both, often small changes can decrease the risk of MAP transmission. When communicating principles of the AJDI to nonparticipating farmers, it is important to highlight that the veterinarian is advised to take farmers' individual goals and constraints into account and develop feasible changes in collaboration with the farmer. This individual approach aims to make JD control more attainable for farmers by selecting specific management strategies from an extensive (and potentially overwhelming) pool of recommended JD control measures. Additionally, for farmers that weigh the expected benefits of JD control against time or financial impact, it should be highlighted that these control strategies might also decrease other fecal-orally transmitted diseases (McKenna et al., 2006) and reduce economic losses. This argument might facilitate enrollment, especially because improved herd health and increased net profit were among the most important on-farm goals for nonparticipants. Similar to participants, nonparticipants also aimed for increased herd longevity and improved herd fertility. Therefore, it can be argued that it is often not the goal itself that differed between groups, but participants seemed to consider the AJDI program beneficial to achieve these goals.

Consistent with findings in a Dutch JD program (Hop et al., 2011), knowledge about JD aspects was positively associated with participation in the control program. Farmers that are aware of potential losses associated with the disease are probably more willing to take action to prevent transmission; in contrast, lack of knowledge could impede uptake of favorable management strategies (Alarcon et al., 2014). However, it cannot be determined whether AJDI participants gained additional knowledge by participation in the program. Knowledge and awareness of a disease are important, albeit not sufficient for implementation of prevention strategies. In that regard, perceived efficiency and practicability are also important considerations for producers (Jansen and Lam, 2012; Garforth et al., 2013). Nonparticipants seemed to be more deferring about the AJDI and it was more important to them that the program has worked on other farms before they consider enrollment. Seemingly, these producers were hesitant to enroll and invest money and time before they had sufficient self-perceived evidence that the AJDI was successful in limiting JD on other producers' farms. However, due to the chronic nature of the disease, the effect of implemented management changes may take years to reduce JD prevalence. Therefore, it is not feasible to wait for definitive results from AJDI participants to motivate nonparticipants. Additionally, the program has more chance of success if the vast majority of farmers participate. To facilitate success of the AJDI, nonparticipants have to overcome their wait-and-see mindset and stakeholders need to promote proactive enrollment. It is therefore fundamental to not only inform farmers about JD control strategies but also highlight that the AJDI was developed based on latest knowledge of MAP transmission and that similar JD control programs in North America have already decreased MAP prevalence in participating herds (Ferrouillet et al., 2009; Collins et al., 2010; Sorge et al., 2011). Currently, it is not known whether veterinary practitioners have this information and to what extent they educate clients about the success of other control programs. To alter farmers' negative perceptions and motivate proactive enrollment, successful communication is key. Many studies concluded that farmers perceived veterinarians as a reliable and credible source with regards to disease risk management (Gunn et al., 2008; Jansen and Lam, 2012; Brennan and Christley, 2013; Garforth et al., 2013). Furthermore, the current study demonstrated that participants used their herd veterinarian more often to get information about new management practices and technologies. Considering that discussions with their veterinarian can alter existing ideas and attitudes, and may initiate farmers to changes in management (Lam et al., 2011; Jansen and Lam, 2012), it is likely that veterinarians have an important role in promoting AJDI participation.

In addition to getting information from their veterinarian, AJDI participants were also more likely than nonparticipants to use workshops and seminars as source of information regarding new management strategies. Perhaps the AJDI with its interactive nature and engagement of the herd veterinarian was more consistent with farmers that liked to be involved through discussions with their veterinarian or in workshops. In contrast, nonparticipants more often used the telephone to receive information on management or technologies. These different learning preferences should be accounted for when communicating the AJDI to producers, as it has been argued that efficacy of communication strategies can be improved when aligned with learning preferences (Fleming and Baume, 2006; Hawk and Shah, 2007). Therefore, it would be advisable to also promote the AJDI via telephone.

Similarly to the findings of this study, previous studies reported that farmers' received information about farm management and biosecurity from a variety of sources, although preference for the delivery of information varied (Jansen et al., 2010; Russell and Bewley, 2011). It is therefore crucial to engage all extension tools that may inform farmers' decision making and ensure that these tools consistently articulate the same message, thereby avoiding confusion from contradictory influences (Moore et al., 2008). Farmers in this study hardly perceived the influence of any of the communication channels used as negative. However, it appeared that many farmers did not receive any influential messages on AJDI enrollment from a variety of sources. Presumably, this was a missed opportunity to reach these producers. For example, in a similar JD control program in Ontario, Canada, participation rates varied among counties and the authors suggested that the observed variations were partly explained by differences in engagement with DHI technicians with regard to motivating farmers to enroll (Pieper et al., 2015).

Temporal associations between AJDI participation and presented results could not always be established. This was especially true for assessment of JD knowledge because it cannot be excluded that farmers gained additional knowledge through participation in the AJDI. Also, data collected in this study did not consist of objective, proven knowledge, but rather what the individual farmer thinks s/he knows in relation to the disease, which might vary from actual knowledge and lead to misclassification bias. Interviewer bias could have been introduced due to the personal nature of face-to-face interviews. Furthermore, involvement of different interviewers could have led to differential responses of the farmers. However, to reduce these potential sources for misclassification bias, fixed-wording questions were applied.

It is possible that the interviewed farmers differed systematically from the farmers that refused to take part in the study. However, this selection bias is likely small, because high percentages of the contacted farmers agreed to be surveyed. List-wise deletion of subjects with missing data could also have led to selection bias. However, <9% of the data were missing in any given model and the effect was therefore assumed to be small.

Farmers eligible for the study comprised the vast majority of Alberta dairy farms. Therefore, it can be assumed that the results of this study were representative for most dairy farmers in Alberta. It was noteworthy that Alberta dairy producers shared similarities with other farmers around the world. In particular, use of various information sources with preference for their veterinarian and a focus on individual-farm performance has been reported not only for dairy producers, but also in other livestock farmers (Jansen et al., 2010; Hop et al., 2011; Garforth, 2012). Therefore, this study provides valuable information regarding enrollment of livestock farmers in voluntary disease programs, and possibly other programs, in countries with a developed livestock industry.

3.6. References

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Table 3-1. Farm and producer characteristics of 61 farms that participated and 163 farms that did not participate in the Alberta Johne's Disease Initiative between September 2012 and April 2014

	Nonparticipants	Participants	Total	*P*-value[1]
Age in years, n (%)				
≤ 30	24 (15)	14 (23)	38 (17)	0.095
31-40	42 (26)	12 (20)	54 (24)	0.906
41-50	49 (30)	22 (36)	71 (32)	0.211
> 50	48 (29)	13 (21)	61 (27)	Reference
Years as producer, n (%)				
≤ 10	44 (27)	18 (30)	62 (28)	Reference
11-20	45 (28)	18 (30)	53 (24)	0.955
21-30	38 (23)	15 (25)	53 (24)	0.931
> 30	36 (22)	10 (16)	46 (21)	0.394
Years until retirement, n (%)[1]				
< 3	11 (7)	1 (2)	12 (5)	0.164
within 3-5	9 (6)	1 (2)	10 (4)	0.234
within 5-10	27 (17)	13 (21)	40 (18)	0.609
> 10	116 (71)	46 (75)	162 (72)	Reference
Education, n (%)				
≤ 12 years	45 (28)	14 (23)	59 (26)	0.480
College diploma	44 (27)	17 (28)	61 (27)	0.893
University degree	74 (45)	30 (49)	104 (46)	Reference
Lactating cows (n)				
Median (IQR[2])	90 (58-120)	120 (86-200)	98 (63-147)	<0.001
Min / Max	15 / 500	42 / 350	15 / 500	
Bulk tank somatic cell count (1,000 cells/mL)				
Median (IQR[2])	160 (120-200)	160 (120-200)	160 (120-200)	0.717
Min / Max	67 / 350	70 / 520	67 / 520	
Average daily production per cow (kg)				
Median (IQR[3])	32 (30-34)	33 (31-36)	32 (30-34)	0.057
Min / Max	17 / 60	20 / 40	17 / 60	

[1]Univariable logistic regression

[2]$P = 0.046$ comparing retirement within ≤ 5 yr and ≥ 5 yr

[3]Interquartile range

Table 3-2. Loadings of Johne's disease (JD) statements of 61 AJDI[1] participating and 163 nonparticipating farmers on Principal Component Analysis components. Displayed are loadings > |0.35|

	Component		
	1 JD effects on industry	2 AJDI[1] elements	3 Worry and concern about JD
Dairy industry is taking a proactive approach to manage JD (Q27[2])	0.552		
Reducing JD may help protect the Canadian dairy industry (Q24a)	0.533		
Effectiveness of management changes (NP: Q32a, P: Q33a)?	0.612		
Dairy product consumption will decrease if a link between CD[3] and JD is proven or portrayed negatively (Q26)	0.787		
Danger of link between JD and CD to dairy industry (NP: Q33d, P: Q34d)	0.713		
Importance that the AJDI is low cost (NP: Q33a, P: Q34a)		0.881	
Importance that risk assessment and new management practices do not take much time (NP: Q33b, P: Q34b)		0.879	
How much of an issue is JD for your farm (Q20b)?			0.865
How much does JD worry you (Q25)?			0.798
Issue of JD for the Canadian dairy industry (Q20a)?			0.664
JD needs to be reduced on my farm to keep family safe (Q24e)			0.391
Crohnbach's alpha	0.713	0.809	0.706

[1]Alberta Johne's Disease Initiative

[2]Number of question in survey

[3]Crohn's disease

Table 3-3. Multivariable logistic regression model with intrinsic variables significantly related to participation in the Alberta Johne's Disease Initiative of 163 nonparticipating and 61 participating farms[1]

	β (SEM)	Odds ratio	*P*-value
Number of lactating cows (Q9[2])[3]	2.35 (0.60)	10.45	<0.001
Animal trade/export will be unaffected by Johne's disease (Q24d)[4]			
1/2	Reference		
3	-0.97 (0.60)	0.38	0.106
4	-2.59 (0.87)	0.07	0.003
5	-0.46 (0.92)	0.63	0.614
Don't know	omitted		
AJDI details well understood (Q31a)[3, 4, 5]			
1	3.22 (1.19)	25.08	0.007
2	-1.36 (0.90)	0.26	0.130
3	-2.37 (0.90)	0.09	0.009
4	-0.88 (0.71)	0.42	0.218
5	Reference		
Don't know	omitted		
New management practices will take too much time (Q31c)[4, 5]			
1	Reference		
2	-1.47 (0.79)	0.24	0.062
3	-1.82 (0.85)	0.16	0.032
4	-0.58 (0.91)	0.56	0.523
5	-3.26 (1.63)	0.04	0.046
Don't know	omitted		
Expect herd to be infected with Johne's disease (Q31f)[4, 5]			
1	Reference		
2	0.11 (0.70)	1.11	0.877
3	-0.35 (1.11)	0.71	0.757
4	-0.80 (0.10)	0.45	0.422
5	0.93 (0.70)	2.53	0.186
Don't know	-3.53 (1.32)	0.03	0.007
AJDI costs outweigh benefits (Q31k)[4, 5]			
1	Reference		
2	-0.75 (0.80)	0.47	0.350
3	-1.28 (0.85)	0.28	0.130
4	0.05 (0.79)	1.05	0.947
5	-3.18 (1.03)	0.04	0.002

Don't know	omitted		
Other disease controls are more important to me (Q31h)[3, 4, 5]			
1	Reference		
2	1.28 (1.00)	3.60	0.202
3	-1.97 (1.01)	0.14	0.052
4	-1.22 (0.90)	0.30	0.175
5	-2.32 (0.93)	0.10	0.013
Don't know	-0.40 (1.53)	0.67	0.796
Importance that AJDI has worked for other farms (NP: Q33e, P: Q34e)?[3, 6]			
1	3.71 (1.25)	40.66	0.003
2	2.55 (1.02)	12.85	0.012
3	0.29 (0.78)	1.34	0.709
4	-0.11 (0.73)	0.89	0.877
5	Reference		

[1]Fourteen nonparticipants and 5 participants could not be included in the model because of a missing value for one or more of the explanatory variables

[2]Number of question in survey

[3]Variable selected for final model

[4]Score: strongly disagree (1) to strongly agree (5)

[5]Participants were asked to answer retrospectively prior to their AJDI enrollment

[6]Score: not important (1) to very important (5)

Table 3-4. Ranking of main farm goals and constraints by 163 Alberta Johne's Disease Initiative nonparticipants (NP) and 61 participants (P)

	Rank, n (%)								
	1		2		3		>3[1]		
	NP	P	NP	P	NP	P	NP	P	*P*-value[2]
Goals (Q7[3])									
Have higher milk production	16 (10)	5 (8)	13 (8)	9 (15)	25 (15)	4 (7)	109 (67)	43 (70)	0.772
Have increased herd fertility	14 (9)	6 (10)	24 (15)	9 (15)	24 (15)	9 (15)	101 (62)	37 (61)	0.821
Increase herd longevity	21 (13)	11 (18)	28 (17)	11 (18)	21 (13)	9 (15)	93 (57)	30 (49)	0.261
Expand	5 (3)	2 (3)	11 (7)	2 (3)	9 (6)	2 (3)	138 (85)	55 (90)	0.315
Have improved herd health	31 (19)	10 (16)	38 (23)	11 (18)	20 (12)	15 (25)	74 (45)	25 (41)	0.867
Meet quota	18 (11)	1 (2)	11 (7)	2 (3)	8 (5)	1 (2)	126 (77)	57 (93)	0.045
Increase net profit	35 (21)	15 (25)	22 (14)	8 (13)	27 (17)	7 (11)	79 (48)	31 (51)	0.962
More family time, less work	19 (12)	8 (13)	11 (7)	5 (8)	17 (10)	9 (15)	116 (71)	39 (64)	0.347
Constraints (Q8)									
Time	50 (31)	17 (28)	42 (26)	6(10)	24 (15)	7 (11)	47 (29)	31 (51)	0.024
Financial resources	34 (21)	11 (18)	19 (12)	11 (18)	13 (8)	9 (15)	97 (60)	30 (49)	0.387
Facilities	17 (10)	8 (13)	20 (12)	6 (10)	21 (13)	9 (15)	105 (64)	38 (62)	0.756
Land	8 (5)	4 (7)	10 (6)	4 (7)	7 (4)	8 (13)	138 (85)	45 (74)	0.086
Knowledge / Skills	7 (4)	3 (5)	10 (6)	3 (5)	11 (7)	6 (10)	135 (83)	49 (80)	0.707
Availability of labour	19 (12)	6 (10)	19 (12)	6 (10)	15 (9)	3 (5)	110 (67)	46 (75)	0.301
Capability of labour	7 (4)	3 (5)	16 (10)	4 (7)	15 (9)	1 (2)	125 (77)	53 (87)	0.136
Quota management	10 (6)	1 (2)	11 (7)	5 (8)	11 (7)	2 (3)	131 (80)	53 (87)	0.255
Farm succession	7 (4)	6 (10)	8 (5)	6 (10)	16 (10)	7 (11)	132 (81)	42 (69)	0.039

[1]Not ranked among the first 3 goals or constraints

[2]Mann-Whitney U test

[3]Number of question in survey

Table 3-5. Self-evaluated knowledge on specific Johne's disease (JD) aspects of 163 Alberta Johne's Disease Initiative nonparticipants (NP) and 61 participants (P)

	Producers (n (%))			
	NP	P	Total	*P*-value[1]
I know JD exists	161 (99)	61 (100)	222 (99)	0.529
I know the clinical signs	134 (82)	55 (90)	189 (84)	0.144
I know the general transmission of the disease	129 (79)	59 (97)	188 (84)	0.001
I know the ages of high susceptibility	100 (61)	47 (77)	147 (66)	0.028
I know the incubation time	44 (27)	26 (43)	70 (31)	0.025
I know some issues with controlling JD	135 (83)	58 (95)	193 (86)	0.018
I know the routes of infection within the animal	79 (48)	31 (51)	110 (49)	0.754
I know all of the vaccination/testing/control issues	33 (20)	25 (41)	58 (26)	0.002
I know the current routes of JD research	34 (21)	32 (52)	66 (29)	<0.001
Average number of positive responses, Mean (SD)	5.21 (2.03)	6.46 (1.74)	5.55 (2.03)	<0.001

[1]Chi-squared test

Table 3-6. Multivariable logistic regression model comparing 163 Alberta Johne's Disease Initiative (AJDI) nonparticipants' and 61 participants' main on-farm goals and constraints and their self-assessed knowledge of Johne's disease (JD)

	β (SEM)	Odds Ratio	*P*-value
Number of lactating cows (Q9[1])[2]	1.28 (0.33)	3.60	<0.001
Herd health as main goal (Q7e)[3]			
1	-0.55 (0.50)	0.58	0.276
2	-0.32 (0.50)	0.72	0.500
3	1.15 (0.49)	3.17	0.019
>3	Reference		
Time as main constraint (Q8a)[2, 3]			
1	-0.50 (0.42)	0.61	0.227
2	-2.04 (0.59)	0.13	0.001
3	-0.92 (0.57)	0.40	0.104
>3	Reference		
Capability of labour as main constraint (Q8g)[3]			
1	-0.32 (0.78)	0.73	0.683
2/3	-1.52 (0.59)	0.22	0.010
>3	Reference		
Knowledge of JD (Q19)[2]	0.36 (0.10)	1.43	<0.001

[1]Number of question in survey

[2]Variable selected for final model

[3]Rank (1 being the largest on-farm goal respectively constraint)

Table 3-7. Multivariable logistic regression model comparing use of information sources by 163 Alberta Johne's Disease Initiative (AJDI) nonparticipants and 61 participants and influence of various sources on AJDI participation[1]

	β (SEM)	Odds Ratio	*P*-value
Number of lactating cows (Q9[2])[3]	1.25 (0.38)	3.49	0.001
Phone (Q5i)[4]			
1	Reference		
2	-0.60 (0.54)	0.55	0.275
3	-1.16 (0.57)	0.31	0.042
4	-1.63 (0.65)	0.20	0.012
5	-2.07 (0.78)	0.13	0.008
Veterinarian (Q5b)[3, 4]			
1/2/3	-1.71 (0.51)	0.18	0.001
4	-0.27 (0.44)	0.76	0.538
5	Reference		
Seminars and workshops (Q5d)[3, 4]			
1/2	-1.06 (0.49)	0.35	0.029
3	-1.29 (0.48)	0.28	0.007
4/5	Reference		
AJDI mail outs (Q35a)[5]			
N/A[6]	0.96 (0.85)	2.60	0.260
1/2	-0.80 (0.82)	0.45	0.333
3	-1.40 (0.57)	0.25	0.014
4	-0.61 (0.55)	0.54	0.270
5	Reference		
DHI (Q35e)[5]			
1/2/3	Reference		
4	-0.40 (0.58)	0.67	0.489
5	0.36 (0.59)	1.44	0.534
N/A	-1.00 (0.49)	0.37	0.041

[1]Three nonparticipants and 2 participants could not be included in the model because of a missing value for one or more of the explanatory variables

[2]Number of question in survey

[3]Variable selected for final model

[4]Score: never (1) to always (5)

[5]Score: negative influence (1) to positive influence (5)

[6]Not applicable

Table 3-8. Final multivariable logistic regression model of factors associated with Alberta Johne's Disease Initiative (AJDI) participation comparing 163 nonparticipants and 61 participants[1]

	β (SEM)	Odds Ratio	*P*-value
Number of lactating cows (Q9[2])	1.17 (0.38)	3.23	0.002
Johne's disease knowledge (Q19)	0.28 (0.11)	1.32	0.010
AJDI details well understood (Q31a)[3, 4]			
1	0.38 (0.72)	1.46	0.600
2	-1.68 (0.69)	0.19	0.015
3	-2.16 (0.65)	0.11	0.001
4	-1.23 (0.57)	0.29	0.031
5	Reference		
Don't know	omitted		
Importance that AJDI has worked for other farms (NP: Q33e, P: Q34e)[5]			
1	1.91 (0.76)	6.82	0.011
2	1.70 (0.84)	5.46	0.044
3	0.59 (0.61)	1.80	0.333
4	0.54 (0.53)	1.72	0.307
5	Reference		
Time is main farm constraint (Q8a)[6]			
1	-0.80 (0.46)	0.45	0.084
2	-2.02 (0.62)	0.13	0.001
3	-0.55 (0.62)	0.58	0.376
>3	Reference		
Use of veterinarian to obtain information on management/technologies (Q5b)[7]			
1/2/3	-1.44 (0.54)	0.24	0.007
4	-0.07 (0.44)	0.94	0.881
5	Reference		

[1]Fourteen nonparticipants and 5 participants could not be included in the model because of a missing value for one or more of the explanatory variables

[2]Number of question in survey

[3]Score: strongly disagree (1) to strongly agree (5)

[4]Participants were asked to answer retrospectively prior to their AJDI enrollment

[5]Score: not important (1) to very important (5)

[6]Rank (1 being the largest on-farm constraint)

[7]Score: never (1) to always (5)

Figure 3-1. Study framework used to assess factors associated with enrollment in the Alberta Johne's Disease Initiative (mod. from Panter-Brick et al., 2006, Ellis-Iversen et al., 2010)

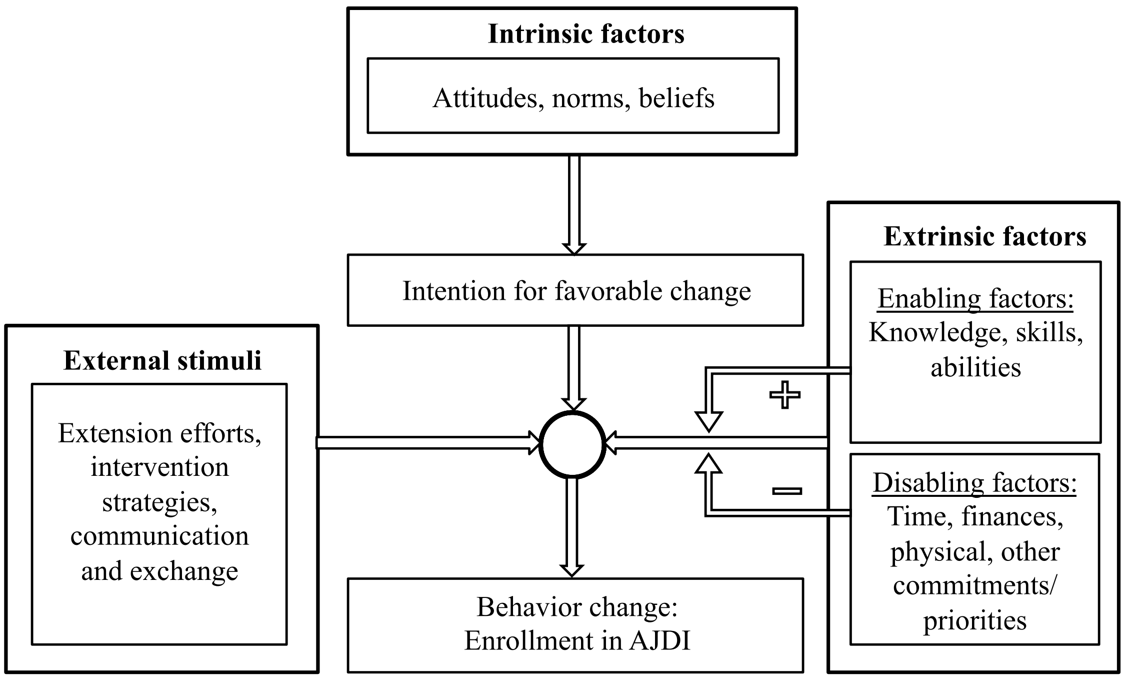


Figure 3-2. Sources of information about new management practices and technologies used by Alberta Johne's Disease Initiative 163 nonparticipants (NP) and 61 participants (P). WCDS=Western Canadian Dairy Seminar

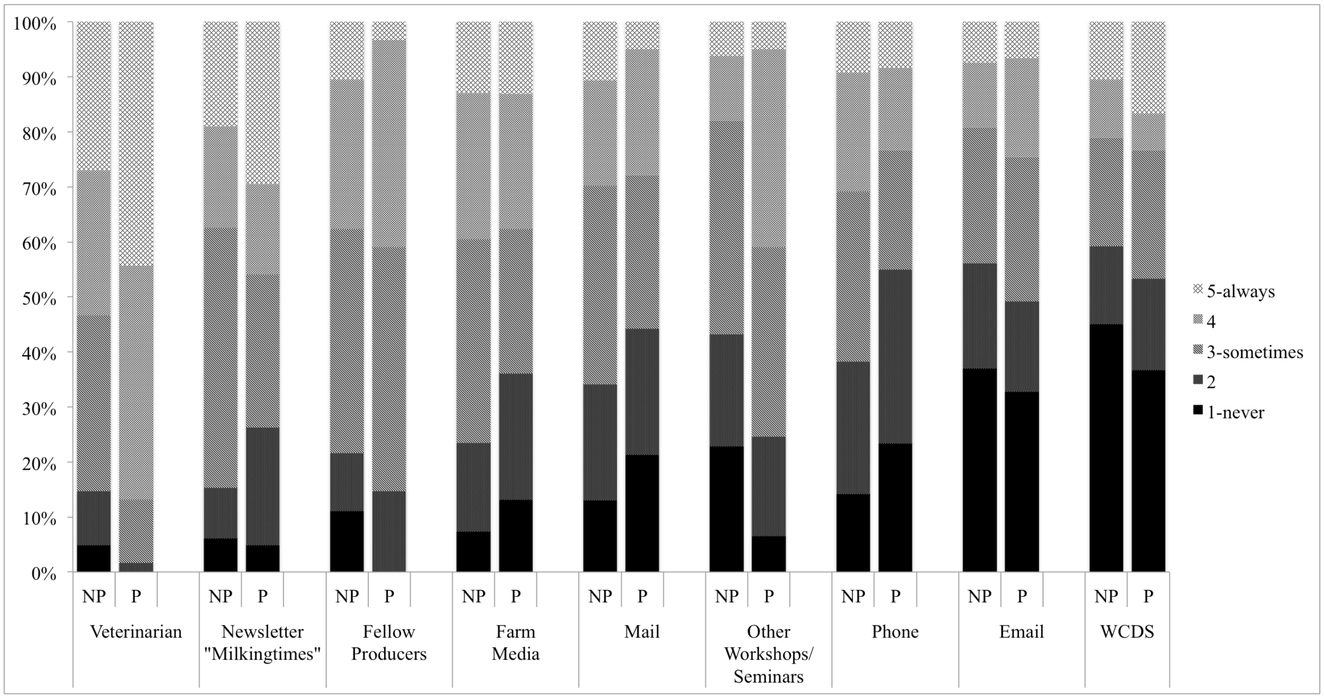
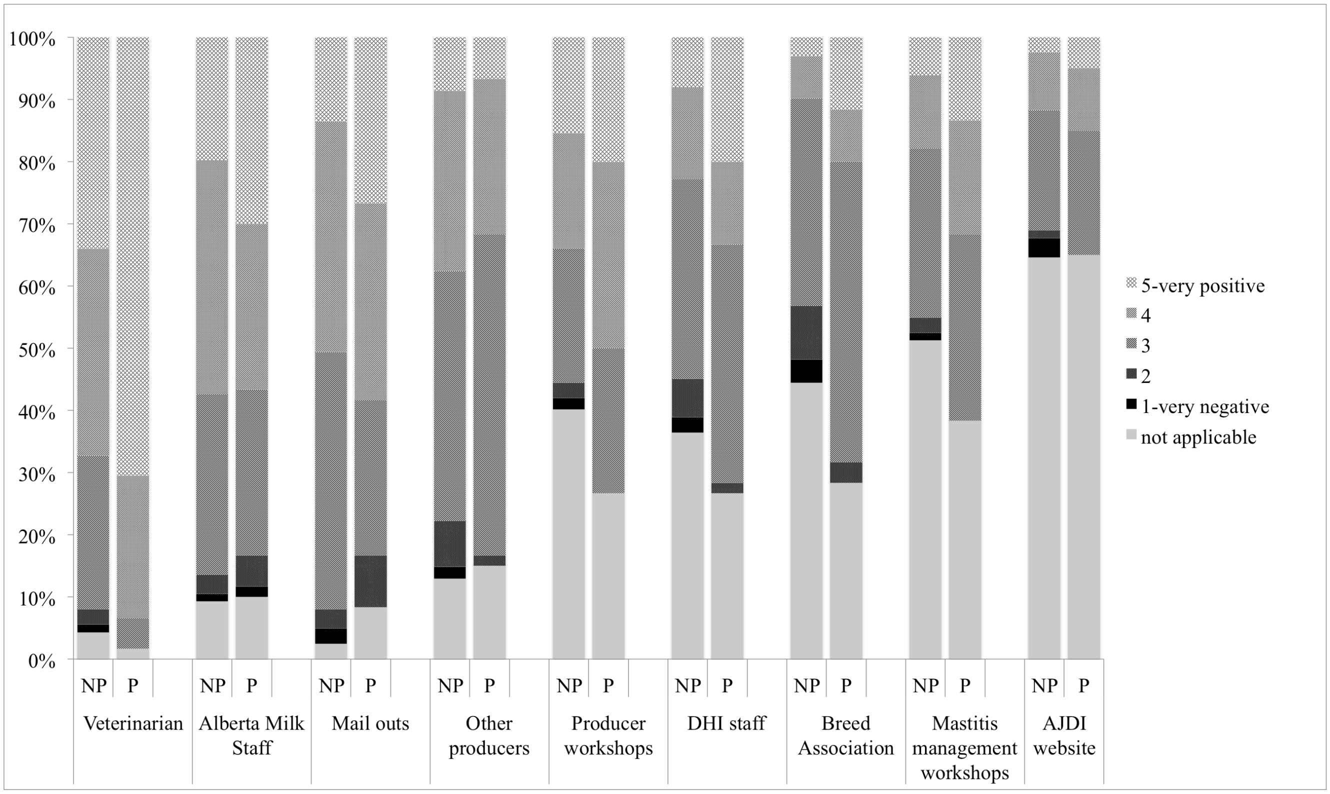


Figure 3-3. Influence of extension tools on 163 nonparticipants' and 61 participants' (P) (NP) participation in the Alberta Johne's Disease Initiative. DHI=Dairy Herd Improvement, AJDI=Alberta Johne's Disease Initiative



CHAPTER 4: Herd-level prevalence of *Mycobacterium avium* subspecies *paratuberculosis* is not associated with participation in a voluntary Alberta Johne's disease control program

4.1. Abstract

Johne's disease (JD) control programs for dairy farms have the general objective of reducing both cow- and herd-level prevalence of *Mycobacterium avium* ssp.. *paratuberculosis* (MAP). An important aspect of many programs is herd testing for MAP to determine the infection status of participating farms. However, it is uncertain whether MAP herd-level prevalence on farms voluntarily participating in a JD control program is different from that on nonparticipating farms. Therefore, the aim was to compare MAP infection status of participants and nonparticipants in the Alberta Johne's Disease Initiative (AJDI), a voluntary JD control program initiated in 2010 in Alberta, Canada. Between September 2012 and August 2013, environmental fecal samples were collected from 93 randomly selected farms not enrolled in the AJDI. Additionally, 81 farms that initially enrolled in the AJDI during the same time interval were also sampled. Samples were collected from 6 defined locations on each farm and cultured for MAP. Results were confirmed using conventional IS900 PCR and F 0285 quantitative PCR. Overall, 51% of participating and 51% of nonparticipating farms were identified as being MAP-infected. Furthermore, based on multivariable logistic regression, the number of MAP-positive samples was not associated with AJDI participation (taking herd size into account as a potentially modifying or confounding variable). In conclusion, there was no indication that voluntary participation in the AJDI was associated with herd-level MAP prevalence.

4.2. Introduction

Johne's disease (JD) is an infectious, chronic enteritis that can affect most ruminants (McKenna et al., 2006), and it is caused by *Mycobacterium avium* ssp. *paratuberculosis* (MAP). Clinical signs include reduced milk production, progressive diarrhea, and weight loss, resulting in financial losses for the producer (Wolf et al., 2014b). Additionally, MAP can be present in milk for human consumption (Okura et al., 2012), and there is a potential association of MAP with Crohn's disease in humans (Barkema et al., 2011). Currently, prevention and control programs focus on decreasing transmission of MAP within a farm and between farms (Sweeney et al., 2012; Barkema et al., 2014). Therefore, many Canadian provinces have implemented voluntary management-based control programs for JD. The Alberta Johne's Disease Initiative (AJDI) was launched in 2010, with approximately 65% of Alberta's 580 dairy farms participating by 2013 (Wolf et al., 2014a). In addition to comprehensive extension efforts from the industry, dairy practitioners in Alberta were encouraged to motivate farmers' enrollment. Furthermore, practitioners had the option to become AJDI-certified and conduct annual risk assessments to identify and reduce high-risk management practices for MAP transmission on producers' farms (Wolf et al., 2014a). Environmental fecal samples were collected (concurrent with risk assessments) and cultured for MAP.

A recent study detected MAP on 47% of AJDI participating farms; however, the true prevalence was estimated to be 68% (Wolf et al., 2014a). It is unclear whether this estimate is representative of all Alberta dairy farms, or if there are distinct differences in MAP herd-level prevalence between farms participating in AJDI versus nonparticipating farms. These 2 distinct farmer groups differed in some of their attitudes toward JD and the AJDI (Ritter et al., 2015), and attitudes have been associated with the incidence of other cattle diseases (Jansen et al., 2009). In a similar voluntary JD control program in Ontario, the herd-level prevalence of MAP was approximately 5% higher in nonparticipating herds, based on bulk tank milk ELISA testing (Kelton et al., 2014). If MAP was indeed less present on AJDI participating farms, the true prevalence in Alberta dairy herds would be even higher than estimated by Wolf et al. (2014a). This finding would have important implications for extension strategies. Whereas every participating farm is an asset to JD control programs, to reduce the risk of MAP transmission and enhance success of the program, there should be increased efforts to encourage more hesitant farmers to enroll. Therefore, the objective of this study was to compare MAP herd-level infection status between farms enrolled and not enrolled in the AJDI.

4.3. Material and methods

4.3.1. Sampling

Between September 2012 and August 2013, 122 farmers not enrolled in the AJDI (i.e., nonparticipants) were randomly selected (the number of nonparticipating farms decreased from 292 to 206 farms over the course of the study). Selected nonparticipants were contacted by telephone and asked to take part in the study. Ninety-three (76%) of the contacted nonparticipants agreed to environmental sampling on their farm and to provide demographic information. During the same time window, all 81 AJDI participating dairy herds that had their initial risk assessment and environmental sampling on their farm were included in the study. Sampling during the same timeframe mitigated bias due to ongoing improvements in laboratory procedures for identifying MAP (Wolf et al., 2014a) and due to changes in farmers' risk-associated behavior as a response to ongoing province-wide JD education.

Sample collection on nonparticipating farms was done by trained University of Calgary and Alberta Milk (Edmonton, AB, Canada) personnel, whereas participating farms were sampled by herd veterinarians. All personnel and veterinarians collecting samples and conducting interviews underwent AJDI-specific training. Detailed descriptions of sample collection and laboratory analyses have been reported (Wolf et al., 2014a). In short, duplicate environmental fecal samples were collected from 3 areas: (1) manure concentration (e.g., alleys); (2) cow concentration (e.g., sick pen); and (3) manure storage (e.g., lagoons, piles, or pits). If there were fewer than 2 cows in a pen or if manure could not be collected from manure storage, additional samples from remaining areas were collected to obtain 6 samples from each farm. Samples were processed using a standardized 3-d decontamination protocol, followed by 48 d of culture using a Trek ESP culture protocol (Trek Diagnostic Systems Inc., Independence, OH; Mortier et al., 2014). Conventional insertion sequence 900 (IS900) PCR was used to confirm culture results. If IS900 results were inconclusive, sequence element F 0285 quantitative PCR (qPCR) was applied for clarification. Therefore, the case definition was positive on either IS900 conventional PCR or F 0285 qPCR.

4.3.2. Statistical analyses

Statistical analyses were done with Stata SE 12 (StataCorp LP, College Station, TX) and $P < 0.05$ was considered significant. First, descriptive statistical analyses were performed. Numbers of MAP-negative and MAP-positive farms (i.e., zero versus at least one environmental fecal sample was MAP-positive) were compared, and differences between

AJDI participants and nonparticipants were assessed using a chi-squared test. Then, numbers of MAP-positive samples on participating and nonparticipating farms were compared using the Mann-Whitney U test. This comparison was done using all 6 samples per farm and by grouping farms into low, moderate, or high MAP infection status (1 or 2, 3 or 4, and 5 or 6 of the 6 samples positive, respectively).

Herd size, represented by the number of lactating cows, was evaluated as a potential confounder and effect modifier of the relationship between number of MAP-positive samples and AJDI participation. In previous studies, larger herds were more likely to be infected with MAP compared with smaller herds (USDA, 2007; Pillars et al., 2009; Wolf et al., 2014a). Also, herds participating in 2 Canadian JD control programs were larger than nonparticipating herds (Kelton et al., 2012; Ritter et al., 2015). Information on number of lactating cows was self-reported and obtained through a face-to-face interview completed concurrent with environmental sample collection or during AJDI risk assessment for nonparticipants and participants, respectively. Univariable ordinal logistic regression analysis was done to determine if herd size was predictive of number of MAP-positive samples. Herd size was also assessed in univariable logistic regression analysis for association with AJDI participation among MAP-negative farms.

Finally, a multivariable logistic regression model was developed to assess the relationship between AJDI participation (i.e., outcome) and number of MAP-positive samples (i.e., exposure), taking into account herd size and the interaction of herd size and exposure. Manual backward elimination of putative explanatory variables was done to arrive at the final model. “Herd size” was considered a confounder if the coefficient of exposure (i.e., number of MAP-positive samples) changed by >30%.

4.4. Results

Overall, 47 (51%) nonparticipating and 41 (51%) participating farms were designated MAP-infected (P = 0.99). Specifically, 16% of nonparticipating farms and 15% of participating farms had 1 MAP-positive environmental sample, whereas 9 and 14%, respectively, had the maximum of 6 positive samples (Figure 4-1). The number of MAP-positive samples out of 6 environmental samples was not different between AJDI participants and nonparticipants (P = 0.45). Similarly, proportions of farms with a low, moderate, or high MAP infection status was not different between groups (P = 0.50). Farms that enrolled in the AJDI between September 2012 and August 2013 had a median of 95 lactating cows (mean = 110, SD = 64), whereas nonparticipants had a median of 90 lactating cows (mean = 104, SD = 70; Figure 4-2). Based on regression analyses, herd size was not predictive of participation among MAP-negative farms ($P = 0.61$; 95% CI = -0.73 – 1.25), but was positively associated with number of positive samples ($P < 0.001$; 95% CI = 0.50 – 1.60).

In the multivariable regression analysis, an increase in herd size did not affect the association between number of MAP-positive samples and participation status ($P = 0.57$). However, removing “herd size” from the model changed the exposure coefficient by 45%. Therefore, herd size was considered a confounder for the relationship between MAP-positive samples and participation status, and it was forced into the final multivariable regression model. Thus, for every additional MAP-positive sample, there was a 1.02 ($P = 0.79$; 95% CI = 0.88 – 1.18) increase in odds of participation.

4.5. Discussion

In this study, MAP was identified on 51% of AJDI participating farms, very similar to the apparent prevalence of 47% recently reported (Wolf et al., 2014a). Furthermore, number of MAP-positive samples on AJDI participating and nonparticipating farms was comparable. Therefore, we concluded that the AJDI was adopted by farms with a MAP infection status that was similar to the general dairy population.

Participants in a similar JD control program in Ontario were 5% less often positive on the bulk tank milk ELISA test (Kelton et al., 2014). Furthermore, these farmers also had better herd performance compared to nonparticipants (e.g. higher milk production and lower bulk tank somatic cell count; Kelton et al., 2014). In contrast, a comparison of participants' and nonparticipants' management characteristics in Alberta did not detect these differences (Ritter et al., 2015). Although JD programs in these two Canadian provinces are based on the same principles, there are slight differences in implementation. For example, environmental manure sampling is done in Alberta, whereas individual cow testing (ELISA on milk or serum) is used in Ontario. Also, farmers in Ontario only receive reimbursement for testing if they permanently remove high-titer cows (Kelton et al., 2012). These differences in program composition could have affected participation and contributed to the apparent divergence in results.

Consistent with the findings of this study, previous research also reported the positive correlation of herd size and MAP infection status (USDA, 2007; Wolf et al., 2014a); however, it was surprising that herd size was not associated with participation in the AJDI. An explanation for this discrepancy is that the AJDI was launched in 2010, but only farmers that enrolled between September 2012 and August 2013 were eligible for this study. Data not included in this study indicates that farms enrolled before September 2012 had a median of 99 lactating cows (mean = 117, SD = 68), and that for these farms, herd size was positively associated with participation among MAP-negative herds ($P = 0.02$). In contrast, the current study included farms more similar in herd size to nonparticipating farms. The larger herd size of farms enrolling early on in the AJDI, and the association between herd size and MAP infection status, argues for a higher herd-level prevalence of MAP on early-participating farms that were not included in the study. Unfortunately, continuous improvement of test sensitivity over the course of the AJDI precluded valid comparison of MAP presence in samples collected at various time points. However, 51% of the 214 participating farms that already had their 2nd or 3rd round of testing done between September 2012 and August 2013 were MAP-positive. This percentage was identical to the proportion of positive farms that had their 1st testing done during this time window, and therefore does not provide proof for the assumption that early participants had higher MAP infection status. Nonetheless, perhaps this group of farmers already implemented management strategies for MAP reduction, as recommended during risk assessments. In particular, culling affected cows could have reduced the within-herd MAP prevalence.

In conclusion, the concern that voluntary JD control programs attracted mostly farms with lower MAP infection status was not confirmed for Alberta dairies, as neither MAP herd-level prevalence nor number of positive environmental fecal samples per farm were associated with participation in the AJDI.

4.6 References

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Figure 4-1. Percentage of *Mycobacterium avium* subsp. *paratuberculosis*-positive environmental samples on 81 farms participating and 93 farms not participating in the Alberta Johne's Disease Initiative

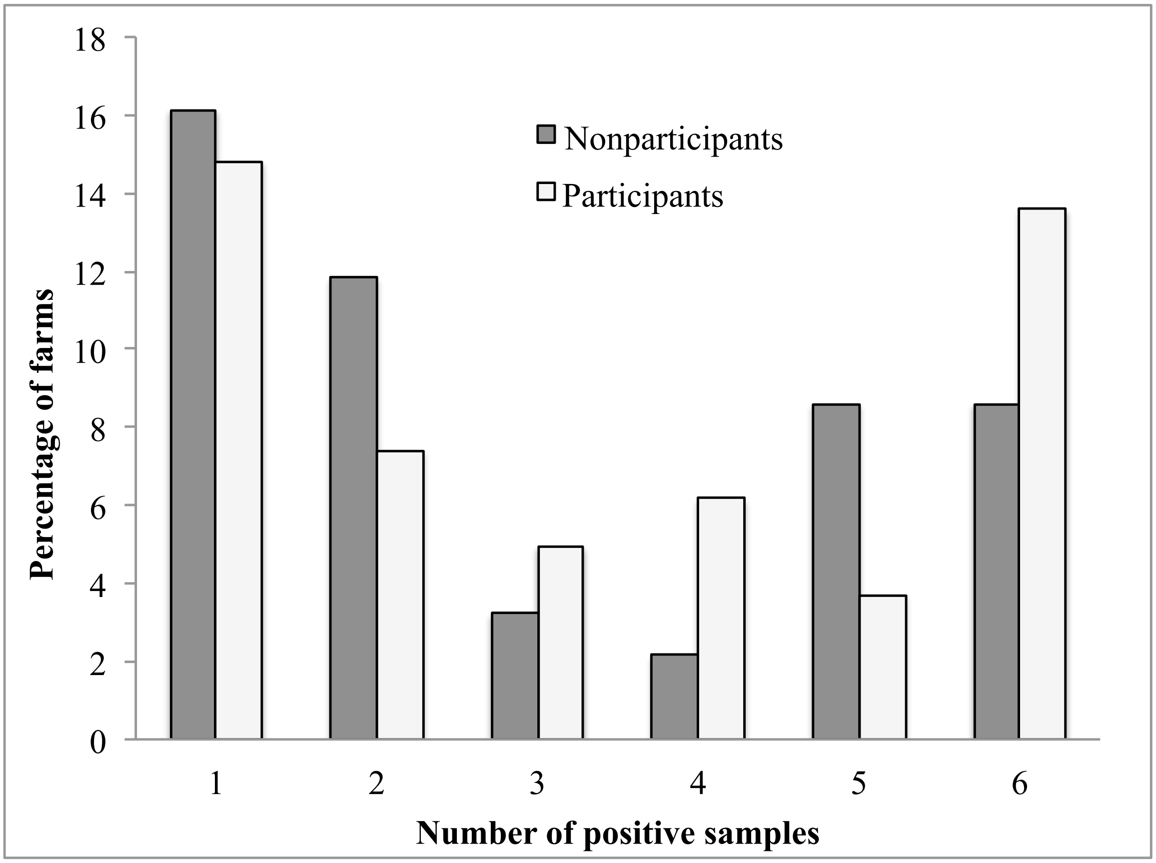
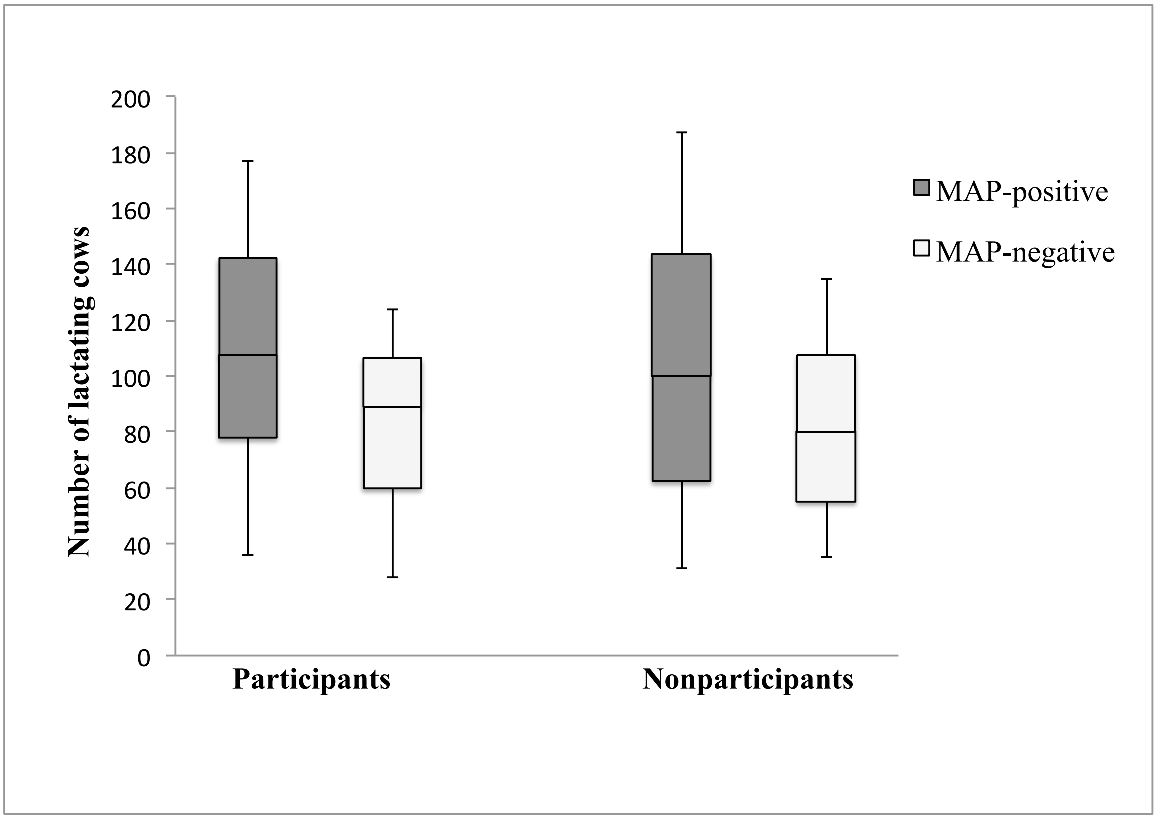


Figure 4-2. Number of adult dairy cows in herds that were *Mycobacterium avium* subsp. *paratuberculosis*-positive or -negative on farms participating or not participating in the Alberta Johne's Disease Initiative



CHAPTER 5: Dairy farmers' perceptions toward the implementation of on-farm Johne's disease prevention and control strategies

5.1. Abstract

Implementation of specific management strategies on dairy farms is currently the most effective way to reduce the prevalence of Johne's disease (JD), an infectious chronic enteritis of ruminants caused by *Mycobacterium avium* ssp. *paratuberculosis* (MAP). However, dairy farmers often fail to implement recommended strategies. The objective of this study was to assess perceptions of farmers participating in a JD prevention and control program toward recommended practices, and explore factors that influence whether or not a farmer adopts risk-reducing measures for MAP transmission. Semi-structured interviews were conducted with 25 dairy farmers enrolled in a voluntary JD control program in Alberta, Canada. Principles of classical grounded theory were used for participant selection, interviewing, and data analysis. Additionally, demographic data and MAP infection status were collected and analyzed using quantitative questionnaires and the JD control program database. Farmers' perceptions were distinguished according to 2 main categories: first, their belief in the importance of JD, and second, their belief in recommended JD prevention and control strategies. Based on these categories, farmers were classified into 4 groups: proactivists, disillusionists, deniers, and unconcerned. The first 2 groups believed in the importance of JD, and proactivists and unconcerned believed in proposed JD prevention and control measures. Groups that regarded JD as important had better knowledge about best strategies to reduce MAP transmission and had more JD risk assessments conducted on their farm. Although not quantified, it also appeared that these

groups had more JD prevention and control practices in place. However, often JD was not perceived as a problem in the herd and generally farmers did not regard JD control as a "hot topic" in communications with their herd veterinarian and other farmers. Recommendations regarding how to communicate with farmers and motivate various groups of farmers according to their specific perceptions were provided to optimize adoption of JD prevention and control measures and thereby increase success of voluntary JD control programs.

5.2. Introduction

Johne's disease (JD) is an infectious enteritis of ruminants that is prevalent in most countries with a developed dairy industry. Infection with the bacterium causing JD, *Mycobacterium avium* subsp. *paratuberculosis* (MAP), can lead to substantial decreases in milk production, chronic diarrhea, and eventually death of affected cattle (Fecteau and Whitlock, 2010). In addition to well-documented effects of JD on animal health, productivity, and welfare, JD is also potentially linked to Crohn's disease in humans (Barkema et al., 2010). To reduce the prevalence and incidence of MAP infection and resultant economic losses for dairy farmers (Wolf et al., 2014b), many countries worldwide have implemented prevention and control programs for JD. One example of a voluntary JD program is the Alberta Johne's Disease Initiative (AJDI), launched in 2010 with the aim to reduce the estimated true herd-level MAP prevalence of 68% through farm-specific management changes (Wolf et al., 2014a). Although a high level of participation is essential for infectious disease control programs to succeed (Barkema et al., 2014), often only a minority of farms enroll in voluntary programs for JD prevention and control (Hop et al., 2011; Nielsen, 2011). With approximately 65% enrollment of Alberta dairy farmers, participation in the AJDI was relatively high (notwithstanding, 35% of farmers chose not to participate). Ritter et al. (2016) reported that MAP infection status did not differ among AJDI participants and nonparticipants. However, farmers not participating in the program were different from participating farmers in several aspects. In particular, they regarded available time as larger constraint on their farms and thought that costs associated with AJDI participation outweighed benefits (Ritter et al., 2015).

In addition to identifying impediments for enrollment of nonparticipants, it is also crucial to better understand participants' perceptions of voluntary programs such as the AJDI, given that its success is ultimately dependent on their continued participation and implementation of recommended management strategies for improved JD prevention and control. Uptake of suggested management changes to reduce MAP transmission was often reported to be < 50% (Wraight et al., 2000; Sorge et al., 2010; Wolf et al., 2015a), and many dairy farmers in Canada felt that there was no need to improve JD control on their farms (Sorge et al., 2010). Farmers participating in Ontario focus groups often did not perceive a recommendation as practical on their farm, whereas their veterinarians regarded the same recommendation as feasible and attainable (Roche, 2014).

Several studies have attempted to explain farmers' decision-making and farm management (e.g., Barkema et al., 1999; Jansen et al., 2009; Ellis-Iversen et al., 2010; Garforth, 2012; Roche, 2014). Important findings of these studies were that a broad variety of factors influenced farmers' behavior (e.g., on-farm resources such as available time or finances, farmers' knowledge of a certain matter, or their sense of responsibility for consumer health and safety). However, dairy farmers are by no means a homogeneous group (Gasson, 1973), and their behavior is influenced by their individual mindsets (i.e., a collection of unique psychological traits including perceptions, beliefs, attitudes, intentions, and skills; Jansen and Lam, 2012). Therefore, although the usefulness of psychological frameworks is indisputable to provide general factors that might influence people, it is also necessary to identify drivers of farmers' decision making and behavior and how those might differ among individuals.

Accordingly, the objective of this study was to gain an understanding of AJDI participants' mindset toward JD prevention and control. Farmers' experiences with the AJDI were explored, with special attention to their perceptions of recommended on-farm management strategies. A qualitative methodology (grounded theory) was chosen. In grounded theory, data are used to generate patterns within the data without testing a specific a priori hypothesis (Glaser and Strauss, 1967). Constant comparison of emerging concepts and their describing subcategories is used to develop a theory that aims to explain why people make certain decisions. This approach allowed us to inductively obtain an understanding of farmers' perceptions without imposing their responses through predefined choices. Based on the findings, recommendations for successful communication with participating farmers were provided to improve on-farm JD prevention and control.

5.3. Materials and methods

5.3.1. Selection of farmers

Dairy farmers participating in the AJDI were eligible for the study. Participation in the program consists of on-farm assessments, during which an AJDI-trained veterinarian identifies high-risk areas for MAP transmission and provides recommendations to mitigate risk (Wolf et al., 2014a). The risk assessment and management plan (RAMP) is combined with environmental fecal sampling to determine the farm's MAP infection status (Wolf et al., 2014a,b). Because of the voluntary nature of the AJDI, farmers can choose whether or not they want to repeat RAMP administration and fecal testing annually. In the present study, a farmer was defined as an AJDI participant if s/he had at least one RAMP and environmental fecal testing done since program implementation. Purposive sampling was used for selection of farmers to capture a variety of different perspectives. In that regard, farmers' statements from conducted interviews guided selection of consecutive participants (e.g., toward the end of the study, efforts were made to primarily recruit participants with MAP-positive test results to obtain more information on the perceived effect of JD on their farm). Another criterion was to select farmers from various geographic regions at a feasible driving distance (maximally 600-km round trip) from Calgary, Alberta, Canada. Selected farmers were contacted by telephone and asked to participate in the study. Of the 30 contacted farmers, 25 (83%) agreed to be interviewed, and a meeting on their farm was scheduled. Reasons to refuse interviewing were no interest (n = 2), no time (n = 2), or the producer had ceased dairy farming (n = 1). Interviews were done between November 2014 and July 2015.

5.3.2. Data collection

The interview process was based on the methodology of classical grounded theory (Glaser and Strauss, 1967). The first 10 interviews were conducted separately, with transcription and coding done after every interview to identify emerging themes and adjust subsequent interviews according to farmers' statements. Afterward, to enhance study feasibility, 2 interviews at a time were scheduled on 4 different days, with transcription and coding done between days. The last 7 interviews were conducted on 2 different days (with 3 and 4 interviews per day, respectively). No more interviews were scheduled when additional farm visits did not generate important new data (i.e., theoretical saturation was achieved). During the early stages of the study, a last-year DVM student (third author) conducted 5 interviews. The rationale for that decision was to interview farmers by someone with knowledge of dairy farming but with limited background of the social-psychological factors that influence farmers' decision-making, and therefore reduce bias that could arise by existing preconceptions. This approach was chosen to obtain a broad spectrum of themes. Emerging themes were explored in subsequent interviews conducted by the first author (DVM, PhD student). The interviews were audio-recorded, and a semistructured interview pattern was used. The interviewer initially asked broad open-ended questions about the farm as an operation, the farmer's perceptions toward JD, and about suggested management changes. Although the farmer was encouraged to guide the conversation, for clarification, or to obtain more information, the interviewer could ask follow-up questions on a specific subject raised by the farmer. A question guide, which was continuously adjusted based on previous interviews, was used to facilitate the interview process (Appendix 3). After every audio-recorded interview, the farmer was asked to complete a short paper-based questionnaire consisting of 9 questions on demographical data (e.g., age and education of the farmer, herd size, current bulk tank SCC, and daily milk production of the herd). Completion of the questionnaire took on average 3 min. Additionally, information on total number of conducted risk assessments and results of environmental fecal MAP testing were derived from the AJDI database and used for analysis.

5.3.3. Data analysis

Quantitative Analysis. Data from the questionnaire and the AJDI database were used for descriptive statistics. For continuous variables, mean and median was assessed, whereas for yes/no questions, number and percentage of affirmative answers was compiled. Differences between farmer groups in regard to continuous variables were assessed using Student's t-test. Questions requiring yes/no answers were analyzed using a 2-sample test of proportions. A P-value < 0.05 was considered statistically significant.

Qualitative Analysis. Audio-recorded interviews were transcribed in full and coded by the first author using specialized software (ATLAS.ti Scientific Software Development, Berlin, Germany). First, open coding was used by assigning in vivo codes (i.e., distinct words that the participant used and that describe an incident well) or label codes (i.e., summaries of a particular incident) to text passages. Second, after identification of the basic social process, coding was limited to codes that related to the identified process (Glaser, 1978). Third, theoretical coding was used explore how identified codes are linked to each other. These relations are used to connect discrete categories into concepts and eventually into a theory (Glaser, 1978). At any stage of interviewing, transcription, or coding, memos (i.e., notes) were written to promote the subsequent development of the theory (Chenitz and Swanson, 1986). Additionally, systematic re-evaluation ensured relevance of coded units and identified inter-relations between codes (Goulding, 2002). No formal reliability test was conducted; however, authors frequently consulted with each other (and other researchers) over the course of the study to review the face validity of emerging themes.

5.4. Results

5.4.1. Descriptive statistics

Twenty-two of the interviews were done with only one person (one of them was a female farmer), 2 interviews were conducted with 2 male farmers, and one was conducted with a family (husband, wife, and daughter). All interviewed participants were largely involved in management decisions. Farmers filling out the questionnaire were on average 45 yr old (median = 45; Table 5-1), and had on average 151 lactating cows (median = 125) with an average daily milk production of 33 kg per cow (median = 34). Most farmers used milk recording systems (80%), had at least one veterinary herd health visit per month (76%), and had purchased cattle in the last 5 yr (68%).

5.4.2. Identified categories and subcategories of the qualitative analysis

Perceptions of farmers interviewed together did not differ, and their responses were treated as if they were derived from only one person. Two main categories were distinguished that described farmers' perceptions toward JD and its prevention and control, namely JD importance to the farmer and the farmer's belief in proposed strategies to prevent or control this disease. The 2 main categories consisted of different themes (i.e., subcategories). Every farmer's perceptions toward each of the subcategories were rated as positive, negative, or neutral (Table 5-2). The latter was assigned if the farmer either had a neutral opinion (e.g., was unsure if there is a link between JD and Crohn's disease) or provided equally positive and negative statements. Additionally, farmers' direct statements regarding importance of JD were taken into account.

1) Importance of JD prevention and control. This category had two distinct subcategories:

This category had 2 distinct subcategories:

(a) Seriousness of JD. The perceived seriousness of JD depended on 2 factors: (1) effect of JD on the producer's operation, and (2) role of JD with regards to consumer safety and the dairy industry. Farmers regarded JD control as more important if they felt the disease had a limiting effect on farm economics, animal health or welfare. The potential for a link between JD and Crohn's disease was for some farmers a reason to take JD more seriously, whereas others did not believe in a link or did not regard it as their responsibility to mitigate risk.

(b) Other major problems or priorities. If farmers struggled with general farm chores (e.g., milking, harvesting), herd performance (e.g., fertility), or other cattle diseases (e.g., mastitis), JD management was often regarded as being less important. Conversely, farmers that did not have other major concerns on their farm could allocate more resources (e.g., time or money) to JD prevention and control.

(2) Belief in Proposed Strategies for JD Control and Prevention

This category was composed of 3 distinct subcategories:

(a) Belief in effectiveness. Farmers differed in their perception about whether proposed management strategies were efficient in preventing introduction of MAP or its reduction on the farm. Also, some farmers regarded environmental fecal testing as an essential tool, whereas others did not believe the test helped them to prevent or control JD.

(b) Feasibility. Even farmers that regarded a recommended management strategy as generally effective could perceive that particular suggestion as not feasible on their farm, due to farm-specific limitations.

(c) Weighing advantages and disadvantages. Whereas some farmers recognized advantages of proposed management strategies beyond improved JD control (e.g., reduced incidence of other calf diseases), perceived disadvantages of JD control were often also taken into consideration when deciding on JD prevention and control strategies for the farm (e.g., reduced colostrum quality after pasteurization).

Based on their ratings in subcategories, each farmer was classified as having a positive (+), negative (−), or neutral (0) perception toward the 2 main categories (Table 5-3). If a farmer did not express an opinion regarding one of the subcategories, that subcategory was not used for classification of this farmer. According to the 2 main categories, 22 farmers were categorized into 4 distinct groups (Figure 5-1). In addition, 3 farmers had a neutral perception to at least one of the main categories and therefore could not unambiguously be assigned to a group.

5.4.3. Identified farmer groups

Proactivists. Farmers in this group believed that JD prevention and control were important and should be pursued. In addition to their sense of accountability toward their animals' health and welfare, they acknowledged their responsibility for consumer health and the dairy industry. One farmer said: "So many things get misrepresented in the media anyways, so we want to make sure that there can be no doubt, we better eliminate JD as much as we can, so we don't even get into that discussion." All proactivists tried to stay on top of things and were well informed. They implemented all or most of the recommended JD prevention and control strategies. If farm-specific resources did not immediately allow for a modification, these farmers implemented the recommendations when their situation changed (e.g., when they could afford to modify the barn). Although 3 of 7 farmers in this group only had one RAMP done, they attempted to maintain a high standard or even further improve their JD prevention and control measures, independent of the AJDI. These farmers reasoned that they did not conduct a follow-up because their farms were tested MAP-negative and their first assessment did not reveal any substantial risks for MAP transmission. Besides their belief in its effectiveness, proactivists also recognized the advantages of JD control; points mentioned were that it improved cows' sustainability and welfare, and that many strategies for JD control were also beneficial in controlling other cattle diseases. Two of 5 farmers in this group with negative MAP test results participated in a certification program for herds that are likely JD free. One of them said: "I think it helps us for sales, so it is important to keep that status. We have to compete with a lot of farms." However, both farmers also stated that the vast majority of buyers did not ask for the JD certification.

Disillusionists. Similar to proactivists, disillusionists believed in the importance of JD prevention and control. Although uncertain about a potential link to Crohn's disease, one of them said, "And even if it's not linked, if we can do better for our cows, for the future of the herd." However, in contrast to proactivists, they often saw disadvantages in a range of management practices due to perceived negative effects on animal welfare, health, or production. Examples included immediate separation of newborn calf and dam ("there is a lot of good stuff in licking the calf"), or having separate calving pens ("the nature of the cow is that she wants to be together”). One farmer even said, “And now the farmer has to make the choice: Go for JD or go for animal welfare?”

Disillusionists were interested in available research, although 3 of them remarked that they did not receive satisfactory information on research outcomes to guide their management decisions. Farmers in this group were skeptical regarding efficiency of management strategies and testing for JD disease. They especially criticized the lack of test sensitivity and questioned how an inaccurate test would benefit their JD control efforts: “How do you control JD if you can’t check?” Lack of commitment from the veterinarian or other farmers was also a source of frustration. One farmer said, “And nobody does it, so why would I do it? My milk gets punched in the same tank as my neighbors. So, doesn’t make sense for me to put extra money in [JD control].” All disillusionists were well informed about general management strategies to reduce JD, but often criticized the feasibility of suggested measures. However, they generally tried to minimize the risk of MAP transmission and all of them had several proposed management strategies in place.

Unconcerned. Farmers in this group did not regard JD prevention and control as their priority. They did not contemplate potential management changes on their farm in detail, and only 2 farmers were well informed about general practices to reduce MAP transmission. Members in this group often mentioned that they enrolled in the AJDI because it was a free-of-cost opportunity to assess MAP infection status of their herd without being too concerned about a potential link to Crohn’s disease. Although they acknowledged the usefulness of the recommended management strategies provided, and liked the concept of the AJDI, they did not feel the urgency to actually make a change: “He [the veterinarian] really made his point and we wrote it all down what I was gonna do. And, uh, my follow-up was a bit poor, I think.” Even farmers in this group that sporadically had clinical cases currently did not perceive JD as a problem in the herd. One of them stated, “It probably all depends on the amount of JD that’s there, and since it’s limited, you are not as motivated to change things.” The unconcerned had aspirations other than JD prevention and control. One of them explained, “With a new barn you can’t start too many things at once.” Two of the farmers in this group hardly had any strategies in place to prevent or control JD, whereas the remaining 3 farmers had implemented a few of the recommended strategies.

Deniers. Deniers did not recognize the importance of JD prevention and control and often had other priorities on their farm. Two of them were well informed about best management practices to reduce MAP transmission, and 2 of the 5 farmers in this group had made efforts to implement some of the recommended strategies. Despite MAP-positive test results, the affected farmers felt that they could manage the disease with culling. Three of the 5 deniers expressed some frustration with the industries’ and governments’ approach to cattle disease control. One of them stated: “[The industry] is pushing down programs, too. That cost us a lot of money. And I don’t think that I ever see the benefit.” Although they did not necessarily exclude a potential link to Crohn’s disease, they were not concerned about the connection: “With everything there is a risk, even with eating food.” Deniers often enrolled in the AJDI because their veterinarian urged them to participate and it did not cost them anything. Four of 5 farmers in this group only had one risk assessment done and regarded it as impossible to improve their management in their current facility and therefore reduce MAP prevalence. They also felt that the risk of (re-) infecting the herd through feed or roaming wildlife was very high, and therefore did not see how it would be possible to permanently eradicate the disease.

Additional observations. All farmers had a (very) good relationship with their herd veterinarian. However, only 2 farmers stated that JD was often brought up with their veterinarian or other farmers. One producer summarized that JD was not a "hot topic" among farmers anymore and 2 others stated that JD was even regarded by some as "taboo topic," and that those farmers were unwilling to talk about the status of their farm or problems they might have with JD. Although infection status of the farm (MAP +/−) influenced the importance farmers attributed to JD control, it did not appear to be the only determinant of the number of adopted management practices. Knowledge about general recommendations for best JD prevention and control practices varied among groups, but each farmer was aware of at least some recommendations (often ones made in the risk assessment). Also, although it was not an interview topic, 10 farmers across all groups indicated that they would like to learn more about MAP transmission and JD status on a provincial scale. Statistical analyses were limited due to the small sample size. The only difference between groups was that farmers regarding JD control as important had, on average, more than 2 RAMP's done (mean: proactivists = 2.1, disillusionists = 2.4). This was different ($P = 0.03$) from the 2 groups that did not see JD control as important and had less than 2 RAMP's done (mean: deniers = 1.2, unconcerned = 1.6). Although not statistically significant (P = 0.07), proactivists tended to have a higher average milk production (36 kg per cow/d) compared with other farmers, which had average daily milk productions of 32.8, 29.4, and 32.3 kg per cow/d (disillusionists, unconcerned, and deniers, respectively).

5.5. Discussion

Results of this study were supported by the psychological framework of the Health Belief Model (Janz and Becker, 1984; Rosenstock, 1974; Figure 2). According to this model, a combination of factors is needed to elicit change. In this study, farmers did not only need to perceive JD as a serious threat for their farm and/or the industry to acknowledge its importance, they also needed to believe in proposed management solutions to be proactive. Unfavorable perceptions about the disease and its prevention and control, rather than a lack of knowledge, appeared to be primary barriers to implement recommended measures. Therefore, extension efforts should not only inform farmers about technical aspects of JD control but should also aim to positively influence farmers' perceptions about the importance and proposed strategies. National or provincial extension tools (e.g., newsletters) are certainly important to reach a large number of producers with information about provincial JD status, latest research or recommended management strategies; however, because of their familiarity with farm and farmer, veterinarians are in an ideal position to assess farmers' individual perceptions, attitudes and beliefs (Ellis-Iverson et al., 2010). General questions that can be asked by herd veterinarians to assess farmers' hesitation to implement changes (e.g., building individual calving pens) include: "What do you think about (individual calving pens)?", or "What is your view on (individual calving pens)?" Knowing in which group a farmer belongs will help veterinarians to adjust their communications accordingly. The following paragraphs offer some suggestions how the authors believe different farmer groups can be targeted more effectively.

It is important to keep Proactivists informed and interested to ensure continuous engagement in JD management strategies. Besides educating them about newest developments in research and industry, discussion groups can be an effective way to allow them to self-directedly talk about their topics of interest. If a particular recommendation is temporarily regarded as not feasible, veterinary practitioners should ensure that the issue is brought forward again when the on-farm situation changes (e.g., when more money or personnel become available). Offering a certification program for negative herds can be a good incentive for Proactivists to maintain their negative status or strive for MAP reduction.

Disillusionists are in a state of cognitive dissonance (Festinger, 1957); therefore, although they are motivated to combat JD, they are hesitant to fully commit to it due to their doubt in proposed management strategies. However, according to the theory of cognitive dissonance, people try to establish internal consistency among their perceptions, values, attitudes as well as their behavior. Consequently, veterinarians should encourage farmers that fall into this group to overcome their ambiguity and increase their trust in recommended strategies. For example, they should be informed that similar JD control programs were successful in decreasing within-herd MAP prevalence (Collins et al., 2010; Sorge et al., 2011). If they see more disadvantages in a management change than advantages (e.g., reduced animal welfare by having separate calving pens), veterinarians should work at a compromise that might not be optimal for JD control but will more likely be implemented (e.g., group pens that are cleaned more often). Having facilitated discussion groups might reduce farmers' doubts, especially if Proactivists are present that can share their experiences and motivate uptake of recommended measures.

Many Unconcerned farmers did not consider JD as important enough to invest in its control. One reason for this perception was that few farmers regarded JD as a problem on their farm, even if they had received MAP-positive test results or observed clinical JD cases. Therefore, changing this perception is key to implementing change. The normative frame of reference (i.e., at what point does a farmer believe a disease is a problem for the herd) has been demonstrated to influence farmers' motivation to take action and explained a substantial part in the variance of disease incidence (Jansen et al., 2009). To change farmers' normative frame of reference with regards to JD, farmers should be made aware that for every cow with clinical JD, there are likely 15-25 subclinically infected cows in the herd (Fecteau and Whitlock, 2010). Furthermore, the potentially negative economic impact of JD on the dairy operation through (sub-)clinically infected animals, should be highlighted (McKenna et al., 2006; Wolf et al., 2014b).

Because of their negative perceptions toward both categories, it will likely be most difficult to motivate Deniers to adopt JD control strategies. Veterinarians need to combine communication strategies outlined for Disillusionists and Unconcerned. However, potentially only external regulations (e.g., (financial) penalties or incentives)) will be effective in motivating on-farm changes in this group.

It is important to realize that farmers can move through the model in time as circumstances change (e.g., financial resources or time availability). Therefore, veterinarians should assess farmers' perceptions in regards to JD on a regular basis. If the farmer has temporarily a different priority than JD control (e.g., a mastitis outbreak) veterinarians should support farmers in combating the urgent issue first while encouraging the farmer to maintain JD control measures that have been already in place.

Dutch farmers classified by their veterinarians as hard-to-reach with information on mastitis had similarities with the four groups identified in the current study (Jansen et al., 2010). Disillusionists questioned the information they received, similar to the Do-it-yourselfers that lacked trust in external information sources (Jansen et al., 2010). Deniers (similar to Reclusive Traditionalists) were critical toward disease control programs on a provincial or national level. The Unconcerned lacked a sense of urgency to take action, similar to the Wait-and-seers identified by Jansen and colleagues. In both studies, Proactivists were well informed and recognized that the importance of disease control extended well beyond their own farm. This indicates that, although the studies differed in geographical location, subject and farmer characteristics ("hard-to-reach" versus voluntary participants), farmers could be characterized by some universal traits. However, in a consecutive quantitative study, Derks et al. (2013) could not confirm the groups identified by Jansen et al. (2010). Different methods (i.e. qualitative semi-structured interviews versus quantitative postal surveys), different time periods and interviewed farmers might come to divergent conclusions without one study being "more valid" than the other. Purposive sampling and continuation of interviewing until theoretical saturation was achieved aimed to reduce the risk of missing relevant (sub-)categories. However, quantitative methods with larger sample sizes could be used to evaluate generated hypotheses of the current exploratory study while being open-minded to other potential influences on farmers' decision making. Due to purposive sampling, this study cannot claim to describe a representative distribution of farmers among the four groups. This question, as well as whether farmers with common perceptions have similar behaviors, could be assessed quantitatively using a random sample of farms.

In this study, farmers had a mean of 151 lactating cows and 11/25 (44%) of farms were MAP-infected. These findings were similar to results from previous studies that included all AJDI participants and reported a mean of 139 lactating cows and a province-wide observed MAP prevalence of 47% (Wolf et al., 2014a; Wolf et al., 2015a). Also, AJDI participants sampled for another recent study had demographic characteristics similar to farms included in the current study, with a median bulk tank SCC of 160,000 cells/mL and a median daily milk yield of 33 kg/cow (Ritter et al., 2015). Therefore, we expect that our findings resonate provincially and potentially internationally.

Correlation between the two main categories is possible (e.g., farmers who do not believe in proposed measures regard the problem as less relevant; Jansen and Lam, 2012). However, a quantitative survey including several questions addressing both categories was conducted with 61 AJDI participants (Ritter et al., 2015), and there was only a weak correlation between categories (Pearson correlation coefficient: 0.28; unpublished data).

The adjustment of questions according to previous interviews is a method used in grounded theory (Glaser and Strauss, 1967). In this study, adjusting questions over the course of the data collection phase resulted in obtaining different depth of information from the farmers regarding each of the subcategories. Classification of the farmers into the four groups was only based on the information obtained. However, we believe that this did not bias the results because: 1) per farmer, there was never more than one or two subcategories without any information regarding the perceived importance of JD and the belief in proposed strategies, respectively; and 2) initially, we always asked broad questions and let the farmers guide the conversation; more specific questions (e.g., regarding the potential link to Crohn's disease) were asked at the end of the interview if not already brought up by the farmer. The possibility that farmers would give socially desirable answers could have led to bias. In this case, we would expect farmers' perceptions toward JD prevention and control to be more negative than assessed in the study.

Qualitative interviews were used to gain a general impression of the farmers' adoption of strategies. Exact quantification of implemented changes would have provided more detail to the study. However, AJDI risk assessments did not comprise whether a specific recommendation from a previous year (if the farmer had more than one RAMP done) had been implemented, but rather provided risk assessment scores for specific categories (Wolf et al., 2015a).

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Table 5-1. Demographic data from 25 interviewed farmers participating in the Alberta Johne's Disease Initiative

Farmer	RAMP[1] & Testing (#)	Age[2] (yr)	Retirement ≤ 10 yr	Education	Lactating cows (#)[2]	Daily production per cow (kg)	Bulk tank SCC (1,000 cells/mL)	Milk recording system	At least 1 HH&PM[3] visit/month	Purchase of cattle in last 5 years
Proactivists (PA)										
PA-1	3		no	Postgrad. degree		34	245	no	yes	yes
PA-2	3		yes	College		42	350	yes	yes	yes
PA-3	1		no	College		36	122	yes	yes	yes
PA-4	1		no	College		27	130	yes	yes	yes
PA-5	1		maybe	Grade 10		36	185	yes	no	yes
PA-6	4		no	High school		39	180	no	yes	no
PA-7	2		maybe	College		38	155	yes	yes	no
Mean / median or affirm. answers, n (%)	2.1 / 2	41.4 / 40			121 / 125	36 / 36	195 / 180	5 (71)	6 (86)	5 (71)
Disillusionists (DI)										
DI-8	3		no	High school		34	142	yes	yes	yes
DI-9	3		no	College		35	170	yes	yes	yes
DI-10	2		maybe	College		30	180	yes	no	yes
DI-11	2		maybe	College		30	210	yes	yes	no
DI-12	2		yes	College		35	95	yes	no	no
Mean / median or affirm. answers, n (%)	2.4 / 2	53.0 / 53			188 / 105	32.8 / 34	159 / 170	5 (100)	3 (60)	3 (60)
Unconcerned (UC)										
UC-18	3		no	College		15	300	yes	yes	no
UC-19	1		yes	College		32.6	89	yes	yes	no
UC-20	1		no	High school		37	105	yes	yes	no
UC-21	2		no	College		32	130	no	no	yes
UC-22	1		no	Grade 8		30.5	330	yes	yes	yes
Mean / median or affirm.answers, n (%)	1.6 / 1	49.4 / 47			109 / 105	29.4 / 32	191 / 130	4 (80)	4 (80)	2 (40)

Deniers (DE)										
DE-13	2		no	College		37	115	yes	yes	yes
DE-14	1		no	High school		34	255	yes	yes	yes
DE-15	1		no	High school		34	200	yes	yes	no
DE-16	1		maybe			29	320	no	no	yes
DE-17	1		yes	College		27.5	140	yes	yes	yes
Mean / median or affirm. answers, n (%)	1.2 / 1	41.3 / 41			172 / 160	32.3 / 34	206 / 200	4 (80)	4 (80)	4 (80)
Not assigned (NA)										
NA-23	3		no	College		30	190	no	yes	yes
NA-24	1		no	College		33	150	yes	no	yes
NA-25	1		yes	High school		34.5	100	yes	yes	yes
Mean / median or affirm. answers, n (%)	1.7 / 1	38.3 / 40			191 / 108	32.5 / 33	147 / 150	2 (67)	2 (67)	3 (100)
Total: Mean / median or affirm. answers, n (%)		44.7 / 45			151 / 125	32.9 / 34	184 / 170	20 (80)	19 (76)	17 (68)

[1]Risk assessment and management plan(s)

[2]To prevent identification and protect privacy of individual farmers the variables "age" and "lactating cows (#)" are solely reported as summary statistics per group.

[3]Herd health and production management

Table 5-2. Examples of positive and negative statements made by Alberta Johne's Disease Initiative (AJDI) participants toward the subcategories comprising the two main categories: Importance of Johne's disease (JD) and farmers' belief in proposed JD prevention and control strategies

	Positive perception (+)	Negative perception (-)
Importance of JD		
Seriousness		
Effects on own farm	It is a problem. We have JD on the farm.	I don't see a problem for JD here on this farm.
Concern for industry / Relationship to Crohn's disease	We have consumers who want healthy milk. And I think this is the only way to go if you want to have for sure JD free milk.	I don't think there is a link to Crohn's disease. And I think if JD was so bad, then a lot of people would have been sick with this disease.
No other major problems or priorities	But that *(JD control)* is one of the top topics, yeah.	Yeah, actually, my mastitis issue has a bigger, higher priority than JD.
Direct statements of JD prevention and control importance	And I always made sure we had the time for it because I think it *(JD control)* is important.	And we are a little bit fed up with all kinds of programs. So, that's where it *(AJDI participation)* ended for me.
Belief in proposed strategies		
Effectiveness		
Management strategies	In order to get rid of it *(MAP[1])* you have to change your management practices.	So you will never ever totally prevent it *(MAP transmission)*.
Environmental fecal testing	Just do it *(MAP testing)* and the uncertainty is gone, I find. Or at least you have a clearer picture you can work with.	But those tests are not accurate, so they don't have too much value I think.

Feasibility	About three, four times that the vets came out and gave suggestions and we have done pretty well all of them.	In our facility, I can't see where we can make it feasible.
Advantages	I know for sure it helps us in selling bulls.	And I don't think that I ever see the benefit *(from participating in control programs)*.
No disadvantages	N/A[2]	The calf grows faster when you leave it longer *(with the dam)*. It has more social skills.

[1]*Mycobacterium avium* ssp. *paratuberculosis*

[2]not applicable: No farmer mentioned that JD prevention and control has no disadvantages.

Table 5-3. Alberta Johne's Disease Initiative (AJDI) participants' perceptions toward the importance of Johne's disease (JD) and their belief in prevention and control strategies proposed by the AJDI[1]

Farmer	MAP[2] status	Seriousness		No other major problems/ priorities	Statements of JD importance	Importance of JD	Effectiveness		Feasibility	Advantages	No dis-advantages	Belief in proposed strategies
		Effects on own farm	Concern for industry				Management strategies	MAP testing				
Proactivists (PA)												
PA-1	-[3]	-	+	0	+		+	+	+	+	-	
PA-2	-	-	+	0	+		+	+	0	+	-	
PA-3	-	-	+	+	0		+	0	+	+		
PA-4	-	-	0	+	+	+	+	+	0	+		+
PA-5	-	-	+	+	+		+	0	0	+		
PA-6	+[4]	+		0	+		+	+	0	+		
PA-7	+	-	+	+	+		+		+	+		
Disillusionists (DI)												
DI-8	-	-	+	+	+		-	0	-	0	-	
DI-9	+	+		0	+		0	-	-		-	
DI-10	+	+	+	+	+	+	0		-		-	-
DI-11	+	0	+		+		-	0	-		0	
DI-12	+	+	+	0	+		0	-	-		-	
Unconcerned (UC)												
UC-18	-	-		-	0		+	0	0	+		
UC-19	-	-	0	-	0		+	+	0	0		
UC-20	-	-	0	-	-	-	+	+	+		-	+
UC-21	+	-		-	-		+	+	0	+		
UC-22	+	-	0	-	0		+	+	0	+		

Deniers (DE)												
DE-13	-	-	-	-	-		-	-	-	-		
DE-14	-	-	-	0	0		0	-	0		-	
DE-15	-	-	0	-	-	-	-		-	0		-
DE-16	-	-	0	-	-		-		-	+		
DE-17	-	-	0	-	0		-	0	-			
Not assigned (NA)												
NA-23	+	0		-	0	0	0	-	-		-	-
NA-24	+	-	0	0		-	0	0	-			0
NA-25	+	-	0	-	+	0	+		-	-		0

[1]Farmers were scored based on their perceptions: + = positive perception; - = negative perception; 0 = neutral perception; missing value=farmer did not state his/her perception about that particular subcategory

[2]*Mycobacterium avium* ssp. *paratuberculosis*

[3]Farm had only MAP-negative test results using environmental fecal sampling.

[4]Farm had at least one MAP-positive test result using environmental fecal sampling

Figure 5-1. Grouping of Alberta Johne's Disease Initiative participants according to their perceptions toward importance of Johne's disease (JD) and in their belief in the strategies proposed for its prevention and control

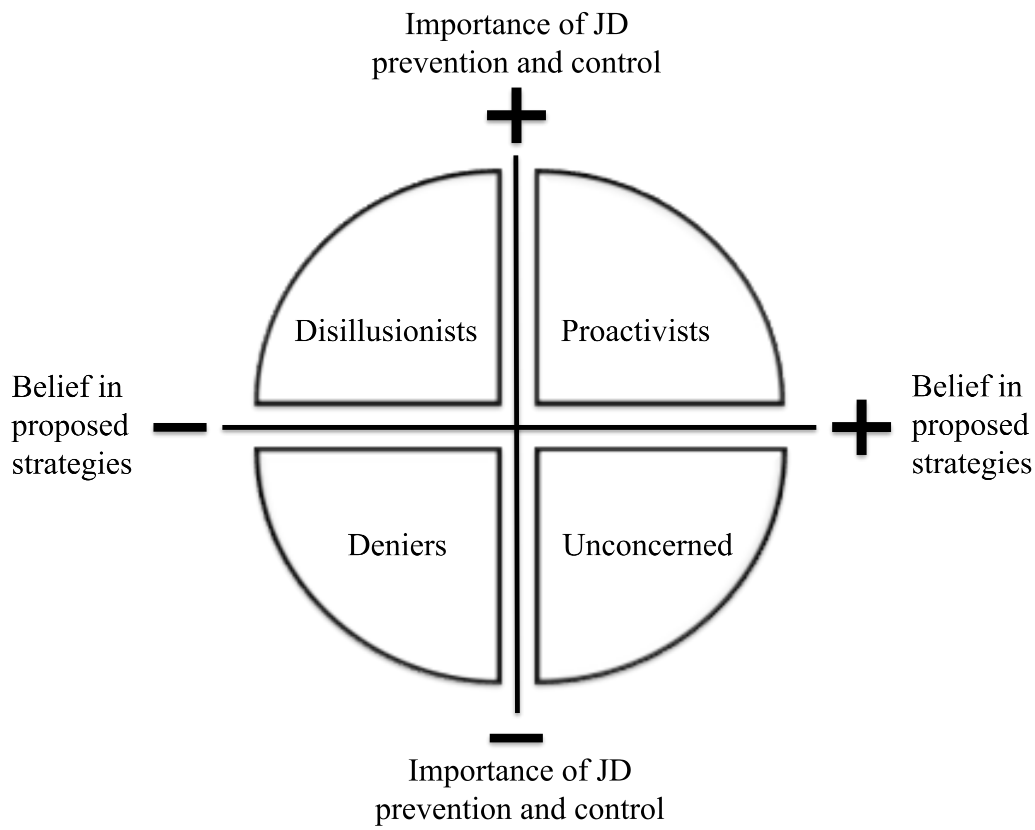
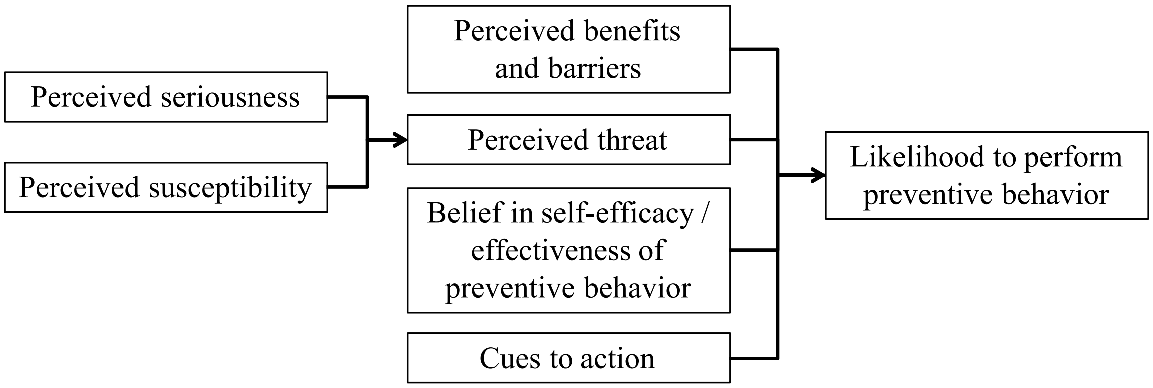


Figure 5-2. Psychological framework of the Health Belief Model (modified from Jansen and Lam (2012))



CHAPTER 6: Action cameras and the Roter Interaction Analysis System to assess veterinarian-producer interactions in a dairy setting

6.1. Abstract

Herd health and production management (HH&PM) are critical aspects of production animal veterinary practice; therefore, dairy veterinarians need to effectively deliver these services. However, limited research that can inform veterinary education has been conducted to characterize these farm visits. The aim of the present study was to assess the applicability of action cameras (e.g., GoPro® cameras) worn by veterinarians to provide on-farm recordings, and the suitability of these recordings for comprehensive communication analyses. Seven veterinarians each recorded three dairy HH&PM farm visits. Recordings were analyzed using the Roter Interaction Analysis System (RIAS), which has been used to evaluate medical conversations in human and companion animal contexts, and provided insights regarding the importance of effective clinical communication. However, the RIAS has never been used in a production animal environment. Results of this pilot study indicate that on-farm recordings were suitable for RIAS coding. Dairy practitioners used a substantial amount of talk allocated to relationship-building and farmer education but communication patterns of the same veterinarian varied considerably between farm visits. Consecutive studies using this method will provide observational data for research purposes and promise to aid in the improvement of veterinary education through identification of communication priorities and gaps in dairy advisory discussions.

6.2. Introduction

Veterinary curricula and postgraduate education programs aim to prepare veterinarians to deliver competent veterinary services to their clients. In production animal practice, herd health and production management (HH&PM) programs have increasingly become the scope of veterinary farm visits (da Silva et al., 2006; Derks et al., 2012). Although there is evidence of a gap between ideal HH&PM programs and reality, little is known about the extent of these shortfalls (Derk et al., 2013). Therefore, veterinary education, at all levels, would greatly benefit from identifying these gaps and addressing them in veterinary curricula or postgraduate training. Surveys are a common approach to collect data about a topic of interest, and survey data have already provided specific information about HH&PM farm visits (Derks et al., 2012; Hall and Wapenaar, 2012). For example, according to surveys distributed in the UK, only 26% of veterinarians initiated discussions with dairy farmers about herd health (Hall and Wapenaar, 2012). However, Derks et al., (2013a) remarked that, in order to obtain in-depth information about HH&PM farm visits, qualitative assessments and/or recording of conversations are essential. Digital recording of veterinarian-client interactions has potential to obtain detailed and objective data, without relying on participants' adequate recollection of events or truthful answers.

Video recording of medical conversations for research and veterinary training purposes has been conducted in companion animal settings (Shaw et al., 2008; Coe et al., 2009; Kanji et al., 2012). However, whereas studies conducted in an examination room can use stationary cameras, one of the challenges of capturing digital data in the production animal context is that practitioners and farmers move throughout the barn. Jansen et al. (2010) and Derks et al. (2013b) addressed this issue by having a third party following and audio-recording the veterinarian and farmer during a farm visit. However, this approach requires substantial time and expense, especially if distances between farms are considerable. A possible solution introduced in this manuscript is the use of action cameras, which can be attached to the veterinarian (and/or farmer) to record veterinary farm visits, independent of a researcher's presence. Cameras not only capture audio, but also enable the viewer to assess the conversation in context through complementary video footage.

A potential application of recorded farm visits is to evaluate how veterinarians communicate with their clients. Developed for interactions between human physicians and patients, the Roter Interaction Analysis System (RIAS) is the leading analytical tool for clinical communication by providing a quantitative dataset suitable for high-level analyses (Roter and Larson, 2002). Its applicability has also been adapted for the companion animal context, where it provided invaluable information about communication patterns used during veterinarian-client interactions (Shaw et al., 2008; Coe et al., 2009; McArthur and Fitzgerald, 2013). Findings from these studies, and many others, have not only highlighted the importance of clinical communication in the veterinary context, but also informed development, conduct and assessment of communication education programs and the nature of communication research around the world (Hecker et al., 2012; Artemiou et al., 2014; Mossop et al., 2015). For example, using the RIAS, researchers determined that pet owners' satisfaction was positively correlated with veterinarians' use of empathy statements, and that a relationship-centered approach (i.e., a balanced dialogue between veterinarian and client) increased client adherence with veterinary recommendations (Kanji et al., 2012; McArthur and Fitzgerald., 2013).

Although communication education programs include production animal health scenarios, the potential of RIAS in this context has apparently never been assessed, perhaps due to challenges of collecting on-farm recordings appropriate for such granular analysis. Therefore, the aims of this article were to evaluate: (1) applicability of action cameras to capture veterinarian-farmer interactions during regular HH&PM farm visits; and (2) suitability of obtained recordings for RIAS analysis, in terms of audio quality and nature of the interactions. Results from this study will be beneficial in informing research projects that aim to record and analyze veterinarian-farmer interactions.

6.3. Material and methods

6.3.1. Study participants

All dairy veterinarians in Alberta, Canada, who conduct regular HH&PM farm visits on at least 10 dairy farms on a regular basis, and who practiced within a feasible driving distance from Calgary (1500km return) were eligible to participate in this study. Seven dairy practitioners (of 25 eligible veterinarians) were selected and asked to record three HH&PM farm visits on different farms. Although veterinarians were encouraged to select farms that would provide a representative sample for this study, recruitment of farms was organized by the veterinarians. Participating veterinarians were asked to record the entire HH&PM farm visit turning the recording devices on before they greet the farmer and turning them off when they had left the farm.

6.3.2. Technical equipment and documents

For this study, GoPro® action cameras (HERO 3+ BlackEdition, GoPro®, San Mateo, California, USA) were used. A protective plastic case ensured that the camera was not contaminated during the farm visit, and an additional battery 'BacPac' (GoPro®) increased maximal recording time (to ~2.5hours). The camera could be worn on the veterinarian's chest or head, with an adjustable harness (Camkix, Dayton, Wyoming, USA). Generally, cameras could be worn concurrently with viewing goggles used during transrectal ultrasonography. SanDisk Ultra 32GB microSDHC memory cards (ScanDisk, Milpitas, California, USA) were used (recommended memory cards for GoPro® cameras can be reviewed at www.gopro.com). At a resolution setting of 1080 pixels and recording of 30 frames/s, a 32GB memory card stored ~3.5hours of recording using the GoPro® HERO3+ BlackEdition (www.gopro.com). To ensure sufficient capturing of the farmer's voice, a voice recorder (Portable Digital Voice Recorder 8 GB Universal Serial Bus Flash Drive, Etekcity, Anaheim, California, USA) was provided, which the farmer wore around the neck. The voice recorder had enough memory capacity for 150hours of recording and no adjustments of recording settings were possible. Camera and voice recorder were not linked, but recordings were merged during file editing. Participants were provided with consent forms (ethics approval was obtained from the University of Calgary's Research Ethics board, REB15-1800). A 'frequently asked questions (FAQ)' information sheet was provided to help veterinarians correctly use camera and voice recorder. Furthermore, surveys in sealed envelopes assessing demographic data and farmers' perceptions about the HH&PM farm visit were given to veterinarians to be distributed to farmers after each recording.

6.3.3. File editing

Camera recordings were edited using Adobe Premiere Pro (Adobe Systems, San Jose, California, USA). Action camera and voice recorder files were merged and the video was exported (.mp4 format) using 1024×600pixel resolution at 24 frames/s, with a maximum bit rate of 3.5. A file size of at least 1GB/hour recording ensured adequate quality of the recording.

6.3.4. Analyses and evaluation of recordings

To evaluate whether recording quality of farm visits was sufficient for RIAS analysis, and to provide examples of HH&PM farm visits using action cameras, recordings were submitted to the laboratory of Dr. Debra Roter in the Department of Health Policy and Management at the Johns Hopkins School of Public Health. In the RIAS, which does not require transcription of recordings, mutually exclusive and exhaustive variables are assigned to each communication unit (e.g., a phrase or single word) spoken during the interaction. Each of these variables can further be categorized into main components of medical communication (Table 6-1). For example, during information gathering, a veterinarian could ask: ‘How are your cows transitioning to the milking robot?’ which would be labelled as an open-ended question. Open-ended questions encourage increased farmer participation in the conversation and enable them to provide a full picture of their thoughts or concerns (Shaw et al., 2004; Adams and Kurtz, 2017).

Communication variables obtained with the RIAS can be descriptively analyzed or used in more complex quantitative analyses (e.g., multivariable regression analysis). Findings can then, for example, be contrasted against generally accepted best practices of communication (e.g., Calgary-Cambridge guide; Adams and Kurtz (2017)). In addition to assigning specific variables to each communication unit, RIAS coders can also evaluate the overall character of the visit (e.g., whether the veterinarian appeared friendly, respectful or rushed), and coding can often be adjusted to take into account specific research objectives (Coe et al., 2009; McArthur and Fitzgerald, 2016).

6.4. Results

Of the 21 recorded HH&PM farm visits, 10 videos were complete (recorded the entire interaction). The remaining 11 recordings were missing either the beginning of the interaction or the end (i.e., farmer was present when camera was turned on/off). However, based on the review of the video material, the authors do not expect that the missing parts were very long. Generally, the veterinarian was still at the vehicle when turning the camera on and in the farm's office or cleaning boots and equipment when it was turned off. Recording length was between 56 and 111 minutes (Table 6-2). Experienced coders were successful at analyzing on-farm conversations using the RIAS, which not only indicates that the audio quality was sufficient for such detailed analysis, but also that the RIAS was a suitable tool to translate specific patterns of veterinarian-farmer conversations into distinct variables. Number of unintelligible utterances (i.e., communication units that could not be coded due to insufficient audio quality) was relatively low and similar between recordings averaging 4% of the total veterinary talk (Table 6-2). RIAS coders provided communication codes for the 21 HH&PM recordings. Results should be interpreted with caution, as definite conclusions were not possible based on the small sample size. However, it appeared that the dairy practitioners used few open-ended questions during the

HH&PM farm visits (accounting for 1% of the total veterinary talk). In relation to the total number of communication units spoken during the visit, veterinarians allocated a substantial amount of talk (41%) to building (and maintaining) a relationship with the farmers. Approximately 37% of the veterinary talk was categorized as 'Education and counseling', which includes giving advice on animal husbandry and health. Comparison of RIAS variables among veterinarians (Table 6-2) and among recordings of the same veterinarian (example of three veterinarians presented in Figure 6-1) demonstrated that there was variability not only among veterinarians but also among HH&PM farm visits. For example, the percentage of total talk that veterinarian 3 allocated to education and counseling ranged from 28 to 46% depending on the HH&PM farm visit (Figure 6-1). Similar variations were detected regarding the other veterinarians and communication variables. Potentially, the greatest differences could be observed regarding social talk, where the percentage of social talk varied up to fivefold between different visits by the same veterinarian (Figure 6-1).

6.5. Challenges and discussion

There are numerous possibilities to analyze HH&PM recordings, including assessment of communication patterns, structure of veterinary farm visits, topics discussed or time spent on specific tasks. Questionnaires are an alternative to using digital recording to learn more about HH&PM farm visits. However, in addition to potential introduction of bias due to false/inaccurate answers, detailed communication analysis cannot be done on questionnaires (Hall and Wapenaar, 2012; Derks et al., 2013a). In the present study, there was considerable variation among HH&PM recordings of the same veterinarian. To analyze recordings and determine differences between veterinarians, the authors therefore recommend obtaining several recordings from the same veterinarian on different farms, as one recording may not be representative. For this study, GoPro® cameras were used, although similar action cameras would likely provide comparable results. Furthermore, a voice recorder was used to enhance communication information obtained from the farmer during HH&PM farm visits (i.e., ensure sufficient recording of the farmer's voice). Alternatively, an external microphone connected to the camera could have been used. However, the authors did not do this because of added weight and bulkiness to the veterinarian's head or chest, and uncertainty of recording quality if the distance between the farmer and veterinarian was excessive. A microphone attached to the farmer and connected to the camera via Bluetooth was excluded, as the necessary equipment could not be attached to a GoPro® with a battery 'Bacpac'. A second camera, worn by the farmer would have provided more detail of the HH&PM farm visit compared with capturing the voice only (e.g., detection of veterinarians' facial expressions). However, the authors decided to use a voice recorder due to financial considerations, and ease of use for farmers and veterinarians. Regarding veterinarian and farmer contributions to the study, the authors experienced three difficulties: (1) Whereas most veterinarians had no problems recruiting farms for the recording, two had response rates of 50%. One could consider increasing farmer participation rates by offering (financial) incentives (Lynn, 2009); (2) Some veterinarians preferred to wear the camera on their head whereas others complained about the weight of the camera. The authors decided to provide veterinarians with both options and have them choose their preference; and (3) Although asked to record the entire HH&PM farm visit, veterinarians often turned the camera on after they had greeted the farmer and turned it off while still in the presence of the farmer. Besides emphasizing how important it is to record the entire interaction, the authors feel that this aspect is out of the control of the present study if there is no researcher present at the time of the recording. Veterinarians and farmers might alter their behavior if they know that they are being recorded (so-called Hawthorne effect; McCambridge et al., 2014). Although this has been documented, the magnitude of its impact in specific study designs remains largely unclear (McCambridge et al., 2014). Therefore, the authors can only speculate to what extent participants in this study were influenced by recording devices. All participating farmers agreed to the survey questions: 'Do you think you were yourself while being in front of the GoPro® video-camera?' and 'Do you think today's herd health visit was representative of other herd health visits?'. However, responses to survey questions might be inaccurate (Rothman et al., 2008; Pedregon et al., 2012). Although recording devices might have made study participants more aware of their behaviour, the authors believe that veterinarians will not be able to substantially change their communication style, considering that it takes veterinary students years of practice to become efficient at clinical communication skills (Mossop et al., 2015). However, it is possible that veterinarians who had communication training, made an effort to include more communication skills that they have been taught into the conversation (e.g., open-ended questions, empathy statements; Adams and Kurtz, 2017). If so, the authors likely overestimated communication skills veterinarians use on a day-today basis if they are not being recorded.

For this study, the RIAS coding was conducted by trained personnel, who can code several interactions of this length per week (cost per recording was US$250). Alternatively, researchers interested in coding recordings can attend a workshop (http://www.riasworks.com), which will provide them with the necessary skills. A meeting before the coding was essential to prepare coders for the dairy context (e.g., explain commonly used terms). Afterwards, coders were able to assign the codes used in human medicine and companion animal medicine without great difficulties. Although it is possible to code interactions among several participants (e.g., veterinarian and two farmers), it was decided to not distinguish between farmers, as this would have made the coding process substantially more tedious. Instead, the coder noted whether the codes for the farmer mainly derived from one person versus two or more.

Anonymization of obtained recordings does not yield major problems if the purpose is to report aggregated communication patterns. However, to use obtained audio-video recordings in the education of veterinary students and veterinary practitioners (e.g., by showing sections of the video), consent of the recorded parties for this particular use is necessary. This consent can be obtained simultaneously with consent for the research study.

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Table 6-1. Examples of veterinarian statements during dairy farm visits and corresponding Roter Interaction Analysis (RIAS) codes (modified from Shaw et al. (2004))

Component	Variable	Example of veterinarian's statement/question
Information gathering		
	Open-ended questions	What can I do for you today?
	Closed-ended questions	Did you start the treatment already?
Education and counseling		
	Information giving and counseling	Make sure the calf drinks enough colostrum.
Relationship building		
Positive talk	Compliment	You have done a nice job cleaning the pens.
	Laughter/Jokes	
	Agreement	You are right.
	Approval	It was great that you had the hoof trimmer over.
Negative talk	Disapproval	No, I don't agree.
	Criticism	He has not been very helpful today.
Social talk	Personal remark	Did you watch the news today?
Rapport building	Empathy	I see that this must be frustrating for you.
	Legitimation	I can understand why this worries you.
	Partnership	Let's see what we can work out together.
	Concern	I am worried about the high somatic cell count.
	Reassurance	I believe it will be alright.
	Self-disclosure	I don't like paperwork either.

Table 6-2. Examples of veterinary communication patterns during herd health and production management (HH&PM) farm visits analyzed using the Roter Interaction Analysis System

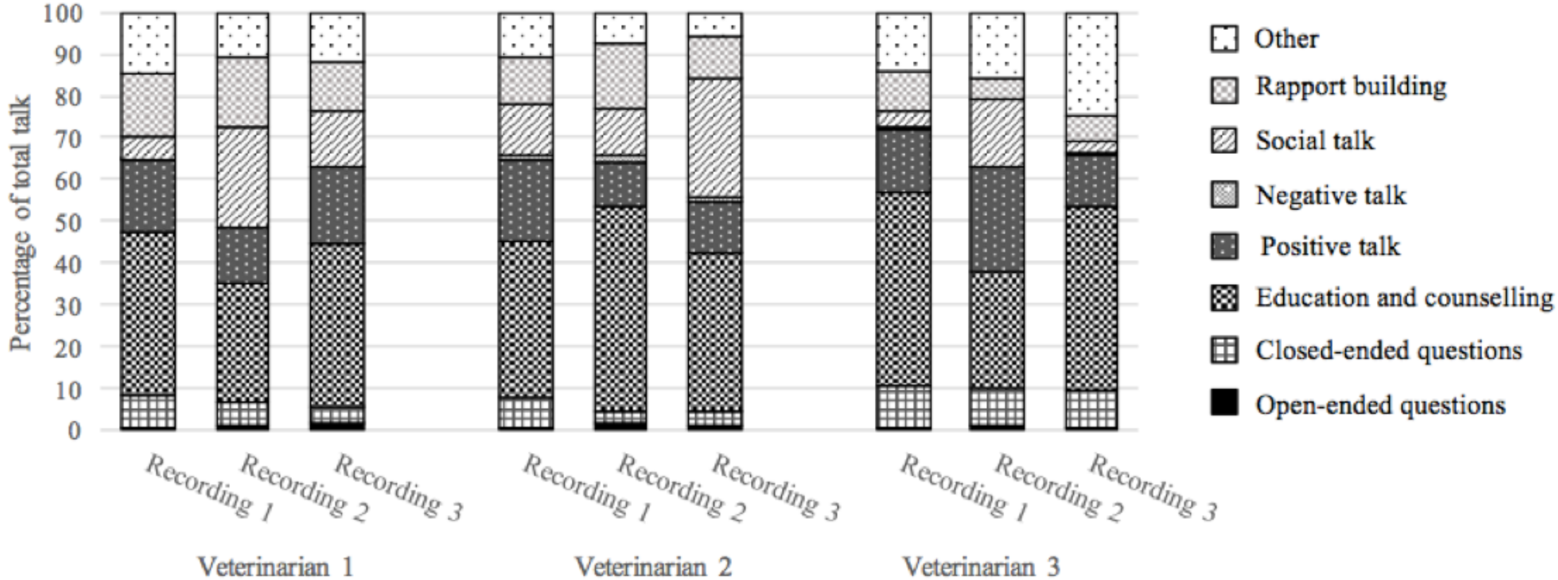
	Communication units by dairy veterinarians[1,2]							
Component	1	2	3	4	5	6	7	Total[2]
Data gathering	62 (7)	53 (5)	42 (10)	23 (5)	47 (7)	20 (5)	15 (4)	37 (6)
Open-ended questions	9 (1)	12 (1)	3 (1)	3 (1)	6 (1)	2 (1)	2(0)	5 (1)
Closed-ended questions	53 (6)	41 (4)	39 (9)	20 (4)	41 (6)	18 (4)	14 (3)	32 (5)
Education and counseling	331 (36)	449 (42)	173 (39)	149 (37)	271 (36)	125 (31)	157 (39)	236 (37)
Relationship building								
Positive talk	149 (16)	140 (14)	65 (18)	93 (22)	137 (21)	51 (12)	78 (19)	102 (17)
Negative talk	0.3 (0)	16 (1)	1 (0)	0 (0)	1 (0)	3 (0)	0 (0)	3 (0)
Social talk	110 (14)	212 (17)	24 (8)	53 (10)	17 (3)	111 (29)	21 (6)	78 (13)
Rapport building	127 (15)	131 (12)	30 (7)	48 (12)	74 (10)	36 (9)	41 (10)	70 (11)
Unintelligible utterances[3]	14 (2)	7 (1)	19 (5)	5 (2)	14 (2)	12 (4)	43 (10)	16 (4)
Communication units total (#)	889	1070	411	423	691	399	404	614
Mean length of visits (min)	103	70	56	111	108	59	61	81

[1]Three HH&PM recordings per veterinarian were analyzed

[2]Data presented as Mean (% of total talk)

[3]Communication units that coders could not understand acoustically

Figure 6-1. Communication patterns used by three veterinarians during three herd health and production management visits each



CHAPTER 7: Clinical communication patterns of veterinary practitioners during dairy herd health and production management farm visits

7.1 Abstract

Effective communication with their clients is an important skill for veterinary practitioners and is, for example, linked to clients' satisfaction with the consultancy and adherence to medical advice. Recently, detailed description of veterinary communication styles in companion animal contexts have added to the communication knowledge base, and have informed veterinary curricula and postgraduate education programs. The objective of this study was to assess veterinary practitioners' communication patterns during dairy herd health and production management farm visits. A total of 14 veterinarians in Alberta and Ontario, Canada, were provided with action cameras (i.e. GoPro® cameras) and recorded 3-7 farm visits each. The Roter Interaction Analysis System (RIAS) was used to analyze the resulting 70 audio-video recordings. Additionally, demographic variables were obtained from study participants to evaluate the influence of these variables on communication patterns. Intraclass-correlation coefficients were calculated for each communication unit, and multilevel negative binomial regression was used to compare communication patterns between demographic groups. Additionally, the relationship-centeredness of the interaction was evaluated and compared between groups using linear regression models. Communication patterns varied considerably among recordings of the same veterinarian interacting with different clients. However, most of the veterinary talk focused on farmer education, counseling, and building a relationship, whereas open-ended questions were rare. When discussion revolved around health issues of an individual animal, veterinarians

used less social talk but focussed on biomedical information gathering. Veterinarians' age, gender and length of the veterinarian-farmer relationship had limited influence on their communication; however, if the farmer and veterinarian were both male, the conversation was more relationship-centered. Communication of veterinarians with previous communication training was very similar to veterinarians without training. Detailed description of veterinary practitioners' communication patterns on dairy farms will contribute to establishing the importance of communication as a clinical skill, and to identify unique aspects of veterinary on-farm communication which will provide opportunities for improvement.

7.2. Introduction

Effective communication is a crucial skill for veterinary practitioners; veterinarians and their clients often regard communication as important or as more important than clinical knowledge (Mellanby et al., 2011; McDermott et al., 2015). An extensive body of research developed over the past decades in human medicine (described by Silverman et al., 2013) and more recently in companion animal medicine (described by Adams and Kurtz, 2017) demonstrates that improving clinical communication in specific ways leads to more effective clinical consultations, to improved adherence with practitioners' recommendations, satisfaction, and health outcomes for patients. Relationship-centered communication, which is defined by a balance of power between the practitioner and client and includes inquiries about social aspects of the presented problem (e.g., how does an animal's sickness affects the daily routine of the owner), has been demonstrated to improve accuracy of data gathering, client satisfaction, and adherence through an improved relationship (Stewart et al., 2003; Kanji et al., 2012; McArthur and Fitzgerald, 2013). Although the research is compelling, the majority of studies assessing communication patterns between veterinarians and animal owners have been conducted in companion animal settings (e.g., Mossop et al., 2015; Shaw et al., 2006; Coe et al., 2009; Nogueira Borden et al., 2010). For example, veterinary communication patterns often differed depending on the reason for a pet owner's visit: Whereas there was more social talk and more rapport building during wellness appointments (i.e., consultations with the goal to prevent future problems such as vaccination appointments), veterinarians had an increased emphasis on gathering biomedical content during health problem consultations (i.e., appointments that were made to address a specific problem; Shaw et al., 2008). The authors concluded that this focus on biomedical information might cause veterinarians to oversee potential social concerns or concerns related to the animal's lifestyle such as food or exercise regime, which could affect client satisfaction and adherence.

Veterinary educators in many countries acknowledge the importance of clinical communication skills by including findings from these studies (and many others) into veterinary communication training. However, although most research exploring veterinary communication was conducted in Europe, and no North American study has assessed veterinary communication patterns to date, there are strong indicators that veterinary communication in the food animal setting is in need for improvement (Cipolla et al., 2015). For example, food animal practitioners frequently have a reactive role instead of being a proactive farm advisor and were often unable to identify a dairy farmer's main farm goal or had different priorities than the farmer (Mee et al., 2007; Lam et al., 2011; Derks et al., 2013). Additionally, three European studies described cattle practitioners' communication patterns evaluating 15 to 30 interactions, and concluded that veterinarians rarely set an agenda, discussed farmers' needs or elicited farmers' opinions (Jansen et al., 2010; Derks et al., 2013: Bard et al., 2017). However, no study has ever assessed clinical communication on farms in as much detail as the research that is available from companion animal clinics.

The objectives of this study were, therefore, to 1) assess veterinary communication patterns of herd health and production management (HH&PM) farm visits, 2) determine whether veterinary communication patterns depend on factors such as: veterinarian's age and gender, duration of the professional work relationship between veterinarian and farmer, previous clinical communication training, and the nature of the conversation (i.e. whether veterinarians communicated differently when problems related to an individual animal were discussed compared to general herd consultancy), and 3) assess the relationship-centeredness of the interaction and investigate its association with veterinary and farmer demographics.

7.3. Material and Methods

7.3.1. Participant recruitment and collection of recordings

Between October 2015 and January 2017, all dairy veterinarians at a feasible driving distance (< 750 km) from Calgary were contacted by email and telephone and asked to enroll in the study. Of the 16 contacted veterinarians, 11 (69%) agreed to participate. Additionally, 30 dairy practitioners who participated in the Dairy Health Management Continuing Education Program (Ontario Veterinary College, University of Guelph, ON, Canada) were asked to participate in the study by sending out a group email. Six of the veterinarians agreed to participate in the study (between June 2017 and September 2017). All veterinarians were informed that they would receive CAN$100 if they completed all study aspects.

Ethics approval was obtained from the University of Calgary's Research Ethics board, REB15-1800. Veterinarians who participated in the study obtained written consent from their dairy clients to record regular HH&PM farm visits. Information about the study and contact information for the researchers were provided to the veterinarian to be handed out to the farmer. Veterinarians were asked to record 7 visits each on different farms; however, in 2 cases the veterinarians did not have enough dairy clients to reach that number, and in 2 other cases the veterinarians stopped recording HH&PM farm visits before reaching 7 recordings. In total, 99 recordings were submitted by the veterinarians. Of these, recordings that were deemed insufficient for analysis (i.e. poor audio quality, large parts of the HH&PM farm visit were not recorded; n=18), had missing paperwork (n=7) or where farmers withdrew their consent after recording (n=2) were discarded. If there were fewer than 3 recordings suitable for analysis remaining for any particular veterinarian, none of his/her recordings were used for the study. Therefore, 70 recordings by 14 different veterinarians (3-7 recordings per veterinarian) were analyzed. Farmers and veterinarians provided information on their demographics after the recorded HH&PM farm visits.

7.3.2. Equipment

The equipment used for this study has been described in detail (Ritter et al., 2017). In short, veterinarians were provided with a GoPro® camera (Hero3 black edition; GoPro Inc., San Mateo, CA, USA) and a BacPac® (GoPro) battery, which increased the maximum recording time to up to 3 h. The camera could be worn on the veterinarian's chest or head, using different adjustable mounts. A new SD memory card was used for every HH&PM farm recording. Veterinarians handed a voice recorder to the farmer to wear during the herd visit, ensuring that the farmer's voice was captured even when distances between veterinarian and farmer were too large for the GoPro® camera to record the farmer's audio. Files from the camera and the voice recorder were subsequently merged by the researchers (Ritter et al., 2017).

7.3.3. Coding of recordings

The most widely used analytical tool to obtain comprehensive information on communication in the clinical context is the Roter Interaction Analysis System (RIAS; Roter and Larson, 2002). The RIAS was developed to assess medical encounters in human medicine and the majority of studies have used RIAS in this context (reviewed by Pires et al., 2014). However, recently, suitability of this tool was demonstrated for veterinarian – farmer interactions during dairy farm visits (Ritter et al., 2017). Recordings were assessed by trained coders at Johns Hopkins Bloomberg School of Public Health using the RIAS (Roter and Larson, 2002; Shaw et al., 2004). The first and second authors met with the coders prior to the coding process to familiarize them with the dairy context and ensure appropriate adaptation of codes.

Using the RIAS, mutually exclusive and exhaustive codes were assigned to the smallest unit of statement or expression that constitute a complete thought (i.e., a communication unit). For example, a veterinarian's communication unit: "You are right" would be coded as agreement, whereas "I believe it will be okay" would be coded as reassurance. Although the coding criteria were identical, to better reflect the dairy context, it was decided to change the RIAS code expression “Lifestyle” into “Animal Care”, which covers general management topics such as animal nutrition or housing. For example, the veterinarian’s communication unit “How do you like the new feed?” would be an Animal Care open-ended question. In contrast, the RIAS code “Biomedical” represented questions or statements related to specific animal health issues (e.g. “Have you started the mastitis treatment yet?” would be a biomedical closed-ended question).

Frequency of each of the codes during the recordings were counted to create a quantitative dataset (Roter and Larson, 2002). Codes were also combined into categories (i.e., communication components) such as “Information gathering”, “Education and Counseling”, and “Relationship building” to reflect the broader form and content of the conversation.

In addition to the verbal codes describing the conversations in detail, the RIAS coders assigned global affect ratings after each on-farm recording on a 6-point Likert scale (1 and 6 representing the lowest and highest possible score, respectively) reflecting their perception of the veterinarian’s affective factors such as warmth, respectfulness, and dominance.

To compare whether veterinarians communicated differently depending on the context, specific criteria were used to distinguish conversations that were categorized as herd health conversations compared to discussions about an issue with a specific animal. In the latter case either the veterinarian or the farmer had to believe there was a problem with an individual animal. Indicators that were used by the RIAS coders to identify these health problem discussions included: verbalizing a concern about the animal, separation of the animal from the group, use of diagnostic tools other than ultrasound (e.g., stethoscope, thermometer), use or prescription of drugs, veterinarian's diagnosis). Routine procedures, such as pregnancy diagnosis or the dehorning of calves, were not classified as health problem conversations unless a concern about a specific animal was brought up. Previous clinical communication training was defined as having had at least 20 hours of professional communication training including at least one official assessment of communication competence (e.g., through objective simulated clinical examinations). Similar to previous studies in human medicine, the relationship-centeredness care (RCC) score of the on-farm interaction was calculated; in human medicine this is referred to as patient-centeredness (e.g., Roter et al., 2008; Weiner et al., 2012). The RCC score was obtained by dividing RIAS variables that contribute to a good relationship, farmer empowerment, veterinarian's understanding of the whole farming enterprise and shared decision-making (e.g., veterinarian's questions about animal care topics, statements of empathy, reassurance, and partnership, as well as farmer questions) by RIAS variables that represent veterinary dominance and a focus on biomedical topics (e.g., medical questions and education from the veterinarian, and farmer medical information giving). Hence, the higher the RCC score, the higher the relationship-centeredness of the farm visit.

7.3.4. Statistical analyses

Stata IC15.0 (StataCorp LP, College Station, TX) was used for statistical analysis, and *P*-values <0.05 were considered statistically significant. Descriptive statistics were estimated on demographic variables for veterinarians and farmers, as well as on recorded communication units and components. In general, communication patterns were reported for the entire recording as a whole, and the percentages of a specific communication unit were obtained by dividing it by the total number of veterinary statements. However, for the purpose of comparing conversations concerning an individual animal and whole herd discussions, communication units were stratified accordingly. Then, to obtain the percentage of a specific communication unit, the counts of that communication unit were divided by the total number of statements made during the whole herd advisory part and individual animal discussions, respectively.

To assess whether the variance of observed communication patterns or global affect ratings was due to variability between recordings by the same veterinarian or due to variability between veterinarians, intraclass correlation coefficients (ICC) were calculated using multilevel linear regression models with veterinarian as random effect. To account for the different lengths of submitted recordings and standardize the number of recorded communication units, recording length and number of total veterinary communication units were considered as a denominator.

Number of communication units were compared between groups. When comparison was made using demographic characteristics measured on a discrete scale, stratification was based on the median. Then, negative binomial regression models with veterinarian as random effect and length of recording as offset were applied. Hence, groups were compared regarding their number of specific statements per minute of recording. Recording length was reported and compared between groups using multilevel linear regression with veterinarian as random effect.

Because the ICC of the RCC score was very close to zero, linear regression models with clustered random errors for veterinarian were applied to compare the RCC score among groups. Univariable correlations between demographic variables and RCC score were assessed using categorical explanatory variables as well as using the actual numbers for variables measured on a discrete scale (e.g., years, number of cows). Because the study only included 7 female farmers, a comparison of RCC scores depending on farmer's gender was not made. However, the effect of gender dyads was assessed by comparing farms visits where both farmer and veterinarian were male (i.e., male concordance) with farm visits where at least one of them was female.

Variables with $P \leq 0.30$ in the univariable regression analysis (using discrete scale for explanatory variables, where applicable) were entered into a multivariable linear regression model with clustered random errors for veterinarian. Interaction terms were considered based on plausibility and if both variables were $P \leq 0.30$ in the univariable analysis. Then, a backward elimination was done, using the Bayesian information criterion (BIC) estimate to assess model fit and to obtain the final model. All variables significant at $P \leq 0.05$ were included in the final model.

Intra-rater reliability for RIAS codes was assessed by re-coding 7 interactions and calculating the Pearson's correlations coefficient for categories that had a mean communication unit frequency of at least 1 across all interactions. For intra-rater reliability for global affect ratings, the same Likert scale was used and the percentage of agreement for each category was calculated.

7.4. Results

7.4.1. Demographic factors of study participants

Ten male and 4 female veterinarians participated in the study providing 46 and 24 recordings, respectively (Table 7-1). Veterinarians were on average 42 yr old, had 14 yr of dairy herd health experience, and conducted 28 HH&PM farm visits per month. Participating veterinarians were educated at 3 different Canadian veterinary faculties. Of the 14 veterinarians, 8 stated that they had extensive communication education during their veterinary education and had been examined on the communication material. Five veterinarians did not have any communication training and one veterinarian participated in courses during conferences but not during veterinary education.

Farmers (63 male and 7 female) were, on average, 39 yr old and had 125 lactating cows with an average milk production of 35 kg/cow/day. They had, on average, 15 years of dairy herd health management experience, 1.7 HH&PM farm visits per month, and had worked with their current veterinarian for 8 yr (Table 7-1).

7.4.2. Communication results

Mean recording time was 82 min, with the shortest recording being 26 min and the longest being 172 min. On average, 10 veterinary statements per recording (2% of the total veterinary talk) were acoustically not understandable for the coders, and hence coded as unintelligible communication units. Intra-rater reliability was very high with an average correlation on veterinary RIAS categories of 0.99, and all veterinary global affect ratings having an agreement of 100%.

Global affect ratings. Overall, coder's perceptions of veterinarians' affective dimensions (Table 7-2) revealed that veterinarians did not appear anxious or nervous (mean 1.2; median: 1). Their responsiveness and engagement received the highest affect rating score (mean: 4.3; median: 5). However, the range of the ratings was generally wide, encompassing the majority of possible scores. Global ratings' ICC were ≤ 0.50, ranging from 0.17 (warmth) to 0.46 (dominance), hence indicating that veterinarians' affective dimensions varied considerably among HH&PM farm visits.

Communication units and ICC. Veterinarians spent 7% of their total talk on information gathering (Table 7-3). Questions were either directly related to the animals' health (i.e., biomedical questions), such as questions about specific health issues, sickness signs, and treatment or related to animal care factors such as animals' nutrition or housing management. Overall, closed-ended questions about biomedical topics dominated the information gathering component (5% of all veterinary talk) with open-ended questions being far less frequently used. Farmer education and counseling accounted for 41% of all veterinary statements, with considerably more statements being related to biomedical topics (which included statements regarding pregnancy status) compared to animal care topics. The component of veterinary relationship building accounted for 44% of all veterinary communication units and consisted of farmer activation and facilitation (8% of all talk; e.g., veterinarian asks for service or checks for correct understanding) as well as rapport building (36% of all talk). Rapport could, for example, be positive through the expression of agreement, laughter or approval, or negative through veterinary criticism and disagreement (i.e., negative talk). Finally, procedural statements (i.e., transition and orientation statements such as "let's go to the heifers now") accounted for 5% of the veterinary talk.

The ICC for the individual communication units and components differed considerably depending on whether they were standardized by time or by number of all veterinary statements (Table 7-3). However, similar to the global affect ratings, estimated ICC were generally ≤ 0.50 indicating that the observed variance in number of communication units was mainly due to variations among recordings of the same veterinarian and less among recordings of different veterinarians.

Gender. Comparison between male and female veterinarians did not reveal any differences in regard to communication patterns and recording length with the exception that male veterinarians asked more closed-ended animal care questions (10 versus 6 questions for male and female veterinarians, respectively; $P = 0.04$).

Veterinarians' age and professional relationship with the farmer. Veterinarians > 37 yr of age educated and counselled farmers more on animal care topics ($P = 0.04$) and used more self-disclosure statements ($P = 0.01$) compared to younger veterinarians (Table 7-4). Furthermore, veterinarians who had a longer professional relationship with their farmer (> 5 yr) asked less questions (especially less biomedical closed-ended questions; $P = 0.01$), expressed less reassurance or optimism ($P = 0.02$), and their recordings were longer ($P = 0.03$; Table 7-4).

Communication training. Previous communication training was only positively associated with veterinary use of facilitation and activation statements ($P = 0.02$) but was negatively correlated with the number of procedural statements ($P = 0.03$; Table 7-5).

Herd health and individual animal discussions. Comparison of veterinary communication patterns between whole herd discussions and individual animal conversations revealed several differences (Table 7-6). Specifically, herd advisory included more animal care-related questions (especially closed-ended questions ($P < 0.01$)), animal care-related education and counseling ($P < 0.001$), and more statements related to building a relationship ($P < 0.001$). This difference was mainly due to more social talk ($P < 0.001$) and laughter ($P < 0.001$) during the herd advisory part. In contrast, conversations related to a specific animal were characterized by more biomedical education and counseling statements ($P < 0.001$), more concern ($P < 0.001$), and more empathy statements ($P = 0.01$) expressed by the veterinarian.

Relationship-centeredness care (RCC) score. Few veterinary and farmer demographic variables were correlated with the RCC score in the univariable analysis (Table 7-7). There was a negative association of the RCC score with number of rectal examinations ($P = 0.04$) and recording length ($P = 0.01$) when regression analysis was conducted with discrete explanatory variables. Variables included in the final multivariable regression model with a positive relationship of RCC score were the veterinarian practicing in Ontario compared to Alberta ($P = 0.01$), veterinarian and farmer both being male compared to having a female veterinarian and/or farmer ($P = 0.01$), and higher average milk production ($P = 0.02$; Table 7-8). Recording length remained negatively correlated to RCC score ($P < 0.001$).

7.5. Discussion

This study was the first to assess dairy practitioners' communication patterns during dairy farm visits using the RIAS. As such, similar to previous studies (e.g. Lam et al., 2011; Derks et al., 2013), it recognizes the importance of functional relationships between veterinarians and their clients that moves beyond a medical focus. It is, therefore, another step toward acknowledgement of the importance of communication skills to facilitate improved animal well-being through a better understanding of the human aspects that are an essential part of animal care (Williams and Jewell, 2012).

Overall, distribution of veterinary talk between communication components was similar to the patterns observed in companion animal medicine (Shaw et al., 2008; McArthur and Fitzgerald, 2013). However, dairy practitioners appeared to spend more talk on building a relationship compared to companion animal veterinarians (44% of all veterinary talk compared to approximately 30% (Shaw et al., 2008) and 26% (McArthur and Fitzgerald, 2013)). The fact that veterinarians generally had a long-lasting professional relationship with their clients and visited the farms on a regular basis likely contributed to their increased use of social talk during their farm visits (10%) compared to companion animal practitioners (1-3%; Shaw et al., 2008; McArthur and Fitzgerald, 2013).

Gathering 3-7 recordings from each veterinarian decreased the risk of obtaining a non-representative recording due to the observed high variability between farm visits. However, this approach resulted in a relatively small number (n=14) of participating veterinarians, therefore, potential differences between groups might not have been detected due to a lack of power. For example, the only difference between male and female veterinarians was the number of closed-ended animal care questions. However, when assessing the effect of gender dyads, interactions where farmer and veterinarian were both male had a higher RCC score than when at least 1 female was involved. This is consistent with the conclusion by Shaw et al. (2006) that opposite genders increased the use of biomedical communication patterns. Similarly, in the human medical care context, gender-concordant visits were characterized by more physicians attempts to understand the whole person without only focusing on biomedical topics (Bertakis, 2009). Whereas biomedical communication was more likely in consultations with younger primary care physicians and older patients (Roter et al., 1997), differences of dairy practitioners' communication patterns depending on age were limited in this study and not associated with the RCC score.

Veterinarians with previous communication training used more statements related to farmer activation and facilitation. However, the overall similarity of the communication patterns used by both groups indicates that the communication training received was either ineffective for the dairy context or veterinarians lost acquired skills after years in practice. Although Shaw et al., (2006) asked for cautious interpretation of their study results, companion animal veterinarians with communication training were more likely to use a biomedical communication pattern compared to veterinarians without communication training, whereas the current study did not find an effect on RCC score. Although these two studies indicated that communication training does not improve communication skills long-term, other research demonstrated its effectiveness in human and companion animal medicine (e.g., Latham and Morris, 2007; Shaw et al., 2010; Clayton et al., 2012; Artemiou et al., 2013). More research is needed to assess the effectiveness of communication training (over time), especially in the farm animal context.

The highest number of differences in communication patterns used were revealed when comparing conversations related to the whole herd compared to issues regarding an individual animal. Whole herd discussions included more social talk and laughter, which is similar to the results by Shaw et al. (2008), who compared veterinary practice wellness appointments with visits where a companion animal was presented with a (health) problem.

Also similar to the results from Shaw et al. (2008), discussions evolving around an individual animal contained more statements of concern and biomedical talk. Patient-centeredness is generally regarded as an important component of effective medical care (Weiner et al., 2012). However, lack of agreement regarding definition and measure of patient-centeredness (or "relationship-centeredness" in veterinary medicine) makes it difficult to compare evaluations that used different analytical tools (Mead et al., 2000; Mole et al., 2016). Stewart et al., 2003) identified six interconnecting components that contribute to the patient-centeredness of the medical encounter: 1) understanding the whole person; 2) exploring both the disease and the illness experience; 3) enhancing the doctor-patient relationship; 4) finding common ground regarding the management; 5) incorporating disease prevention and health promotion; 6) 'being realistic' about personal limitations and barriers such as the availability of time and resources. Although the veterinary context might be more comparable to pediatric consultations where the primary caretakers are not the patient but the decision-makers the general principles of patient- or relationship-centeredness are likely transferable and a subset of the six components has been applied to assess euthanasia discussions in companion animal medicine (Nogueira Borden et al., 2010; Williams and Jewell, 2012). In this study, being the first to calculate the relationship-centeredness of dairy farm interactions using RIAS, variables that enable a good relationship, veterinarian's interest in the farm management as a whole, shared power and decision-making were contrasted against variables representing veterinary dominance and a sole focus on medical issues. Overall, in this study, veterinarians' RCC score had a mean of 0.47 which was lower than the RIAS-based RCC score (mean: 1.0) reported in companion animal interactions (Kanji et al., 2012) but similar to the RCC score when only appointments with a biomedical communication pattern were taken into account (0.40; Shaw et al., 2006). This relatively low RCC score in combination with low use of other tools that have been demonstrated to improve medical outcomes (e.g., open-ended questions to assess farmers' views and empathy statements (Roter and Hall, 1987; McArthur and Fitzgerald, 2013) constitutes an opportunity to enhance veterinary on-farm communication.

Because statements related to the cows' pregnancy status were coded as biomedical information giving, number of pregnancy assessments through rectal palpations was counted by the RIAS coders. This was done to assess the influence of the number of pregnancy assessments on the RCC score. In the univariable analysis there was a negative relationship of the number of pregnancy assessments to RCC score, possible due to an inflation of the denominator of the RCC. Although this relationship was not confirmed in the multivariable analysis, length of recordings, which was highly correlated number of pregnancy assessments had a negative relationship with the RCC score.

The difference between veterinarians from Alberta and Ontario could be due to the different participant selection methods. Whereas random sampling was used in Alberta, veterinarians who participated in a Dairy Health Management Continuing Education Program were asked to volunteer. The fact that veterinarians selected the farmers for recording could be another source of bias because veterinarians might have only selected farmers with whom they get along well.

As previously discussed, awareness of being recorded could have altered participants' behavior (Derks et al., 2013; Ritter et al., 2017). However, compared to having a researcher present, providing veterinarians with action cameras is likely less disturbing for the course of the farm visit and exhibited communication patterns.

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Table 7-1. Demographic characteristics of veterinarians and dairy farmers participating in the study

	Veterinarians		
Demographic variable	Veterinarians (n=14)	Recordings (n=70)	Farmers (n=70)
Gender (n (%))			
Male	10 (71)	46 (66)	63 (90)
Female	4 (29)	24 (34)	7 (10)
Age (yr; mean, median (SD))	42, 37.5 (13)		39, 36 (11)
Dairy herd health experience (yr; mean, median (SD))[1]	14, 11.5 (13)		15, 12 (11)
Number of HH&PM[2] farm visits per month (mean, median (SD))	28, 28 (21)		1.7, 2 (0.7)
Veterinary education (n (%))			
Ontario Veterinary College	7 (50)	38 (54)	
University of Calgary Faculty of Veterinary Medicine	3 (21)	15 (21)	
Western College of Veterinary Medicine	4 (29)	17 (24)	
Yr of graduation (n (%))			
Before 2001	6 (43)	24 (34)	
After 2005	8 (57)	46 (66)	
Percent dairy clients (mean, median (SD))	67, 80 (31)		
Number of farms with regular HH&PM[2] farm visits (mean, median (SD))	19, 15.5 (13)		
Number of lactating cows (mean, median (SD))			125, 100 (84)
Milk production (kg/cow/day; (mean, median (SD))			34.8, 35 (3.6)
Years working with the same veterinarian (mean, median (SD))			8, 6 (8)

[1]For farmers: Years of involvement in dairy farm management decisions

[2]Herd health and production management

Table 7-2. Global ratings for veterinarians' affective dimensions during herd health and production management dairy farm visits

Affective dimension	Mean	Median	Range	ICC[1] (95% CI)
Anxiety/Nervousness	1.2	1	1-3	0.29 (0.10-0.60)
Dominance	3.5	3	2-5	0.46 (0.22-0.71)
Interest/Attentiveness	4.1	4	2-5	0.27 (0.09-0.60)
Warmth	4.2	4	2-5	0.17 (0.03-0.57)
Responsiveness/Engagement	4.3	5	2-5	0.19 (0.05-0.52)
Sympathetic/Empathetic	3.9	4	2-5	0.33 (0.12-0.62)
Hurried/Rushed	2.8	3	1-5	0.42 (0.19-0.69)
Respectfulness	3.9	4	2-5	0.27 (0.09-0.60)

[1]Intra-class correlation coefficient

Table 7-3. Communication patterns and intra-class correlation coefficients (ICC) of 14 dairy practitioners during 70 herd health and production management farm visits

Communication component	Mean (% all talk)	Median	Range	ICC (95% CI): standard. by time	ICC (95% CI): standard. by talk
Information gathering	42 (7)	36.5	7-114	0.56 (0.31-0.78)	0.34 (0.13-0.63)
Biomedical	33 (6)	29	5-93	0.50 (0.26-0.74)	0.22 (0.06-0.54)
Closed-ended questions	27 (5)	23.5	4-77	0.41 (0.18-0.68)	0.21 (0.06-0.53)
Open-ended questions	5 (1)	3	0-23	0.45 (0.21-0.72)	0.22 (0.05-0.58)
Animal care	10 (2)	8	0-31	0.32 (0.11-0.63)	0.35 (0.14-0.65)
Closed-ended questions	8 (1)	7	0-25	0.23 (0.06-0.58)	0.29 (0.10-0.61)
Open-ended questions	1 (0)	1	0-10	0.46 (0.23-0.72)	0.37 (0.15-0.66)
Education and Counseling	246 (41)	208.5	57-676	0.42 (0.18-0.71)	0.17 (0.03-0.58)
Biomedical	212 (35)	177.5	53-641	0.47 (0.23-0.73)	0.32 (0.10-0.66)
Animal care	34 (5)	24	0-173	0.21 (0.04-0.61)	0.14 (0.02-0.56)
Relationship building	269 (44)	234	58-888	0.60 (0.35-0.81)	0.37 (0.15-0.67)
Facilitation and activation	45 (8)	37	5-155	0.40 (0.18-0.67)	0.46 (0.23-0.71)
Rapport building	222 (36)	184	48-815	0.61 (0.37-0.81)	0.39 (0.17-0.68)
Social talk	60 (10)	31	0-355	0.41 (0.18-0.69)	0.26 (0.09-0.57)
Agreement	46 (8)	42.5	3-120	0.34 (0.14-0.64)	0.70 (0.48-0.86)
Laughter	34 (5)	26.5	0-220	0.51 (0.26-0.76)	0.15 (0.02-0.62)
Reassurance / Optimism	37 (6)	30	5-130	0.21 (0.05-0.57)	[1]
Concern/Worry	28 (4)	24.5	0-111	0.47 (0.22-0.74)	0.21 (0.05-0.57)
Approval	11 (2)	8	0-41	0.43 (0.20-0.69)	0.32 (0.12-0.61)
Self-disclosure	0 (0)	2	0-17	0.12 (0.02-0.53)	0.11 (0.02-0.50)
Empathy	1 (0)	1	0-11	[1]	[1]
Negative talk	2 (0)	0.5	0-20	0.72 (0.49-0.87)	0.40 (0.17-0.69)
Procedural statements	28 (5)	21	1-125	0.33 (0.13-0.62)	0.28 (0.09-0.60)
Recording length (min)	82	75.5	26-172	0.13 (0.02-0.54)	
RCC score[2]	0.47	0.42	0.23-0.89	[1]	

[1]Unable to obtain ICC and 95% CI due to within-veterinarian correlation very close to 0

[2]Relationship centered care score

Table 7-4. Veterinary communication patterns stratified by veterinarians' age and years of working with the same dairy farmer

Communication component	Veterinarian's age[1]				Veterinarian-farmer relationship[2]			
	Mean (% of talk)				Mean (% of talk)			
	< 37 yr	≥ 37 yr	Coeff. (95% CI)	*P*-value	≤ 5 yr	> 5 yr	Coeff. (95% CI)	*P*-value
Information gathering	34 (7)	51 (8)	0.24 (-0.18-0.67)	0.27	46 (8)	39 (7)	-0.23 (-0.44-(-0.01))	0.04
Biomedical	26 (5)	39 (6)	0.25 (-0.18-0.68)	0.26	36 (6)	30 (5)	-0.27 (-0.50-(-0.04)	0.02
Closed-ended questions	22 (4)	32 (5)	0.22 (-0.18-0.63)	0.28	30 (5)	25 (4)	-0.31 (-0.54-(-0.07)	0.01
Open-ended questions	4 (1)	7 (1)	0.35 (-0.27-0.96)	0.27	6 (1)	5 (1)	-0.11 (-0.58-0.36)	0.65
Animal care	7 (2)	12 (2)	0.22 (-0.37-0.80)	0.47	10 (2)	9 (2)	-0.14 (-0.51-0.22)	0.45
Closed-ended questions	6 (1)	10 (2)	0.20 (-0.35-0.75)	0.47	8 (1)	8 (2)	-0.12 (-0.50-0.26)	0.53
Open-ended questions	1 (0)	2 (0)	0.40 (-0.48-1.28)	0.37	2 (0)	1 (0)	-0.28 (-0.94-0.38)	0.41
Education and Counseling	199 (38)	295 (42)	0.23 (-0.11-0.58)	0.19	251 (41)	244 (40)	-0.06 (-0.29-0.16)	0.57
Biomedical	178 (34)	247 (36)	0.16 (-0.17-0.50)	0.34	214 (36)	212 (35)	-0.05 (-0.25-0.14)	0.59
Animal care	21 (4)	48 (6)	0.64 (0.03-1.27)	0.04	37 (6)	32 (5)	-0.19 (-0.73-0.35)	0.49
Relationship building	241 (47)	296 (41)	-0.03 (-0.48-0.42)	0.89	265 (45)	271 (44)	0.00 (-0.23-0.23)	1.00
Facilitation and activation	40 (8)	49 (7)	-0.03 (-0.46-0.40)	0.88	45 (8)	44 (8)	-0.12 (-0.41-0.17)	0.43
Rapport building	200 (38)	244 (33)	-0.04 (-0.55-0.45)	0.85	219 (37)	225 (36)	-0.00 (-0.25-0.24)	1.00
Social talk	55 (10)	66 (8)	-0.29 (-1.26-0.67)	0.56	54 (9)	66 (10)	0.03 (-0.64-0.71)	0.93
Agreement	44 (9)	48 (7)	-0.11 (-0.42-0.18)	0.44	44 (8)	47 (9)	-0.11 (-0.32-0.12)	0.35
Laughter	34 (6)	34 (5)	-0.28 (-1.16-0.60)	0.53	31 (5)	36 (6)	0.11 (-0.26-0.48)	0.55
Reassurance / Optimism	31 (6)	43 (6)	0.16 (-0.22-0.54)	0.41	41 (7)	34 (5)	-0.34 (-0.61-(-0.06)	0.02
Concern/Worry	23 (4)	32 (4)	0.05 (-0.53-0.64)	0.87	29 (5)	27 (4)	-0.07 (-0.44-0.31)	0.73

Approval	9 (2)	12 (2)	0.16 (-0.56-0.88)	0.67	12 (2)	9 (2)	-0.23 (-0.66-0.19)	0.29
Self-disclosure	1 (0)	3 (0)	1.12 (0.24-1.99)	0.01	2 (0)	2 (0)	-0.14 (-1.12-0.83)	0.78
Empathy	1 (0)	1 (0)	0.11 (-0.85-1.07)	0.82	1 (0)	1 (0)	-0.32 (-1.11-0.48)	0.43
Negative talk	1 (0)	3 (0)	0.86 (-0.70-2.42)	0.28	1 (0)	2 (0)	0.53 (-0.41-1.47)	0.27
Procedural statements	22 (4)	35 (6)	0.38 (-0.03-0.78)	0.07	25 (4)	31 (6)	0.15 (-0.15-0.45)	0.34
Recording length[3]	74	89	0.45 (-0.42-1.32)	0.31	77	85	1.30 (0.15-2.45)	0.03

[1]Included 35 recordings from 6 veterinarians <37 yr (coded as 0) and 35 recordings from 8 veterinarians ≥ 37 yr (coded as 1)

[2]Included 31 recordings from 6 veterinarians with a professional farmer relationship < 5 yr (coded as 0) and 39 recordings from 8 veterinarians with a professional farmer relationship ≥ 5 yr (coded as 1)

[3]Linear regression was conducted on discrete scales

Table 7-5. Veterinary communication patterns stratified by whether or not they received previous communication training

Communication component	Communication training[1]		No communication training[2]		Coeff.	95% CI	*P*-value
	Mean	Range	Mean	Range			
Information gathering	47 (8)	7-114	35 (7)	7-85	0.21	-0.22-0.64	0.24
Biomedical	36 (6)	6-96	27 (5)	5-71	0.24	-0.19-0.68	0.27
Closed-ended questions	30 (5)	5-77	23 (4)	4-54	0.23	-0.17-0.64	0.26
Open-ended questions	6 (1)	0-23	4 (1)	0-16	0.29	-0.34-0.92	0.63
Animal care	10 (2)	0-31	8 (2)	0-23	0.20	-0.40-0.81	0.51
Closed-ended questions	9 (1)	0-25	7 (1)	0-21	0.16	-0.41-0.74	0.58
Open-ended questions	2 (0)	0-10	1 (0)	0-4	0.46	-0.44-1.32	0.32
Education and Counseling	250 (39)	57-676	241 (42)	57-613	-0.02	-0.39-0.35	0.92
Biomedical	215 (34)	56-641	210 (37)	53-490	-0.05	-0.40-0.30	0.78
Animal care	36 (5)	1-173	32 (5)	0-169	0.13	-0.62-0.87	0.74
Relationship building	286 (46)	68-663	239 (40)	58-888	0.26	-0.18-0.69	0.25
Facilitation and activation	51 (9)	8-155	33 (6)	5-79	0.44	0.06-0.81	0.02
Rapport building	233 (37)	58-634	203 (34)	48-815	0.23	-0.26-0.71	0.36
Social talk	62 (10)	0-245	58 (9)	0-454	0.47	-0.51-1.44	0.35
Agreement	48 (9)	12-117	41 (7)	3-120	0.21	-0.09-0.50	0.17
Laughter	35 (5)	4-220	31 (5)	0-100	0.38	-0.49-1.26	0.39
Reassurance / Optimism	40 (6)	8-130	32 (6)	5-92	0.19	-0.19-0.57	0.34
Concern/Worry	28 (4)	0-79	28 (5)	5-111	0.10	-0.49-0.70	0.74
Approval	13 (2)	0-41	6 (1)	0-21	0.61	-0.04-1.27	0.07
Self-disclosure	2 (0)	0-17	2 (0)	0-13	0.18	-1.09-1.43	0.78
Empathy	1 (0)	0-8	1 (0)	0-11	0.35	-0.64-1.33	0.49
Negative talk	1 (0)	0-10	3 (0)	0-20	-0.81	-2.36-0.74	0.30
Procedural statements	25 (4)	1-78	35 (7)	8-125	-0.44	-0.82-(-0.05)	0.03
Recording length (min)	82	26-163	81	30-172	-0.08	-21.89-21.73	0.99

[1]Included 44 recordings from 8 veterinarians (coded as 1)

[2]Included 26 recordings from 6 veterinarians (coded as 0)

Table 7-6. Comparison of communication patterns used by veterinarians during whole herd conversations compared to discussion of individual animals

	Herd[1]		Individual animal[2]				
Communication component	Mean (% of talk)	Range	Mean (% of talk)	Range	Coeff.	95% CI	*P*-value
Information gathering	40 (7)	2-111	5 (5)	0-24	-0.43	-0.48-0.01	0.04
Biomedical	31 (6)	2-86	4 (4)	0-24	-0.12	-0.38-0.14	0.37
Closed-ended questions	26 (5)	1-69	4 (4)	0-22	-0.06	-0.04-0.21	0.66
Open-ended questions	5 (1)	0-23	1 (1)	0-5	-0.39	-0.97-0.19	0.18
Animal care	9 (2)	0-31	1 (1)	0-3	-0.92	-1.44-(-0.39)	0.001
Closed-ended questions	8 (1)	0-25	0 (0)	0-3	-0.97	-1.53-(-0.39)	0.002
Open-ended questions	1 (0)	0-10	0 (0)	0-1	-0.73	-1.89-0.44	0.22
Education and Counseling	227 (39)	12-609	44 (50)	0-141	0.24	0.14-0.34	<0.001
Biomedical	194 (34)	5-568	42 (48)	0-121	0.35	0.24-0.56	<0.001
Animal care	33 (5)	0-173	2 (2)	0-20	-0.93	-1.35-(-0.52)	<0.001
Relationship building	255 (45)	30-885	30 (33)	0-130	-0.25	-0.35-(-0.14)	<0.001
Facilitation and activation	42 (8)	4-146	6 (6)	0-33	-0.11	-0.36-0.14	0.41
Rapport building	211 (36)	16-812	24 (28)	0-97	-0.26	-0.39-(-0.14)	<0.001
Social talk	60 (10)	0-454	1(1)	0-12	-2.45	-3.14-(-1.77)	<0.001
Agreement	43 (8)	3-117	7(8)	0-43	0.03	-0.15-0.21	0.77
Laughter	33 (6)	0-220	2 (2)	0-10	-0.97	-1.33-0.61	<0.001

Reassurance / Optimism	34 (6)	3-130	6 (7)	0-22	0.13	-0.07-0.35	0.21
Concern/Worry	25 (4)	0-111	7(8)	0-23	0.67	0.43-0.92	<0.001
Approval	10 (2)	0-40	1(1)	0-6	-0.03	-0.73-0.12	0.16
Self-disclosure	2 (0)	0-17	0 (0)	0-1	-0.69	-1.94-0.57	0.28
Empathy	1 (0)	0-11	0 (0)	0-5	0.99	0.21-1.77	0.01
Negative talk	2 (0)	0-20	0 (0)	0-2	-0.29	-1.33-0.75	0.58
Procedural statements	26 (5)	1-125	5 (5)	0-18	0.04	-0.24-0.33	0.77

[1]Coded as 0

[2]Coded as 1

Table 7-7. Univariable associations of demographics with relationship-centered care (RCC) score.

Demographic variable	RCC score (Mean)	RCC score (Range)	Coeff. (95% CI)[1]	*P*-value[1]	*P*-value[2]
Veterinarian					
Gender					
Female	0.44	0.23-0.74	0.03 (-0.02-0.10)	0.27	N/A[3]
Male	0.48	0.24-0.89			
Age (years)					
< 37 yr	0.46	0.28-0.89	0.01 (-0.07-0.09)	0.78	0.71
≥ 37 yr	0.47	0.23-0.86			
Province[1]					
Alberta	0.44	0.24-0.89	0.05 (-0.02-0.13)	0.17	N/A[3]
Ontario	0.50	0.23-0.86			
Veterinary school					
OVC	0.48	0.23-0.86	baseline		N/A[3]
UCVM	0.43	0.28-0.89	-0.04 (-0.12-0.04)	0.27	
WCVM	0.47	0.24-0.75	-0.01 (-0.11-0.10)	0.93	
Communication training					
No	0.46	0.24-0.75	0.01 (-0.08-0.09)	0.85	N/A[3]
Yes	0.47	0.23-0.89			
Farmer					
Age (years)					
< 37 yr	0.48	0.23-0.77	-0.03 (-0.09-0.04)	0.37	0.85
≥ 37 yr	0.45	0.27-0.89			
Education					
High school or less	0.46	0.23-0.86	0.03 (-0.04-0.10)	0.31	N/A[3]
Postgraduate education	0.49	0.28-0.89			
Lactating cows (No.)					
≤ 100	0.50	0.24-0.86	-0.07 (-0.14-0.01)	0.09	0.24
> 100	0.43	0.23-0.89			
Milk production (kg/cow/day)					
≤ 35	0.46	0.23-0.77	0.02 (-0.06-0.10)	0.65	0.30
> 35	0.47	0.27-0.89			
General					
Farmer-veterinarian relationship (years)					
≤ 5 yr	0.48	0.23-0.86	-0.03 (-0.11-0.05)	0.44	0.41
> 5 yr	0.45	0.24-0.89			

Gender					
Female farmer and/or veterinarian	0.44	0.23-0.74	0.05 (-0.01-0.12)	0.07	N/A[3]
Concordant male	0.49	0.24-0.89			
Discussion					
Herd advisory	0.47	0.23-0.89	-0.03 (-0.09-0.04)	0.41	N/A[3]
Individual animal	0.45	0.25-1.00			
Pregnancy examinations (No.)					
< 30	0.49	0.31-0.86	-0.07 (-0.14-0.01)	0.07	0.04
≥ 30	0.43	0.23-0.89			
Recording length (min)					
< 75	0.49	0.24-0.89	-0.05 (-0.12-0.02)	0.12	0.01
≥ 75	0.44	0.23-0.85			

[1]Based on linear regression analysis with stratified explanatory variables

[2]Based on linear regression analysis with explanatory variables on discrete scale

[3]Not applicable

Table 7-8. Multivariable effects of demographic variables on relationship-centeredness care (RCC) score

Demographic variable	Coefficient	95% CI	*P*-value
Province Ontario	0.09	0.02-0.15	0.01
Concordant Male	0.08	0.02-0.14	0.01
Milk production (kg/cow/day)[1]	0.01	0.00-0.02	0.02
Recording length (min)[1]	-0.002	-0.003-(-0.001)	<0.001

[1]Based on linear regression analysis with explanatory variables on a discrete scale

CHAPTER 8: Summarizing discussion

8.1. Concluding remarks

8.1.1. Socio-psychological influences

Dairy farmers have to balance industry standards, consumer expectations, and economic sustainability of their farm while also meeting their own standards and social norms. Socio-psychological factors are important influences in farmers' adoption of recommended management strategies, and disease prevention and control interventions will likely be more effective if these influences are taken into consideration (Schewe et al., 2015). Recommendations for policy-makers and other stakeholder who aim to motivate on-farm changes are presented in this thesis (Chapter 2) based on a literature review and lessons learned from experiences with the Alberta Johne's Disease Initiative (AJDI). Farmer participation in the AJDI was with 65% comparably high. However, the fact that the AJDI risk assessment could be used by farmers to apply for funding of on-farm biosecurity measures through the Growing Forward 2 Animal Health Biosecurity Producer Program, could have motivated farmers to enroll in the AJDI without truly believing in the program (http://www.growingforward.alberta.ca). In total, 82 farmers (~16% of all farmers) applied for funding through the Growing Forward 2 program between 2013 and 2018 (unpublished data), therefore it can be concluded that this motivation, although it might have played a role, was not the main reason for farmers to participate in the AJDI.

It appeared that AJDI nonparticipants adopted a "wait-and-see" mindset (Chapter 3), likely because they were either not sufficiently informed or skeptical regarding the benefits and costs associated with AJDI participation. This group especially regarded time on their farm as a major constraint and it was important to them that the program was successful on other farms before they committed to it. Other studies reported similar barriers that prevented farmers to enroll in voluntary disease prevention and control programs or implement recommended management practices. Especially, insufficient time, labor, finances, facilities, and feasibility are barriers often mentioned by farmers (e.g., Gunn et al., 2008; Benjamin et al., 2010; Sorge et al., 2010; Garforth, 2011; Horseman et al., 2014). To promote AJDI enrollment, it is therefore important to educate farmers about the disease, program benefits, and emphasize that even minor management changes can decrease the risk of transmission of *Mycobacterium avium* subsp. *paratuberculosis* (MAP), and that these changes are not necessarily costly nor time consuming (Chapter 3).

Because cost estimates of Johne’s disease (JD) are difficult and farmers make their decisions based on a variety of reasons, financial arguments should not be the only focus when motivating JD prevention and control (Hop et al., 2011). Instead, internal drivers need to be addressed. It is undisputed that farmers' unique circumstances affect every decision about adopting a management strategy; their awareness of a problem, and the perceived effectiveness and feasibility of recommended strategies are certain to play important roles in farmers' decision to change management (Chapter 2, 3, and 5; Leach et al., 2010; Jansen and Lam, 2012; Garforth et al., 2013; Relun et al., 2013). The effect of internal drivers (e.g., farmers’ sense of responsibility, pride, and perceived social pressure), and their perceived behavioral control has been described in a few studies (e.g., Nielsen et al., 2011; Swinkels et al., 2015; Toma et al., 2015), but needs to be investigated further in order to estimate the magnitude of each of these effects.

Farmers who participated in the AJDI often only enrolled because their veterinarian urged them to, or because they wanted to take advantage of the opportunity to test their herd for MAP free of charge (Chapter 5). Although most farmers did not perceive JD as a current problem on their farm, they differed in their perceptions of the importance of the disease and their belief regarding proposed prevention and control strategies. If unfavorable, these perceptions, and not a lack of knowledge, inhibited implementation of recommended strategies to improve JD management. Although knowledge is a necessary precursor of making informed management decisions, it is generally accepted that knowledge alone is not sufficient to motivate management changes (Wells and Wagner, 2000; Ellis-Iversen et al., 2010). The main reasons why farmers did not adopt recommended management practices to prevent and control JD included lack in the belief of the importance of JD, and of the effectiveness or feasibility of recommended practices (Chapter 5). Additionally, other priorities on their farm (e.g., mastitis, fertility), and the belief that changes in management would lead to disadvantages (e.g., reduced colostrum quality after pasteurization) prevented farmers from implementing recommended management strategies (Chapter 5).

Because of its chronic nature, the difficulties estimating associated costs, lack of test sensitivity, and the numerous transmission pathways, it is especially challenging to motivate farmers to implement measures for JD (Chapter 2, 3, and 5). However, many of the strategies that are recommended for the prevention and control of JD might also have an immediate positive impact on other fecal-orally transmitted pathogens such as *Salmonella* subsp., *Escherichia coli*, and *Campylobacter* spp. (Roche, 2014). To increase the effectiveness of extension efforts aiming to reduce MAP transmission, it is therefore recommended to highlight the potential benefits of management changes on the reduction of the latter bacteria, which often lead to more visible clinical signs and hence convey a greater sense of the necessity of action. In Canada, the proAction initiative of Dairy Farmers of Canada includes the evaluation of biosecurity measures on dairy farms using a structured risk assessment, which facilitates identifying weaknesses in management practices and routes for pathogen transmission (DFC, 2018). Therefore, Canada takes a more holistic approach toward combating not only JD but addressing biosecurity as whole. Five other components of proAction address milk quality, food safety, animal care, traceability, and the environment. Establishing nation-wide standards in one comprehensive on-farm initiative aims to improve credibility, practicability, and the marketing and branding of Canadian milk (DFC, 2018).

Frameworks such as the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) provide stakeholders with theoretical foundations that can facilitate accounting for socio-psychological factors when designing and implementing interventions. In the veterinary context, several studies assessed the value of these models for interventions on farm-level and generally concluded that they provide a benefit for understanding and measuring farmers' attitudes (e.g., Jemberu et al., 2015; Jones et al., 2015; Vande Velde, 2015). In this thesis, several concepts of both models were described as important barriers or motivators for farmers' decision making regarding JD prevention and control (Chapter 2, 3, 5). However, it could have been expected that farmers with a higher MAP prevalence on their farm were more likely to enroll in the AJDI because of an increased sense of the threat of JD and its associated impact on animal health and financial costs. Yet, farmers who enrolled in the AJDI and farmers who did not, had a very similar on-farm MAP prevalence (i.e., 51%) as assessed by environmental fecal samples (Chapter 4). Potential explanations for this lack of an expected relationship include: 1) farmers of uninfected herds enrolled to be proactive and used the AJDI to assess their herd's infection status and improve disease prevention, 2) the sample of farms used to assess difference in MAP prevalence between AJDI participants and nonparticipants (only farms enrolling between September 2012 and August 2013 were eligible for study participation), 3) farmers who expected MAP-positive test results were worried that their herd status would not be treated confidentially, and, therefore, did not enroll, and 4) farmers who expected their herd to be infected with MAP preferred a suspicion over official knowledge that is more difficult to deny. However, when asked whether they expected their herd to be MAP-infected (prior to AJDI-participation), answers between participants and nonparticipants were very similar (Chapter 3), indicating that the two latter notions did not play an important role in farmers' decision to enroll or not.

Some authors believe that the HBM and TPB, although they provide valuable frameworks, do not necessarily account for all factors that proceed or inhibit behavior changes (Janz and Becker, 1984; Orji et al., 2012). For example, there is evidence that intentions offer superior prediction of behavior compared to the measurement of peoples' attitudes, norms, and perceptions (Sheraan and Webb, 2016). Whereas the TPB accounts for intentions as a precursor of behavior, the HBM does not. However, even when intentions are accounted for, it often remains elusive what drives (or hinders) people to convert their intentions into actions. Sheeran and Webb (2016) synthesized research aiming to explain reasons for this so-called "Intention-Behavior-Gap". They concluded that factors such as over-optimistic goals, difficulty of changing the behavior, and past experience with the behavior change can affect the conversion from intention to behavior.

Lam et al. (2017) built onto the principles of frameworks such as the HBM and TPB and developed a RESET Mindset Model that is meant to be used in practice and consists of five components: Rules and regulations, Education and Information, Social pressure, Economics, and Tools. The RESET Mindset Model postulates that these cues can motivate people (e.g., farmers) to change their behavior, and are most effective when applied in combination (Lam et al., 2017). Application of this model on dairy farms in the Netherlands demonstrated that it can facilitate decrease of antibiotic usage (Lam et al., 2017). Because of the similar management practices in the Netherlands and Canada, application of this model in the Canadian dairy context is worth consideration when developing prevention and control programs.

8.1.2. Farmers' information sources

Farmers are not an isolated group but are influenced by their context, which can impede or facilitate on-farm changes. To effectively inform farmers about recommended management measures, a range of communication channels has been used by agricultural extension professionals and other stakeholders (Chapter 2 and 3). Different farmers prefer using different information sources to receive information on farm management and disease prevention and control (Relun et al., 2013). Mass media have the advantage of reaching a broad audience and many farmers value printed media in form of magazines or newsletters, whereas the Internet is (still) less popular among farmers (Russell and Bewley, 2011; Brennan and Christley, 2013; Derks et al., 2013a). Similarly, in Alberta, the newsletter "Milking times" was among the most frequent sources of information for dairy farmers, whereas the AJDI website was only visited by less than 40% of the dairy farmers (Chapter 3). More personal means of communication can move beyond simple education and take farmers' individual beliefs, goals, and constraints into account. Fellow producers were also regularly used by Alberta dairy farmers to receive information, consistently with the findings from other studies (Chapter 2 and 3; Hansson and Ferguson, 2011; Lindberg et al., 2006; Swinkels et al., 2015). In discussion groups and other forms of participatory group learning, farmers' appreciation for other producers' experiences can be used to explore issues relevant to the farmers with the objective to provide solutions that convert scientific information into feasible on-farm practices (Roche et al., 2015). Although a few studies in the agricultural context evaluated the benefits of participatory group learning (e.g., Crawford et al., 2007; Roche et al., 2015), more research is needed to gain a better understanding of the most effective ways to deliver information to farmers as part of a group learning experience.

Peripheral extension tools (i.e., "nudges") hold the promise to elicit behavior change in farmers who will not be convinced by rational reasoning (Jansen et al., 2010b). According to Thaler and Sunstein (2008) nudges "alter people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid." In the Netherlands, Jansen et al. (2010b) were able to improve farmers' attitudes toward milking gloves by distributing free samples and humorous postcards. Considering that, across countries, a substantial percentage of farmers appears to be hesitant to adopt recommended management strategies to decrease pathogen transmission for a variety of diseases (Nielsen, 2011; Brennan and Christley, 2013), the benefits of peripheral extension tools should be further explored. The most recent (2017) Nobel prize in economics to Richard Thaler for his work in psychological analyses of individual decision-making with a focus on “nudging” highlights the relevance of this approach and its undiscovered potential to improve farm management practices.

In most studies, farmers regard their herd veterinarian as trustworthy and credible source of advice on farm management, and veterinary practitioners appear to be a major influence on farmers’ management decisions (Jansen et al., 2010c; Derks et al., 2013a; Alarcon et al., 2014). This influence can be used to facilitate positive on-farm changes; for example, AJDI participants used their veterinarian considerably more often to obtain information on management practices than AJDI nonparticipants (Chapter 3). Veterinarians can therefore be important mediators, who help farmers to implement recommendations from industry and research given that they are aware of their responsibility as advisors (Jansen and Lam, 2012).

8.1.3. Veterinary communication

Medical advisory is known to be more effective if clinical communication skills are used (Silverman et al., 2005). Current evidence for the benefit of communication skills mainly derives from human medicine, and to a much smaller extent, from companion animal medicine (e.g., Silverman et al., 2005; Adams and Kurtz, 2017). In various studies, it has been demonstrated that communication tools such as a relationship-centered approach, and sufficient patient education are related to improved satisfaction and adherence with medical advice (Little et al., 2001; Kanji et al., McArthur and Fitzgerald, 2013). Furthermore, sues for malpractice in the veterinary context were often related to ineffective communication such as clients’ lack of understanding of examination findings, necessary procedures needed for a definite diagnosis, and instructions for aftercare (Dinsmore and McConell, 1992).

One objective of this thesis was to provide a basis for the assessment, and ultimately, the improvement of dairy practitioners' communication skills. Whereas comprehensive communication evaluation of 300 companion animal appointments was conducted more than a decade ago (Shaw et al., 2004), the most detailed studies done in the dairy cattle context entailed analysis of a total of 15 to 30 interactions, respectively, without using comprehensive analytical tools such as the RIAS (Jansen et al., 2010a; Derks et al., 2013b; Bard et al., 2017). Nevertheless, these studies concluded that veterinary communication skills are in need for improvement, which was confirmed in a later study by Cipolla and Zecconi (2015) who demonstrated that veterinary communication skills as perceived by the farmers were significantly lower than desired communication skills.

To evaluate a method to obtain quantitative in-depth information on veterinary communication patterns during dairy farm visits, suitability of GoPro® action cameras and the RIAS were assessed (Chapter 7). The results demonstrated that action cameras can be used to obtain objective recordings from veterinarian-client interactions without having a third party present. The focus of the current study was HH&PM farm visits conducted by dairy practitioners; however, other applications are certainly possible. Obtained recordings could be used in veterinary education to demonstrate and discuss current practices in production animal care if anonymization and consent can be arranged.

Action camera recordings were also suitable for comprehensive communication analyses (i.e., using the RIAS (Chapter 6 and 7)), and can supplement knowledge gained from recordings obtained in companion-animal settings. Veterinary communication patterns varied considerably between veterinarians and between different farm visits of the same veterinarian (Chapter 6). Therefore, for the analysis of veterinary communication (Chapter 7), between 3 and 7 farm visits each of 14 different veterinarians were used. Age, gender, and length of the professional veterinarian-farmer relationship only had small effects on veterinary communication patterns. However, similar to findings from companion animal and human medicine, the conversation was more relationship-centered when both, veterinarian and farmer, were male (Shaw et al., 2006; Bertakis, 2009). The fact that veterinarians with and without previous communication training had very similar communication patterns might indicate that communication skills training needs to be repeated regularly to ensure that veterinarians retain acquired skills. As one of the first studies assessing veterinary communication in the dairy farm environment, it contributed to a better understanding of "what is going on" during HH&PM farm visits. Furthermore, this study demonstrated that dairy practitioners rarely made use of communication tools that have previously been linked to more effective medical interactions (e.g., open-ended questions, empathy statements). Identification of these opportunities to enhance veterinary communication skills is a first step to inform and improve veterinary communication education.

8.2. Future directions

In summary, future research should focus on the following aspects:

1) A better understanding of socio-psychological factors that play a role in farmers' management decision-making.

Although some factors undoubtedly play a major role in farmers' management decisions (Chapter 2), especially the influence of internal motivators such as farmers' sense of responsibility, pride, perceived social pressure, and their perceived behavioral control have not been sufficiently explored. Because of the sensitive nature of these topics and the difficulty of obtaining in-depth information using questionnaires, a qualitative approach (or a mixed methods approach) likely yields the most detailed information. Furthermore, a changing focus of research priorities in the farm animal context, for example the reduction of antimicrobial resistance on dairy farms, requires evaluating farmers' motivators and barriers in respect to these emerging issues. Recently, the results of an increasing number of studies have been published on veterinarians' and farmers' attitudes toward antimicrobial use (e.g., Jones et al., 2015; Speksnijder et al., 2015; Kayitsinga et al., 2017). However, in Canada, research is limited. Therefore, establishing a baseline of antimicrobial use and assessing farmers' and veterinarians' perceptions and attitudes toward antimicrobial use is necessary.

2) Importance of, and factors contributing to, the "Intention-Behavior Gap" (i.e. failure to convert intentions into actions) in the agricultural context.

To date, very limited research has been conducted in the agricultural environment on the "Intention-Behavior-Gap" although it is well described in the human health context (Sheeran and Webb, 2016). Differentiating circumstances in which a behavior change is voluntary (e.g., implementing on-farm measures to control JD) and in which it is mandatory will further deepen the understanding of the discrepancy between intention and behavior. For example, Dairy Farmers of Canada's proAction Initiative, a mandatory program, could provide an appropriate setting to evaluate attitudes of farmers who comply with the program and who do not comply with certain aspects. Assessing precursors of their intentions and assessing the correlation between intentions and compliance, while exploring factors that might explain a potential discrepancy, will shine light on the "Intention-Behavior Gap" in a mandatory setting.

3) The benefit and effectiveness of "non-traditional" extension strategies such as participatory group learning, the Internet, and peripheral extension tools.

Whereas farmers' use and attitudes of traditional information channels have been assessed in some detail, little is known regarding emerging non-traditional extension approaches. For example, dairy farmers' use of social media to communicate with their peers and exchange information about farm management practices, the extent to which the dairy industry and extension specialists could use social media to convey their messages, the use and benefit of blogs and educational videos broadcasted on the Internet, are research areas that are worth further exploration.

Peripheral extension tools appear to be a valuable approach to motivate farmers who are immune to educational arguments (Jansen et al. 2010b) and yield the promise to enhance on-farm disease prevention and control when used appropriately. However, to be effective, peripheral extension tools need to be designed specifically to the desired behavior change and the targeted group (Thaler and Sunstein, 2008). Therefore, involving social scientists in the development of peripheral extension strategies is recommended.

4) The effectiveness of dairy practitioners' clinical communication skills to improve farmers' satisfaction with veterinary consultancy and adherence to recommendations. Description of veterinary communication skills is an important first step. However, evaluation of their effect on farmers' management strategies is ultimately the goal. Companion animal owners' satisfaction has been demonstrated to be associated with adherence to medical recommendations (Kanji et al. 2012). Measuring the effect of specific communication skills on farmers' satisfaction will be a logical next area of research. Tying communication skills to measurable on-farm changes will be challenging due to the variety of influencing factors on farmers' management decisions such as other social referents and information transmitted through mass media. Therefore, specific short-term cases such as the treatment of an individual animal or the culling of a cow with a high-titer MAP infection is recommended.

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Appendices

Appendix 1a. Survey used for nonparticipants and participants of the Alberta Johne's Disease Initiative (Identical part).

Survey ID # (*for office use only*) ____

Date ____

Name of Person Conducting Survey ____

Name of Producer ____

Farm Name ____

Herd Veterinarian ____

These questions are intended to help us learn how to improve our communication with you.

1. Which age category are you in?
   a) 30 or under
   b) 31-40
   c) 41-50
   d) 51-60
   e) 61-70
   f) Over 70

2. How many years have you been a dairy producer *(involved in management decisions)*?
   a) Less than 1
   b) 1-5
   c) 6-10
   d) 11-20
   e) 21-30
   f) 31-40
   g) More than 40 years

3. When do you expect to retire?
   a) Within a year
   b) Within 1-2 years
   c) Within 3-5 years
   d) Within 5-10 years
   e) More than 10 years from now

4. What is your highest level of education, or closest equivalent?
   a) Some high school
   b) High school diploma
   c) College diploma
   d) University degree
   e) Masters
   f) PhD

5. How often do you use these sources to get your information on new management practices/technologies (*on a scale of 1-5, with 1 being never and 5 being always*)?

	Never	Sometimes	Always
a) Milking Times	1------------2------------3------------4------------5		
b) Veterinarian	1------------2------------3------------4------------5		
c) Western Canadian Dairy Seminar	1------------2------------3------------4------------5		
d) Other producer workshops and seminars	1------------2------------3------------4------------5		
e) Fellow producers	1------------2------------3------------4------------5		
f) Farm Media	1------------2------------3------------4------------5		
g) Direct communication by email	1------------2------------3------------4------------5		
h) Direct communication by mail	1------------2------------3------------4------------5		
i) Direct communication by phone	1------------2------------3------------4------------5		
j) Other (*please specify*):	1------------2------------3------------4------------5		

____

6. What is your most preferred route to receive direct communication?
   a) Mail
   b) Email
   c) Phone
   d) In Person

7. What are your most important goals on your dairy farm (*Please select 3 and rank your choices, with 1 being the most important*)?
   a) ____ To have higher milk production
   b) ____ To have increased herd fertility
   c) ____ To increase herd longevity
   d) ____ To expand
   e) ____ To have improved herd health
   f) ____ To meet quota
   g) ____ To spend more time with family and less time working
   h) ____ To increase net profit
   i) ____ Other (please specify):

   ____

8. What are the largest constraints on your farm (*Please select 3 and rank your choices, with 1 being the most important*)?
   a) ____ Time
   b) ____ Financial resources
   c) ____ Facilities
   d) ____ Land
   e) ____ Knowledge / Skills
   f) ____ Availability of labour
   g) ____ Capability of labour
   h) ____ Quota management
   i) ____ Farm succession

9. How many cows are in your herd (*lactating only*)?

____

10. What breed of cattle makes up the majority of your herd?

____

11. What is your daily production per cow (*kgs*)?

____

12. What is your current Somatic Cell Count?

____

13. How many people work on your dairy operation *(total including yourself)*?

____

14. Do you use some type of milk recording system?
    a) Yes – DHI
    b) Yes – Other milk recording system
    c) No
15. How often do you take cattle to shows?
    a) Never
    b) Once in the last 5 years
    c) More than once in the last 5 years
    d) Once in the last year
    e) More than once in the last year
    f) Have not attended a show since 2007

16. If you knew that making a management change would reduce disease risk in your herd, how would you rank the following in your decision making?
    a) ____ Scientific evidence
    b) ____ Veterinarian advice
    c) ____ Impact on consumers
    d) ____ Time commitment
    e) ____ Labour availability
    f) ____ Initial Costs
    g) ____ Cost Benefit
    h) ____ Deviation from current practice
    i) ____ Other producers' experiences
    j) ____ Training
    k) ____ Other (*please specify*):

    ____

17. What is your preferred innovation style for implementing new technologies and management practices?
    a) Immediate – I like to be on the cutting edge
    b) Prove it – I like to see it implemented by others first
    c) Status quo – I don't like to change something that's working fine

18. Are you aware that Johne's disease is present in Canada?
    a) Yes
    b) No

19. How would you rate your knowledge on Johne's disease (*check all that apply*)?
    a) ____ I know it exists
    b) ____ I know the clinical signs
    c) ____ I know the general transmission of the disease
    d) ____ I know the ages of high susceptibility
    e) ____ I know the incubation time

f) ____ I know some issues with controlling it

g) ____ I know the routes of infection within the animal

h) ____ I know all of the vaccination/testing/control issues

i) ____ I know the current routes of Johne's disease research

20. a) How much of an issue is Johne's disease for the Canadian dairy industry?

1--------------------2--------------------3--------------------4---------------------5

Not an issue *Somewhat of an issue* *An important issue*

b) How much of an issue is Johne's disease for your farm?

1--------------------2--------------------3--------------------4---------------------5

Not an issue *Somewhat of an issue* *An important issue*

c) If you answered that Johne's disease is an issue for the Canadian dairy industry but not for your farm, please explain why.

____

21. With regards to Johne's disease, in the last five years have you (*check all that apply*):

a) ____ Observed any cows with clinical signs, if so how many? _______________

b) ____ Received any positive tests, if so how many? _______________

c) ____ Received any negative tests, if so how many? _______________

d) ____ Implemented any management practices

e) ____ Completed no testing

22. What is the most important risk factor for introducing Johne's disease to your farm from an outside source?

____

23. How could a calf on your farm get Johne's disease?

____

24. In regards to Johne's disease, please circle the answer for each that best applies to you (*on a scale of 1-5, with 1 being strongly disagree and 5 being strongly agree, DK=don't know*).

	Strongly disagree ... Strongly agree
a) Reducing Johne's disease prevalence may help protect the Canadian dairy industry	1-------2-------3-------4-------5-------DK
b) Johne's bacteria may have a role in Crohn's disease	1-------2-------3-------4-------5--------DK
c) Reducing Johne's disease will support higher production on my farm	1-------2-------3-------4-------5--------DK
d) Animal trade/export will be unaffected by Johne's disease	1-------2-------3-------4-------5---------DK
e) Johne's disease needs to be reduced on my farm to keep my family safe because they drink the milk we produce	1-------2-------3-------4-------5--------DK

25. On a scale of 1-5 how much does Johne's disease worry you (*with 1 being not worried at all and 5 being very worried*)?

1---------------------2---------------------3---------------------4---------------------5

Not Worried *Somewhat Worried* *Very Worried*

26. How likely is it that there will be reduced dairy product consumption if a link between Crohn's disease and Johne's disease is proven or portrayed negatively on a scale of 1-5, (*with 1 being very unlikely and 5 being very likely*)?

1--------------------2---------------------3---------------------4---------------------5

Very Unlikely *Somewhat Likely* *Very Likely*

27. Do you think this initiative is an effective way to show consumers that the dairy industry is taking a proactive approach to managing the possible risks of Johne's disease (*on a scale of 1-5, with 1 being very ineffective and 5 being very effective*)?

1---------------------2---------------------3--------------------4--------------------5

Very Ineffective *Somewhat Effective* *Very Effective*

<u>Because the veterinarians play an important role in the Alberta Johne's Disease Initiative (AJDI), we are trying better to understand the relationship between dairy producers and their veterinarian.</u>

28. How would you describe your relationship with your veterinarian?
    a) Trusted advisor with regular herd health visits
    b) Trusted advisor
    c) Regular herd health visits
    d) Occasionally I ask for advice
    e) Emergencies only

29. What does your veterinarian say about the AJDI?
    a) They think it is a good idea
    b) They think it is not necessary
    c) I don't know

30. What do other producers say about the AJDI?
    a) They think it is a good idea
    b) They think it is not necessary
    c) I don't know
    d) Mixed opinions

32. (NP) 33.(P) a) How effective do you think changing management practices is in reducing the prevalence of Johne's disease on a scale of 1-5 (*with 1 being very ineffective and 5 being very effective*)?

1---------------------2---------------------3--------------------4--------------------5

Very Ineffective *Somewhat Effective* *Very Effective*

b) Why do you think this?

____

36. Was there any part of the delivery/promotion/content of the AJDI that made you hesitant to participate? If so, please explain.

____

37. What changes (*if any*) need to be made to our promotion/delivery to ensure your participation in future programs?

____

38. Are there any other diseases for which you would like to see voluntary disease control programs implemented, and if so, which ones?

____

General Comments:

____

____

Appendix 1b. Non-identical part of survey used for nonparticipants of the Alberta Johne's Disease Initiative.

31. Based on what you know about the AJDI please circle the option for each statement that best applies to you (*on a scale of 1-5, with 1 being strongly disagree and 5 being strongly agree).*

a) I have a good understanding of the details of the AJDI	1-------2-------3------4-------5------DK
b) I think the risk assessment will be quick and easy	1-------2-------3------4-------5------DK
c) I think the new management practices will take too much time	1-------2-------3------4-------5------DK
d) I dislike change	1-------2-------3------4-------5------DK
e) I think it is necessary	1-------2-------3------4-------5------DK
f) I expect that my herd is infected with Johne's disease	1-------2-------3------4-------5------DK
g) I am concerned about someone finding out my herd is infected with Johne's disease	1-------2-------3------4-------5------DK
h) Other disease controls are more important to me – if so, which ones? ________________	1-------2-------3------4-------5-----DK
i) Other things are more important to me – if so, what? ________________	1------2-------3------4------5------DK
j) I see major benefits in the program	1-------2------3------4------5-----DK

k) I think the costs outweigh the benefits 1-------2------3-----4-------5------DK

l) I didn't know it existed 1------2------3------4-------5------DK

33. How important are each of the following in your decision about participation in the AJDI (*on a scale of 1-5, with 1 being not important and 5 being very important*)?

	Not important ... very important
a) Knowing the program is low cost to producers	1-------2-------3-------4-------5
b) Knowing it takes little time for the risk assessment and new management practices	1-------2-------3-------4-------5
c) Knowing production can increase by implementing control measures for Johne's disease	1-------2-------3-------4-------5
d) The need to control Johne's disease in case of link to Crohn's disease and the subsequent danger to the dairy industry	1-------2-------3-------4-------5
e) Knowing it has worked for other farms	1-------2-------3-------4-------5
f) Preventing more than one disease with a single new management practice	1-------2-------3-------4-------5
g) Other (*please specify*):	1-------2-------3-------4-------5

____

34. How influential are the following information sources on your participation in the AJDI (*on a scale of 1-5, with 1 being a negative influence and 5 being a positive influence*; *circle N/A if you did not receive information from this source*)?

	Negative Influence		Not Influential		Positive Influence	
a) Mail outs from the AJDI	1	2	3	4	5	N/A
b) Other producers	1	2	3	4	5	N/A
c) Veterinarian	1	2	3	4	5	N/A
d) Alberta Milk Staff	1	2	3	4	5	N/A
e) DHI staff	1	2	3	4	5	N/A
f) Breed Association	1	2	3	4	5	N/A
g) Mastitis management workshops	1	2	3	4	5	N/A
h) Producer workshops	1	2	3	4	5	N/A
i) AJDI website (*albertajohnes.ca*)	1	2	3	4	5	N/A
j) Other (*please specify*):	1	2	3	4	5	N/A

____

35. Are you aware of the grants available that support this program, and the funding available to you as a producer?

____

Appendix 1c. Non-identical part of survey used for participants of the Alberta Johne's Disease Initiative.

31. Prior to your participation in the AJDI, please circle the option for each statement that best applied to you (*on a scale of 1-5, with 1 being strongly disagree and 5 being strongly agree, DK=don't know*).

	Strongly disagree Strongly agree
a) I had a good understanding of the details of the AJDI	1-------2-------3------4-------5------DK
b) I thought the risk assessment would be quick and easy	1-------2-------3------4-------5-----DK
c) I thought the new management practices would take too much time	1-------2-------3------4-------5-----DK
d) I disliked change	1-------2-------3------4-------5-----DK
e) I thought it was necessary	1-------2-------3------4-------5-----DK
f) I expected that my herd was infected with Johne's disease	1-------2-------3------4-------5-----DK
g) I was concerned about someone finding out my herd was infected with Johne's disease	1-------2-------3------4-------5-----DK
h) Other disease controls were more important to me – if so, which ones?	1------2------3------4-----5-----DK

____

i) Other things were more important to me – if so, what? 1-----2-------3------4------5------DK

____

j) I saw major benefits in the program 1-------2-------3------4------5------DK

k) I thought the costs outweighed the benefits 1-------2-------3------4------5------DK

l) I didn't know it existed 1-------2-------3------4------5------DK

32. Now that you are participating in the AJDI, how do you feel about any concerns you had previously?

---

34. How important were each of the following in your decision about participation in the AJDI (*on a scale of 1-5, with 1 being not important and 5 being very important*)?

a) Knowing the program is low cost to producers 1---------2--------3--------4--------5

b) Knowing it takes little time for the risk assessment and new management practices 1---------2--------3--------4--------5

c) Knowing production can increase by implementing control measures for Johne's disease 1---------2--------3--------4--------5

d) The need to control Johne's disease in case of link to Crohn's disease and the subsequent danger to the dairy industry 1---------2--------3--------4--------5

e) Knowing it has worked for other farms 1---------2--------3--------4--------5

f) Preventing more than one disease with a single new management practice 1---------2--------3--------4--------5

Other (*please specify*): 1---------2--------3--------4--------5

---

35. How influential were the following information sources on your participation in the AJDI (*On a scale of 1-5, with 1 being a negative influence and 5 being positive influence; circle N/A if you did not receive information from the source*)?

	Negative Influence		Not Influential		Positive Influence	
a) Mail outs from the AJDI	1---------2-----------3---------4---------5-----N/A					
b) Other producers	1---------2-----------3---------4---------5-----N/A					
c) Veterinarian	1---------2---------3---------4---------5-------N/A					
d) Alberta Milk Staff	1---------2---------3---------4---------5-------N/A					
e) DHI staff	1---------2---------3---------4---------5-------N/A					
f) Breed Association	1---------2---------3---------4---------5-------N/A					
g) Mastitis management workshops	1---------2---------3---------4---------5-------N/A					
h) Producer workshops	1---------2---------3---------4---------5-------N/A					
i) AJDI website (*albertajohnes.ca*)	1---------2---------3---------4---------5-------N/A					
j) Other (*please specify*):	1---------2---------3---------4---------5-------N/A					

Appendix 2. Intrinsic discrete variables associated in the univariable analysis ($P < 0.20$) with enrollment of participants (P) and nonparticipants (NP) in the Alberta Johne's Disease Initiative (AJDI)

	Score, n (%)											
	1		2		3		4		5		Don't know	
	NP	P	NP	P	NP	P	NP	P	NP	P	NP	P
Animal trade/export will be unaffected by JD (Q24d)[1]	59 (37)	32 (53)	46 (29)	13 (22)	19 (12)	3 (5)	11 (7)	1 (2)	5 (3)	5 (8)	21 (14)	6 (10)
AJDI details well understood (Q31a)[1,3]	11 (7)	10 (16)	27 (17)	12 (20)	48 (30)	9 (15)	54 (33)	15 (25)	17 (10)	15 (25)	5 (3)	0 (0)
Risk assessment will be quick and easy (Q31b)[1,3]	8 (5)	2 (3)	18 (11)	8 (13)	30 (19)	10 (16)	58 (36)	19 (31)	18 (11)	20 (33)	30 (19)	2 (3)
Management practices will take too much time (Q31c)[1,3]	15 (9)	17 (28)	47 (29)	19 (31)	43 (27)	13 (21)	14 (9)	7 (11)	7 (4)	3 (5)	36 (22)	2 (3)
I dislike change (Q31d)[1,3]	35 (22)	20 (33)	43 (27)	18 (30)	47 (29)	12 (20)	19 (12)	4 (7)	17 (10)	7 (11)	1 (1)	0 (0)
AJDI participation is necessary (Q31e)[1,3]	5 (3)	3 (5)	12 (7)	4 (7)	45 (28)	8 (13)	58 (36)	22 (37)	38 (24)	23 (38)	3 (2)	0 (0)
My herd is probably infected with JD (Q31f)[1,3]	45 (28)	18 (30)	33 (21)	12 (20)	18 (11)	6 (10)	18 (11)	5 (8)	15 (9)	17 (28)	32 (20)	2 (33)
I am concerned about someone finding out my herd is infected with JD (Q31g)[1,3]	56 (35)	28 (46)	41 (25)	20 (33)	25 (15)	1 (2)	14 (9)	5 (8)	23 (14)	7 (11)	3 (1)	0 (0)
Other disease controls are more important (Q31h)[1,3]	23 (15)	14 (25)	14 (9)	11 (19)	43 (27)	8 (14)	35 (22)	10 (18)	38 (24)	12 (21)	4 (3)	2 (4)
Other things are more important (Q31i)[1, 3]	14 (10)	10 (18)	4 (3)	7 (13)	35 (24)	15 (27)	39 (27)	12 (22)	30 (27)	8 (15)	13 (9)	3 (5)

The AJDI costs outweigh the benefits (Q31j)[1,3]	24 (15)	22 (36)	30 (19)	12 (20)	30 (19)	12 (20)	18 (11)	10 (16)	7 (4)	1 (2)	52 (32)	4 (7)
I don't know the AJDI exists (Q31k)[1,3]	129 (80)	36 (62)	14 (9)	9 (16)	10 (6)	3 (5)	4 (2)	1 (2)	5 (3)	9 (16)	0 (0)	0 (0)
Importance that production can increase by implementing JD measures (NP:Q33c, P:Q34c)[2]	6 (4)	1 (2)	6 (4)	6 (10)	39 (24)	13 (21)	64 (40)	20 (33)	46 (29)	21 (34)	-	-
Importance that AJDI has worked for other farms (NP:Q33e, P:Q34e)[2]	6 (4)	11 (18)	8 (5)	6 (10)	30 (19)	11 (18)	77 (48)	21 (35)	40 (25)	11 (18)	-	-

[1]Strongly disagree (Score 1) to strongly agree (Score 5)

[2]Not important (Score 1) to very important (Score 5)

[3]Participants were asked to answer retrospectively prior to their AJDI enrollment

Appendix 3. Question guide used to interview farmers participating in the Alberta Johne's Disease Initiative (AJDI)

General questions	Probing questions
Please describe your farm	• How would you describe the general performance of your farm? • What are the largest goals and constraints on your farm? • Would you do anything differently if you could re-build this barn?[1] • What are your plans for the future?[1]
What comes to mind when you think about JD[2]?	
To what extent is JD a problem for you?	• Do you have JD on your farm? • Is there anything that worries you about JD?
How do you try to prevent JD transmission?	• What measures do you have in place to prevent JD transmission within the farm and introduction onto the farm? • What do you think about your efforts to prevent JD transmission?
What is your impression about JD issues and control on other farms?	• What do other farmers do/think about JD control? • In relation to others – do you think you are doing a good job to reduce JD on your farm?
Tell me about your experience with the AJDI	• Why did you decide to participate? • What did you like? What did you not like? • Is there anything about the AJDI that could be improved?
How would you describe your relationship with your veterinarian?	• In what situations do you call the veterinarian on your farm? • How often and in what ways do you communicate with your veterinarian? • Is there anything that could be improved in your communication or relationship with the veterinarian? • What does your veterinarian say about JD and the AJDI?

Could you describe how you came up with the management recommendations made in the risk assessment?	• Where/When did you talk about the management changes? • How did the veterinarian support you with the implementation of the changes? • Did the veterinarian follow up on the recommendations from the previous year?
What do you think of the management changes the veterinarian suggested?	• What do you think is important to consider when coming up with a management strategy? • Do you feel the recommendations make sense? • What did you like/not like about the recommendations? • At the time of the risk assessment how did you feel about the management changes then? Were you confident you would implement them? • What influences whether you implement a change or not? • Have you changed anything that is not mentioned in the risk assessment? • Would you do anything differently if you were tested MAP[3] positive / negative?[1] • Do you think MAP can be eradicated from a farm by implementing management changes?[1]
Do you think there is a connection between JD and Crohn's disease?[1]	
Do you have anything to add?	

[1]Question was added during the course of the study

[2]Johne's disease

[3]*Mycobacterium avium* ssp. *paratuberculosis*

Appendix 4. Copyright permissions: Co-authors

Re: Permission to include manuscripts in thesis

Jodi Flaig

Sent: Wednesday, March 14, 2018 at 4:14 PM

To: Caroline Manuela Nancy Ritter

You replied to this message on 2018-03-14, 4:16 PM. Show Reply

Hello Caroline,

I, Jodi Flaig, co-author of the manuscript below, grant Caroline Ritter permission to include the listed manuscript in her doctoral thesis.

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Thanks for the reminder!
Cheers,
Jodi

Jodi
Industry Development Coordinator
Alberta Milk

RE: Permission to include manuscripts in thesis

Erskine, Ronald

Sent: Wednesday, February 14, 2018 at 9:33 AM

To: Caroline Manuela Nancy Ritter

"I, *Ronald Erskine*, co-author on the manuscript cited below, grant Caroline Ritter permission to include this manuscript in her doctoral thesis."

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

RE: Permission to include manuscripts in thesis

Steve Mason

Sent: Monday, February 19, 2018 at 9:09 AM

To: Caroline Manuela Nancy Ritter

"I, *Steve Mason*, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Ritter C., R. Wolf, C. L. Adams, D. F. Kelton, C. Pickel, S. Mason, K. Orsel, J. De Buck, and H. W. Barkema. 2015. Herd-level prevalence of *Mycobacterium avium* subspecies *paratuberculosis* is not associated with participation in a voluntary Alberta Johne's disease control program. J. Dairy Sci. 99:2157-2160.

Keliesha Roth

Sent: Wednesday, February 14, 2018 at 10:52 AM

To: Caroline Manuela Nancy Ritter

" I, keliesha roth, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., J. Jansen, K. Roth, J. P. Kastelic, C. L. Adams, and H. W. Barkema. 2016. Dairy farmers' perceptions toward the implementation of Johne's disease prevention and control strategies on Alberta dairy farms. J. Dairy Sci. 99:1-12.

Permission to include manuscripts in thesis

Wolf Robert

Sent: Wednesday, February 14, 2018 at 11:53 PM

To: Caroline Manuela Nancy Ritter

To whom it may concern,
I, Robert Wolf, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis.

Best regards,
Robert Wolf

Dr. Robert Wolf, PhD
Amtstierarzt

I, Theo J.G.M. Lam, co-author on manuscript mentioned below, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis.

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

Re: Permission to include manuscripts in thesis

Jolanda Jansen

Sent: Thursday, February 15, 2018 at 7:45 AM

To: Caroline Manuela Nancy Ritter; jansen jolanda

"I, Jolanda Jansen co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

Ritter C., J. Jansen, K. Roth, J. P. Kastelic, C. L. Adams, and H. W. Barkema. 2016. Dairy farmers' perceptions toward the implementation of Johne's disease prevention and control strategies on Alberta dairy farms. J. Dairy Sci. 99:1-12.

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

RE: Permission to include manuscripts in thesis
beneveld@home.nl
Sent: Wednesday, February 14, 2018 at 1:45 AM
To: Caroline Manuela Nancy Ritter

"I, *Geart Benedictus*, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Re: Permission to include manuscripts in thesis
Karin Orsel
Sent: Thursday, February 15, 2018 at 9:18 AM
To: Caroline Manuela Nancy Ritter

"I, *Karin Orsel* co-author one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

Ritter C., R. Wolf, C. L. Adams, D. F. Kelton, C. Pickel, S. Mason, K. Orsel, J. De Buck, and H. W. Barkema. 2015. Herd-level prevalence of *Mycobacterium avium* subspecies *paratuberculosis* is not associated with participation in a voluntary Alberta Johne's disease control program. J. Dairy Sci. 99:2157-2160.

Karin Orsel

RE: Permission to include manuscripts in thesis

Mike Slomp

Sent: Tuesday, February 13, 2018 at 4:20 PM

To: Caroline Manuela Nancy Ritter

Here is my *statement*: "I, Mike Slomp, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

All the best with the completion of your thesis.

Mike Slomp
Manager, Producer Services
Alberta Milk

I, *Cindy Adams*, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., H. W. Barkema, and C. L. Adams. 2018. Action cameras and the Roter Interaction Analysis System to assess clinical interactions of veterinary practitioners and their clients. Vet. Rec., published online: http://dx.doi.org/10.1136/vr.104423.

Ritter, C., C. L. Adams, D. F. Kelton, and H. W. Barkema. Clinical communication patterns of veterinary practitioners during dairy herd health and production management visits, in preparation.

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

Ritter C., J. Jansen, K. Roth, J. P. Kastelic, C. L. Adams, and H. W. Barkema. 2016. Dairy farmers' perceptions toward the implementation of Johne's disease prevention and control strategies on Alberta dairy farms. J. Dairy Sci. 99:1-12.

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Re: Permission to include manuscripts in thesis

Charlotte Pickel

Sent: Tuesday, February 13, 2018 at 6:35 PM

To: Caroline Manuela Nancy Ritter

"I, Charlotte Pickel, co-author on the following listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Ritter C., R. Wolf, C. L. Adams, D. F. Kelton, C. Pickel, S. Mason, K. Orsel, J. De Buck, and H. W. Barkema. 2015. Herd-level prevalence of *Mycobacterium avium* subspecies *paratuberculosis* is not associated with participation in a voluntary Alberta Johne's disease control program. J. Dairy Sci. 99:2157-2160.

Sincerely,
Charlotte Pickel

Re: Permission to include manuscripts in thesis

Herman Barkema

Sent: Friday, March 9, 2018 at 4:33 PM

To: Caroline Manuela Nancy Ritter

Hi Caroline,

"I, Herman Barkema, co-author of the manuscripts below, grant Caroline Ritter permission to include the listed manuscripts in her doctoral thesis."

Kind regards.

Herman

Permission to include manuscripts in thesis

John Kastelic

Sent: Tuesday, February 13, 2018 at 8:02 PM

To: Caroline Manuela Nancy Ritter

Hello Caroline

I, John Kastelic, co-author of the following manuscript, grant Caroline Ritter permission to include this manuscript in her doctoral thesis.

Ritter C., J. Jansen, K. Roth, J. P. Kastelic, C. L. Adams, and H. W. Barkema. 2016. Dairy farmers' perceptions toward the implementation of Johne's disease prevention and control strategies on Alberta dairy farms. *J. Dairy Sci*. 99:1-12.

Regards
John Kastelic

Permission to include manuscripts in thesis

David Kelton

Sent: Friday, March 9, 2018 at 4:45 PM

To: Caroline Manuela Nancy Ritter

Hello Caroline,

I, David Kelton, co-author of the manuscripts listed below, grant Caroline Ritter permission to include the listed manuscripts in her doctoral thesis.

Ritter, C., C. L. Adams, D. F. Kelton, and H. W. Barkema. Clinical communication patterns of veterinary practitioners during dairy herd health and production management visits, in preparation.

Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347.

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Ritter C., R. Wolf, C. L. Adams, D. F. Kelton, C. Pickel, S. Mason, K. Orsel, J. De Buck, and H. W. Barkema. 2015. Herd-level prevalence of *Mycobacterium avium* subspecies *paratuberculosis* is not associated with participation in a voluntary Alberta Johne's disease control program. J. Dairy Sci. 99:2157-2160.

Re: Permission to include manuscripts in thesis

Steven Roche

Sent: Tuesday, February 13, 2018 at 5:17 PM

To: Caroline Manuela Nancy Ritter

"I, Steven Roche, co-author on the manuscript "Ritter C., J. Jansen, C. L. Adams, K. Orsel, S. Roche, J. Jansen, D. F. Kelton, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329-3347" grant Caroline Ritter permission to include the manuscript in her doctoral thesis".

Let me know if that's okay!

Thanks,
Steve

Steven Roche, MSc, PhD
Director & Principal Consultant

Re: Permission to include manuscripts in thesis

Jeroen De Buck

Sent: Tuesday, February 13, 2018 at 4:09 PM

To: Caroline Manuela Nancy Ritter

You replied to this message on 2018-02-13, 4:10 PM. Show Reply

"I, Jeroen De Buck, co-author on at least one of the listed manuscripts, grant Caroline Ritter permission to include the listed manuscript(s) in her doctoral thesis."

Ritter C., G. P. S. Kwong, R. Wolf, C. Pickel, M. Slomp, J. Flaig, S. Mason, C. L. Adams, D. F. Kelton, J. Jansen, J. De Buck, and H. W. Barkema. 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. J. Dairy Sci. 98:7831-7845.

Ritter C., R. Wolf, C. L. Adams, D. F. Kelton, C. Pickel, S. Mason, K. Orsel, J. De Buck, and H. W. Barkema. 2015. Herd-level prevalence of *Mycobacterium avium* subspecies *paratuberculosis* is not associated with participation in a voluntary Alberta Johne's disease control program. J. Dairy Sci. 99:2157-2160.

Kind regards
Jeroen De Buck, Msc, PhD

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