ABSTRACT

INVESTIGATING THE ROLE OF AGRICULTURAL EXTENSION IN INFLUENCING ONTARIO DAIRY PRODUCER BEHAVIOUR FOR JOHNES DISEASE CONTROL

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Study objectives were to: (a) describe Ontario (ON) dairy producer and veterinarian perceptions of the barriers and motivators to adopting on-farm management practices for Johne’s disease (JD) control, (b) implement and evaluate an agricultural extension program, called ON Focus Farms (FF), to improve the adoption of JD control practices, (c) compare changes in knowledge, attitude, perception, and behaviour towards JD control among FF participants and a group of non-participating producers, (d) investigate dairy producer learning preferences and perceptions of various sources of information, and (e) economically assess the costs and benefits of implementing FF over a 10-year period. To meet these objectives, pre- and post-FF intervention questionnaires, JD risk assessments, and post-FF intervention focus groups were administered.

Both producers and veterinarians identified physical resource barriers (i.e. time, money, infrastructure) and intrinsic barriers (i.e. perceived priority of JD, motivation, perceived practicality of JD control recommendations) to adoption. They also suggested extrinsic (i.e. incentives, premiums, penalties, and regulations, extension and communication) and intrinsic (i.e. pride and responsibility) methods for motivating
producers. While producer preferences for sources of information were varied, the majority (68%) ranked veterinarians as their top information source. Furthermore, 61% had a preference for learning kinesthetically (i.e. experience, context and practice).

Overall, 176 dairy producers participated in FF. Focus group discussions revealed that a facilitator-moderated and producer-centred environment were the key characteristics in making FF effective. Over two-thirds of respondents self-reported improvements in awareness, confidence, knowledge, and attitude towards JD control. Furthermore, 81% of FF respondents reported implementing at least one on-farm management change for JD control, resulting in a significant reduction in the their JD risk assessment scores; knowledge changes were significantly higher, and risk scores significantly lower, than control respondents. Participating in FF, having a moderate herd management score, a positive perception about the practicality of on-farm recommendations, and having a singular learning preference were associated with increased odds of making an on-farm change. Lastly, the economic evaluation of FF implementation in ON over a 10-year period yielded positive net benefits, suggesting that its implementation would be valuable for reducing the burden of disease on ON dairy farms.
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The pre- and post-intervention questionnaires were created and administered by Steven Roche, with the guidance of Drs. David Kelton and Andria Jones-Bitton. All focus group materials (i.e. recruitment letter, script, questioning route) were created by Steven Roche, with the guidance of Drs. Michael Meehan, Andria Jones-Bitton, and David Kelton. Focus groups were coordinated by Steven Roche and moderated by Dan Shock; with Laura Pieper as note-taker. Additional data were provided by George McNaughton (Dairy Farmers of Ontario), Richard Cantin (CanWest Dairy Herd Improvement Corporation), Karen Hand (Strategic Solutions), Nicole Perkins and Taika von Konigslow (University of Guelph), and Ann Godkin (OMAF/MRA).

All Focus Farm meetings were run by regional veterinarians (Dave Douglas, Brian Keith, Rob Walsh, Chris Church, Christie Morrow, Geert Jongert, Reg Clinton) and supervised by Steven Roche, Tim Nelson, and Danielle Julien. All quantitative data were collated, cleaned, and coded in Microsoft Excel for Mac, and analyzed in STATA®, by Steven Roche. All audio records were transcribed by Kathy Kimmerly, and all transcripts were collated and analyzed using ATLAS.ti©. Statistical analysis for all chapters was completed by Steven Roche, with the help of William Sears and Drs. Olaf Berke, David Pearl, and David Kelton when needed.
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Figure 4e | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 5 (calf feeding and maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).

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producers with Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), cost, persistence, and
effect of each on-farm management changes, number of FF participants, number of networked
producers, proportion of networked producers making changes, proportion of FF participants
making changes, proportion of those making changes implementing two changes, start-up,
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CHAPTER ONE

Johne’s disease control, dairy producer behaviour, and the role of agricultural extension and communication for change – A literature review

INTRODUCTION

Johne’s disease

Johne’s disease (JD), or paratuberculosis, is a chronic, incurable, gastroenteritis of domestic and exotic ruminants, which was first clearly described in cattle in Germany in 1895 (Sweeney et al., 2012). The etiologic agent of Johne’s disease is a hardy bacterium called Mycobacterium avium subspecies paratuberculosis (MAP), which is characterized as a slow-growing, obligate parasitic pathogen of mammals that can survive freely in the environment for up to one year (Chacon et al., 2004; JIC, 2010).

Wild and domestic ruminants, including dairy and beef cattle, sheep, goats, alpaca, and deer, are the natural hosts for MAP (Kennedy and Benedictus, 2001). However, additional non-ruminant species, including foxes, weasels, birds, feral cats, horses, rabbits, mice, badgers, and raccoons have also been known to harbour MAP (Daniels et al., 2001; Beard et al., 2001; Palmer et al., 2005; Raizman et al., 2005; Begg and Whittington, 2008).

Economic impacts

Conservative estimates suggest that the national cost of JD in Canada is upwards of CAD$15 million per year (McKenna et al., 2006). Three Canadian studies (Chi et al., 2002b; Hendrick et al., 2005; Tiwari et al., 2008) have created partial-budgets to quantify the costs of JD. Chi et al. (2002b) reported an annual loss of CAD$2,472 for a 50-cow dairy herd ($49.44 per
cow) with an apparent MAP prevalence of 7%. Hendrick et al. (2005) reported an annual loss of CAD$12,300 for a 100-cow dairy herd ($123 per cow) with an apparent prevalence of 10%. Lastly, Tiwari et al. (2008) reported an annual loss of CAD$1,196 for a 100-cow dairy ($11.96 per cow) with an apparent prevalence of 3.1%. Although estimates vary, reduced milk production and suboptimal culling of MAP-infected cows were the primary sources of economic loss due to JD.

Economic losses associated with JD in Canada are largely attributed to reduced milk production (Benedictus et al., 1987; Wilson et al., 1993), premature culling (Merkal et al., 1975), and reduced slaughter weight at culling (Whitlock et al., 1985). Some reports have also acknowledged, and attempted to quantify, the impact of JD on fertility (Whitlock et al., 1985) and increased incidence of mastitis (Nordlund et al., 1996); however, these losses are substantially less costly than the former (McKenna et al., 2006).

Milk production losses associated with both subclinical and clinical JD (Buergelt and Duncan, 1978; Abbas et al., 1983; Whitlock et al., 1985; Benedictus et al., 1987; Johnson-Ifearulundu and Kaneene, 1998; Ott et al., 1999; Hendrick et al., 2005; Lombard et al., 2005; Raizman et al., 2009; Nielsen et al., 2009; Sorge et al., 2011b), range from 2.2 to 25.0% reduction in annual milk production. Differences in these estimates are due to a number of factors, including stage of infection (Benedictus et al., 1987), parity (Sorge et al., 2011b), diagnostic accuracy (i.e. sensitivity and specificity) of tests (Hendrick et al., 2005), and on-farm management practices (Vanleeuwen et al., 2002).

The financial costs of suboptimal culling as a result of JD are considerable for dairy operations. Suboptimal culling comprises (1) premature culling of JD test-positive animals, and
(2) reduced slaughter weight at culling. Studies that examined the increased risk of culling due to MAP infection reported that test positive cows were between 1.7 and 3.2 times more likely to be culled than test negative herd mates (Hendrick et al., 2005; Tiwari et al., 2005; Lombard et al., 2005; Raizman et al., 2009; Sorge, 2010). Losses attributed to premature culling are a result of increased need for purchasing replacements and a loss in breeding value (Buergelt and Duncan, 1978). In addition, the slaughter weight and value of JD clinical animals has been reduced by 20% to 30% in some cases (Benedictus et al., 1987; Kudahl and Nielsen, 2009).

Relationships between JD test status and reduced fertility are inconsistent in the literature. Tiwari et al. (2003) reported that JD seropositive first-lactation heifers in Atlantic Canada were open for 49 days more than seronegative first-lactation heifers. Similarly, Johnson-Ifearulundu et al. (2000) found that JD seropositive cows were open an average of 28 days longer than test-negative herd mates. However, McNab et al. (1991) and VanLeeuwen et al. (2010) found no association between test status and days open. Therefore, the impact of JD on fertility and reproductive performance is uncertain (McKenna et al., 2006), and further research is needed to accurately identify this association.

Relationships between JD test status and increased incidence of mastitis are also unclear. A number of studies have reported MAP-infected cows were most likely to be culled for mastitis (Merkal et al., 1975; Buergelt and Duncan, 1978; McNab et al., 1991; Tiwari et al., 2002; Baptista et al., 2008); however, contradictory evidence has been put forward by a number of other studies, which have found no association (Nordlund et al., 1996), or even lower levels of mastitis among test positive cows, as compared to test negative herd mates (DeLisle and Milestone, 1989; Wilson et al., 1993). Therefore, associations between JD status and mastitis
remain unclear (McKenna et al., 2006). As a result, more research is required to confirm and quantify this association.

**Public health**

Over the years, MAP has gained increased interest as a potential zoonotic pathogen. It has been suggested that MAP plays a role in causing Crohn’s disease (CD) in genetically susceptible humans (Sweeney et al., 2012). Published reports have observed high proportions of MAP infection in CD patients (Mishina et al., 1996; Naser et al., 2004), and that MAP is substantially more common in patients with CD (Feller et al., 2007). A number of systematic reviews and meta-analyses have accepted that an association between CD and MAP infection exists; however, they suggest that evidence of a causal relationship between MAP and CD is inconclusive (Hermon-Taylor and El-Zaatari 2004; Feller et al., 2007; Waddell et al., 2008; Chiodini et al., 2012).

Importantly, while causality of CD due to MAP infection is heavily debated in the scientific community, reports continue to detect the presence of viable MAP in doses believed to be large enough for infection, in the following: water (Ireland (Grant, 2005) and U.K. (Pickup et al., 2005)), retail pasteurized milk and infant formula (Ireland (Grant et al., 2001; Grant, 2005), Czech Republic (Ayele et al., 2004), U.S. (Ellingson et al., 2005), and Cyprus (Botsaris et al., 2012)), cheese (Scotland (Williams and Withers, 2010)), and beef (Ireland (Grant et al., 2001) and Canada (Mutharia et al., 2010)). Thus, there is strong evidence of human exposure to MAP through a variety of sources. A causal-link between MAP and CD, or even a perception among consumers that MAP exposure (through the consumption of dairy products) is a health risk, could have devastating financial impacts on the Canadian dairy industry. Groenendaal and Zagmutt (2008) investigated these potential impacts in the U.S. dairy industry, and reported that
strict regulatory changes and reduced milk demand could result in over USD$1 billion lost. Therefore, efforts to control JD are not only important from a herd-level economic standpoint, but potentially, from a public health perspective as well.

**Prevalence**

With increased global trade and animal movement, within and across national borders, JD has been widely dispersed. In fact, cases of JD have been reported in most countries worldwide (JIC, 2010). In Canada, estimates suggest that between 10% and 43% of dairy herds have at least two seropositive cows (Tiwari et al., 2006; 2009). Provincial estimates range widely as well; however, it is important to consider that differences in the diagnostic accuracy of tests used, date of testing, testing protocols, cut-offs used to indicate a positive animal, and number of animals tested make these estimates difficult to compare reliably. Overall, 15% of ~250 environmental samples were fecal culture positive in Atlantic Canada in 2012 (Prince Edward Island, Nova Scotia, New Brunswick, Newfoundland and Labrador; Keefe et al., 2012), 12.1% of 579 milk samples were ELISA positive in Quebec in 2010 (Gilles Fecteau – personal communication), 26% of 2153 herds had at least one milk ELISA positive in Ontario (OJEMAP, 2013), 61% of 319 milk samples were ELISA positive in Manitoba in 2013 (David Kelton – personal communication), 24.3% of 1530 milk samples were ELISA positive in Saskatchewan in 2004 (VanLeeuwen et al., 2005), and 24% of 177 environmental fecal samples were culture positive in Alberta in 2011 (Barkema et al., 2012). Currently, there are no estimates available from herds in British Columbia. Overall, despite varying provincial estimates of JD prevalence, it is clear that JD is widely dispersed across Canada and is thus an important disease affecting the Canadian dairy industry today.
It is estimated that the true within-herd prevalence of Canadian dairy herds is around 5% (Chi et al., 2002a); numerous studies have reported apparent within-herd prevalence ranging from 0.5% to 5.4% (Chi et al., 2002a; Tiwari et al., 2008; Sorge et al., 2010a, 2011a; Pieper et al., unpublished). These estimates are similar to apparent within-herd prevalence estimates from Europe (Nielsen and Toft, 2007). However, they are lower than estimates from the U.S., which show apparent within-herd prevalence upwards of 10% (Wells et al., 2008), with 70% of all American dairy herds having at least one JD-positive animal (USDA, 2008). Due to differences in sampling and testing protocols, results are difficult to compare, but it is important to note that the majority of prevalence estimates likely underestimate the true prevalence of disease due to the low sensitivity of diagnostic tests (Tiwari et al., 2006).

**Infection**

MAP infection in cattle can be characterized as having three distinct stages, (I) silent infection, (II) subclinical infection, and (III) clinical infection, and are well described by Whitlock and Buergelt (1996). Stage I infection generally includes calves, heifers, and young stock up to two years of age. Infected animals in this stage show no clinical signs of infection, are rarely detected by currently available diagnostic tests, and may be shedding MAP in their feces at low levels. Disease progression at this stage is slow, with Stage II taking months or even years to reach. Stage II infection is generally observed in older heifers and adult cows. While no clinical signs are visible, cows in this stage intermittently shed MAP through their milk and manure, and infection may be detected using diagnostic tests. Infected cows may be in this stage for up to 10 years and represent an important source of environmental contamination due to lack of clinical signs and imperfect screening tests which may miss positive animals. Following a long incubation of 2 to 10 years, Stage III, considered advanced infection, is characterized by
gradual weight loss despite normal appetite, intermittent, but gradually worsening diarrhea, and decreases in milk production. While many animals are culled prior to this stage due to decreased reproductive performance or other health-related issues, further progression of JD usually results in increasingly lethargic and emaciated animals. At this stage, animals can shed billions of MAP bacteria into the environment.

In a cattle herd, the proportion of animals in each stage of infection is often represented as an ‘iceberg’ (Whitlock and Buergelt, 1996). For every one clinically infected cow, it is estimated that there at least 15 to 20 subclinically infected cows (Whitlock et al., 2000). Thus, the number of visibly diseased animals is only the ‘tip of the iceberg’, which means there are likely several more animals with Stage II infection, and even more cows with Stage I infection, in the herd.

**Transmission**

Calves within six months of birth are regarded as the most susceptible to MAP infection (Whittington and Windsor, 2009), as younger animals are known to require a lower infective dose (~2 grams of infected fecal material needed (Waters et al., 2003)) than older animals (Chiodini et al., 1984; Chiodini, 1996). However, older heifers and adult cattle can still be infected when exposed to higher, or repeated, doses of MAP (Rankin, 1962).

The primary route of transmission of MAP is the fecal-oral route, where an animal ingests MAP bacteria (Sweeney, 1996). As MAP infection progresses into the second and third stages of disease, infected adult cows intermittently shed MAP bacteria in their feces, colostrum and milk (JIC, 2010). There are three important routes of MAP exposure for calves. First, is the ingestion of MAP-contaminated feces, as a result of environmental contamination, particularly in the maternity area (Benedictus et al., 2008). This is considered the most important source of
exposure for young animals (Mitchell et al., 2008). Second, infected manure from adult cows may contaminate milk and/or colostrum being fed to calves (McKenna et al., 2006), representing an important form of indirect transmission. Lastly, MAP may also be directly transmitted to calves through the colostrum and milk from an infected dam (Streeter et al., 1995; Sweeney, 1996).

Another important transmission route is in utero, where calves born to test-positive cows have been shown to be up to six times more likely to be infected with MAP than calves from non-infected cows (Benedictus et al., 2008; Whittington and Windsor, 2009). While this transmission is generally considered to be infrequent, and typically associated with animals with advanced JD (Seitz et al., 1989; Sweeney et al., 1992), it is important to consider this source of infection (Sweeney 1996).

THE CHALLENGES OF EFFECTIVE JOHNE’S DISEASE CONTROL

Approaches to control

As there is no cost-effective form of treatment for MAP-infected animals (Sweeney et al., 2012), research has focused on identifying effective approaches for JD prevention and control. In particular, efforts have focused on test-and-cull programs and/or risk assessment-based control programs, which focus on influencing producer behaviour to implement on-farm management practices to break MAP transmission (McKenna et al., 2006; Sweeney et al., 2012).

Test-and-cull

Test-and-cull approaches to JD control focus on repeated testing to identify and remove infected animals (Kudahl et al., 2008). Numerous JD simulation models have assessed the impact of these approaches, under a wide variety of herd conditions; JD control using a solely test-and-
cull approach is generally ineffective in reducing the within-herd prevalence of JD (Groenendaal and Galligan, 1999; Groenendaal et al., 2002; 2003; Dorshorst et al. 2006; Kudahl et al., 2008). Although these approaches may be effective on farms with exceptional on-farm management and biosecurity practices (Lu et al., 2008), this approach is generally thought to have little impact on JD prevalence. A number of factors contribute to the impact of a test-and-cull program, such as: test sensitivity and specificity, stage of infection, testing frequency, age at testing, and number of cows tested (Groenendaal et al., 2002). The major limitation contributing to the poor success observed with these approaches is that existing tests lack the appropriate sensitivity (Sn range from 7% to 94%) to accurately detect all MAP-infected cows in a herd. As a result, herds must be tested repeatedly in an attempt to identify all MAP-infected cows (Kudahl et al., 2008), which becomes very expensive and time consuming. Given that animals are likely to be intermittently shedding MAP in their feces by the time the pathological process is detectable, and the relatively high proportion of false negatives present due to tests with low sensitivity, test-positive animals will likely have already contaminated the environment with MAP prior to being culled, further perpetuating JD within the herd (McKenna et al., 2006; Sweeney et al., 2012). Furthermore, routine culling of animals due to JD, over and above the normal culling rate of a herd, results in animals leaving the herd faster than they can be replaced, requiring producers to purchase costly replacements. While the test-and-cull approach can be useful for managing infected animals, the economic costs, the time required, and the failure to break the exposure cycle, make this approach to long-term JD control unsustainable and ineffective.

**Changes in on-farm management**

Given the chronic and persistent nature of MAP, it is generally accepted that the only way to effectively control JD is by improving on-farm hygiene and biosecurity through changes
in management (Groenendaal et al., 2002, 2003; Dorshorst et al., 2006; Kudahl et al., 2008; Sweeney et al., 2012). Risk factors for MAP transmission are generally categorized into three main categories: (1) introduction of new animals into the herd, (2) exposure of young stock to cows and their manure, and (3) poor farm hygiene and manure management (McKenna et al., 2006; Sorge, 2010).

The introduction of new animals into the herd has long been considered an important risk factor for JD (Doyle, 1956; Cetinkaya et al., 1997; Fridriksdottir et al., 2000; Chi et al., 2002a; Hirst et al., 2004; Pillars et al., 2009; Sorge et al., 2012). The long subclinical phase and poor detectability of JD using currently available diagnostic tests means that JD may be brought in to the herd through seemingly healthy cows, an important consideration and potential risk for test-and-cull approaches.

Given the susceptibility of young calves to MAP infection, the most important risk factors are exposure of young stock to infected cows and their manure. The following are specific risk factors related to calf management that are associated with increases in within-herd prevalence of JD: group maternity pens (Wells and Wagner, 2000; Mee and Richardson, 2008), calving test positive cows in maternity area (Benedictus et al., 2008), the longer a calf spends with the dam (Berghaus et al., 2005; Ferrouillet et al., 2009), calf being allowed to suckle dam (Nielsen et al., 2008), lack of colostrum hygiene (Dorshorst et al., 2006; Pithua et al., 2009) feeding pooled colostrum (Nielsen et al., 2008; Sorge et al., 2012), feeding pooled milk (Nielsen et al., 2008; Ferrouillet et al., 2009), direct calf exposure to cow manure (Goodger et al., 1996; Obsanjo et al., 1997; Ridge et al., 2005), closer proximity of calf housing to adult cow housing (Berghaus et al., 2005; Dorshorst et al., 2006), and calves born from a test-positive dam (Aly and Thurmond, 2005; Luyven et al., 2002; Benedictus et al., 2008).
Poor farm hygiene and manure management is also associated with an increased risk of MAP transmission on the farm, as a result of increased likelihood of calves being exposed to cow manure. The following are specific risk factors related to hygiene and manure management that are associated with increases in within-herd JD prevalence: use of maternity pen as sick pen (Merkal et al., 1975; Berghaus et al., 2005), poor maternity pen hygiene (Merkal et al., 1975; Dorshorst et al., 2006; Ferrouillet et al., 2009), poor cow cleanliness (Berghaus et al., 2005; Ansari-Lari et al., 2009), contaminated feed and water (Neilsen et al., 2008), feeding young stock leftover cow feed (Ferrouillet et al., 2009), and using the same equipment for handling manure and feed (Goodger et al., 1996; Berghaus et al., 2005; Tavornpanich et al., 2008).

Simulation studies (Collins and Morgan, 1992; Groenendaal and Galligan, 1999; Groenendaal et al., 2002; 2003; Dorshorst et al. 2006; Kudahl et al., 2008) and several longitudinal studies (Merkal et al., 1975; Benedictus et al., 2008; Wells et al., 2008; Ferrouillet et al., 2009; Collins et al., 2010; Sorge et al., 2011a) provide evidence that changes in on-farm management, based on identified high-risk practices for MAP transmission, are successful at reducing the within-herd prevalence of JD over time. Perhaps most importantly, the implementation of these management practices is the responsibility of each producer. Therefore, influencing producer behaviour towards adopting these on-farm practices is of paramount importance for JD control.

**Control programs**

Given the numerous risk factors for MAP transmission, effective farm-level control requires that high-risk management practices are identified and on-farm changes are implemented in order to prevent new infections. In response to this need, veterinarian administered risk assessments (RA)
have been developed (Goodger et al., 1996; Ferrouillet et al., 2009; Sorge, 2010) based on current knowledge of MAP and JD, known risk factors, biological plausibility, and expert opinion (Kalis et al., 2004). These questionnaire-based RAs are used to highlight high-risk management area practices for dairy producers and to recommend changes in on-farm management for JD control. Generally, scores are assigned for specific management areas (e.g. maternity pen management, young stock housing, etc.) based on a number of specific management practices (e.g. feeding pooled colostrum, feeding waste milk, etc.). Scores are then tallied over all management areas to provide an overall risk of MAP transmission, and recommendations for change are made based on specific high-risk practices.

A number of countries have developed national JD control programs, primarily based on the use of periodic testing and RAs (McKenna et al., 2006; Sorge, 2010). More specifically, Australia (Kennedy and Allworth, 2000; Jubb and Galvin, 2004; Condron and Basham, 2012; Citer and Kennedy, 2012), Japan (Kobayashi et al., 2007), Austria (Khol et al., 2007), France (Marcé et al., 2009), Denmark (Nielsen, 2007; Nielsen et al., 2008), the Netherlands (Benedictus et al., 2000; Groenendaal et al., 2003), United Kingdom (Orpin et al., 2012), Republic of Ireland (Mullowney and Graham, 2012; AHI, 2013), United States (Collins et al., 2010; Godden et al., 2012), and Canada (Barker et al., 2012) have all established programs for JD control.

In Canada, JD control is coordinated nationally through the Canadian Johne’s Disease Initiative (CJDI), and each province is responsible for administering their own control program (Barker et al., 2012). A voluntary RA-based control program was implemented between 2005 and 2007, with over 600 dairy producers from 5 provinces (Sorge et al., 2010a). The results of this pilot project led to the establishment of a set of guidelines for the implementation of each provincial program. Each program incorporates four common elements: (1) stakeholder education, (2) a
veterinarian administered on-farm RA, called the Risk Assessment and Management Assistance Plan (RAMP), (3) herd and/or cow-level testing, and (4) applied research. As of 2012, nine Canadian provinces (Atlantic Canada (Prince Edward Island, Nova Scotia, New Brunswick, Newfoundland and Labrador), Quebec, Ontario, Manitoba, Alberta, British Columbia) have established voluntary control programs based on these guidelines, and involve industry, government, and academic partners (Barker et al., 2012).

**Adoption of JD control measures**

While RA-based programs have been widely implemented, and appear to facilitate the identification of management areas and practices to address for effective JD control, the success of these programs is ultimately dependent on producer adoption of the recommended on-farm management practices (Sorge et al., 2010a). Several studies examining the uptake of on-farm management practices to control JD have reported poor levels of adoption (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010a). In particular, Wraight et al. (2000) reported that 48% of Australian dairy producers did not comply with a single recommendation made by their herd veterinarian for on-farm change. Another study from Victoria, Australia suggested that the Victorian Johne’s disease Test and Control program was likely unsuccessful in reducing the prevalence of JD on participating farms due to poor compliance with control recommendations (Jubb and Galvin, 2004). In Canada, Sorge et al. (2010a) found that producer compliance with veterinary recommendations was low, with producers implementing, on average, only one-third of recommendations. Interestingly, Ridge et al. (2005) reported that compliance with veterinary practitioners’ recommendations, among Australian dairy farmers in Gippsland who were contractually bound to comply, was “disappointingly poor”. While an update to this study in 2010 reported small improvements in
producer compliance, they concluded that producer adoption was still well short of what should be expected given that participants signed contracts requiring them to make recommended changes (Ridge et al., 2010).

The reason for the poor levels of adoption reported in these studies is relatively unclear, and more research is needed to investigate these adoption issues. Given the results presented above, it appears that the RA, and the veterinarians communicating their recommendations, have been unable to effectively influence producers to adopt on-farm changes for JD control. This is likely because they are not adequately addressing important barriers (either physical, perceived, or both) that influence producer decisions with regard to adoption. These issues appear to be common in the control of other diseases; several studies have investigated and described barriers influencing the adoption of control behaviours for mastitis control (Kuiper et al., 2005; Jansen, 2010; Lam et al., 2011) or the adoption of biosecurity practices more broadly (Rehman et al., 2007; Gunn et al., 2008; Heffernan et al., 2008; Ellis-Iversen et al. 2010; Garforth, 2011; Garforth et al., 2013; Brennan and Christley, 2013). To date, few studies have been conducted to investigate dairy or beef producer perceptions about the barriers and motivators influencing the adoption of on-farm management practices for JD control. Three published studies have investigated dairy producer attitudes and perceptions (Sorge et al., 2010a; Hop et al., 2011; Nielsen, 2011), while one study has investigated dairy veterinarian perceptions (Sorge et al., 2010b). However, it is important to note that only one of these studies (Sorge et al., 2010a) investigated dairy producer perceptions of JD control, the remaining three studies focused on reasons for, and evaluation of, participation in JD control programs. A similar situation exists within the literature on JD control among beef producers, with only two published studies available (Benjamin et al., 2010; Bhattarai et al., 2013).
All of these studies provide a broad overview of various attitudes and perceptions, and primarily investigated the perceptions of the economic costs of JD and the implementation of on-farm changes (Sorge et al., 2010a, b; Benjamin et al., 2010; Bhattarai et al., 2013). Many of these studies reported a wide range of reasons for participating in a JD control program such as, improving on-farm health and performance, minimizing economic costs of disease, improved animal welfare, establishing a JD-free status, and concern about the zoonotic potential of MAP (Hop et al., 2011; Sorge et al., 2010a; Benjamin et al., 2010; Nielsen, 2011). Only Sorge et al. (2010a) investigated reasons for non-compliance with on-farm recommendations, reporting that one of the main reasons was because respondents did not believe a change was necessary. Gaining a more in-depth understanding of why they did not feel a change was worthwhile will be an important step in improving approaches to influence producer behaviour.

It is important to note that, upon further examination, all but one of the dairy and beef studies presented above (Hop et al., 2011) investigated attitudes and perceptions using solely questionnaire-based instruments. While surveys and other questionnaire-based methods provide some information on an individual’s attitudes and behaviours, qualitative methods provide a rich, holistic understanding of the social factors that influence producer behaviour towards JD control. Additionally, while the studies discussed above provide insight into producers’ attitudes and perceptions about JD and JD control programs, they do not provide a theory of behaviour explaining how people’s attitudes and perceptions may influence producer adoption. In addition, they did not address how these factors could be influenced to improve adoption. Detailed information on producer attitudes and perceptions is crucial to not only understand producer behaviour, but also to developing tailored JD control programs and communication strategies to address the key barriers and motivators influencing producer behaviour.
UNDERSTANDING PRODUCER BEHAVIOUR

The antecedents of behavioural change

A producer’s attitude towards JD, and subsequent on-farm behaviour with respect to JD control, and can be best understood by using a validated theory that explains people’s behaviour. A person’s behaviour, and decision to adopt a given recommendation to change their behaviour, is influenced by a complex set of relationships among knowledge, attitudes, perceptions, motivation, external communication, and other social factors (Rosenstock, 1974; Leeuwis and van den Ban, 2004; Boxelaar and Paine, 2005; Ajzen, 1991; Rehman et al., 2007).

Knowledge

An individual’s knowledge with respect to a given topic or issue, provides the foundation for their behaviours relating to that topic or issue (Pratt and Bowman, 2008; Garforth et al., 2013). Leeuwis and van den Ban (2004; p. 95) provide a useful definition of knowledge that will be used in this thesis:

“Knowledge is regarded as the body of mental inferences and conclusions that people build from different elements of information, and which allows them to take action in a given context”

Therefore, ensuring that producers have sufficient knowledge about JD and its control is an important component to influencing their behaviour towards adoption of on-farm management practices for JD control.

More in-depth investigations into the application of knowledge and its role in decision-making have distinguished two forms of knowledge: objective and subjective (Chiou, 1998). ‘Objective knowledge’ refers to what an individual knows about a given topic, and can recall
from long-term memory, while ‘subjective knowledge’ refers to what an individual thinks they know about a given topic, whether it be they think they know a lot or a little (Chiou, 1998). These two forms of knowledge have important implications when considering how knowledge influences behaviour. Certainly, increasing one’s objective knowledge towards JD and JD control measures will be useful in facilitating changes in behaviour. However, assuming that increases in knowledge alone will result in behaviour change relies on the assumption that producers make on-farm decisions purely based on scientific merit and logic (Petty and Cacioppo, 1986). Subjective knowledge is also an important consideration, as Chiou (1998) suggests that what a person thinks they know about a given topic is often affected by their self-confidence, and other emotional and attitudinal considerations. Social factors other than knowledge play an important role in influencing behaviour. Numerous studies have investigated the impact of knowledge of disease and biosecurity measures on the adoption of control practices and have concluded that, while knowledge is certainly necessary, it is far from sufficient for behaviour change (Kuiper et al., 2005; Pratt and Bowman, 2008; Ellis-Iversen et al., 2010; Jansen, 2010; Kristensen and Jakobsen, 2011; Lam et al., 2011; Garforth, 2011; Garforth et al., 2013). For example, Kuiper et al. (2005) reported that a lack of general knowledge about mastitis, among Dutch dairy farmers, were not the key factors influencing the adoption of preventative practices. Rather, they found that external triggers (e.g. sanctions, incentives) and internal beliefs and perceptions were the key factors influencing producer behaviour. Therefore, while an understanding of JD and JD control measures is important for producers, knowledge alone is likely insufficient to influence behaviour.
**Attitudes and perceptions**

Research on the factors that influence an individual to change their behaviour reiterates the importance of a person’s attitude and perception about that behaviour (Leeuwis and van den Ban, 2004; Garforth, 2011). While an individual’s behaviour is influenced by a unique and complex set of attitudes and perceptions, researchers have created models and frameworks to help explain the key factors, their relationships and interconnections, and their roles in influencing an individual’s behaviour (Leeuwis and van den Ban, 2004). Leeuwis and van den Ban (2004) provide a particularly useful model that describes the basic variables relevant to understanding a producer’s behaviour, which are: evaluative frame of reference, perceived environmental effectiveness, perceived self-efficacy, and social relationships and perceived social pressure. The following variables are further discussed within the context of JD and JD control, below.

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

A producer’s perception of environmental effectiveness refers to whether or not they believe that their existing socio-economic environment can support the behaviour(s) they are
being asked to undertake. For example, a producer considering on-farm changes for JD will consciously consider: the availability of support from their veterinarian and fellow farmers, the availability and reliability of physical and organizational resources (e.g. colostrum and/or milk replacer), and market prices (e.g. milk price, cow replacement price). Essentially, the availability of resources, which can facilitate the adoption of these behaviours, is a key consideration for adopting a given behaviour.

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

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

Motivation

An individual’s motivation is another important factor influencing behaviour. A producer can be motivated externally or internally (Leeuwis and van den Ban, 2004), using methods that promote voluntary or compulsory behaviour change (Lam et al., 2011). External, or extrinsic,
motivation relates to when a behaviour or activity is performed in order to obtain a separable outcome (e.g. money) (Ryan and Deci, 2000). While incentive and reward-based systems are often used to externally motivate voluntary behaviour change (Nightingale et al., 2008), extrinsic motivation can also relate to the performance of a behaviour to avoid a separable outcome (e.g. financial fine or penalty). In the case of penalties, externally motivated behaviour change is focused on compulsory behaviours, mandates, and coercion (Lam et al., 2011). Interestingly, research into the impact of external motivation suggests that penalty systems related to milk quality (i.e. penalties applied for milk with high bulk tank somatic cell counts) are more effective than premium systems (i.e. incentives for milk with low bulk tank somatic cell counts) (Valeeva et al., 2007). However, these approaches are generally unsustainable, as the behaviour will likely only last while the coercion, either positive or negative, exists (van Woerkum et al., 1999).

Conversely, internal, or intrinsic, motivation refers to performing a behaviour purely out of interest or for enjoyment (Ryan and Deci, 2000). Lam et al. (2011) suggests that producers can be internally motivated through reasoned opinions and the use of numerous communication techniques (e.g. articles in magazines, study groups, discussions between producers and veterinarians), which target a producer’s attitudes and perceptions. Very little research has been conducted to investigate the factors that motivate dairy producers to adopt on-farm changes to address JD. While numerous studies suggest that the economic losses associated with JD will motivate producers (Raizman et al., 2009; Benjamin et al., 2010; Bhattarai et al., 2013), little is known about other motivating factors for producers to change. Additional investigations are needed to highlight the key motivating factors, which can then be addressed to internally motivate producers to change their behaviour.
Theories of behavioural change

The field of social psychology has developed numerous health behaviour theories (NIH, 2005), which describe, assess, and predict changes in behaviour based on an individual's perceptions, attitudes, and opinions. Central to many of these theories are three key assumptions: (1) behaviour is mediated by what people know and think, (2) knowledge is necessary for, but not sufficient to produce, most behaviour changes, and (3) perceptions, motivations, skills, and social environment are key influences on behaviour (NIH, 2005). Many of these theories are particularly useful in facilitating the investigation of intrapersonal factors such as knowledge, attitudes, beliefs, motivation, experiences, and skills, and how they influence change, and therefore are well suited for exploring producers’ attitudes towards JD.

Two prominent theories, the Health Belief Model (HBM) and the Theory of Planned Behaviour (TPB), are discussed below. In many human health fields, the constructs of the HBM and TPB are often used in the development of questionnaires to investigate the attitudes and perceptions held by the target audience with respect to a given behaviour (Carpenter, 2002; Nejad et al., 2005; Ramsay et al., 2010). Communication strategies are then developed based on the results to effectively target the specific beliefs that are likely to contribute to non-compliance or resistance to change. These theory-based communication approaches have been shown to be highly effective and efficient in influencing behaviour to achieve desired outcomes (Fishbein and Capella, 2006; Glanz et al., 2008), and may provide a useful theoretical framework for exploring and addressing the issue of on-farm adoption for JD control, a novel approach that has not been taken previously.
Health Belief Model

The HBM identifies six main constructs that are believed to influence an individual’s decision to make a behavioural change (Rosenstock, 1974; NIH, 2005). The following are the constructs of the HBM: (1) perceived susceptibility (e.g. ‘Is my herd susceptible to JD?’), (2) perceived severity (e.g. ‘Does JD have serious consequences?’), (3) perceived benefits (e.g. ‘Will making on-farm changes to control JD reduce my susceptibility or its severity?’), (4) perceived barriers (e.g. ‘Are the costs of controlling JD outweighed by the benefits?’), (5) cues to action (e.g. ‘What is being communicated to me about JD control?’), and (6) self-efficacy (e.g. ‘Am I confident that I can make on-farm changes to control JD?’) (Glanz et al., 2008; NIH, 2005).

Theory of Planned Behaviour

The TPB identifies three constructs that influence behavioural intentions (e.g. intent to perform the behaviour) and actual behaviour (Ajzen, 1991). Each construct can be split up into ‘behavioural beliefs’, which are comprised of two separate components. The first TPB construct is ‘attitudes toward the behaviour’ (e.g. ‘Is JD control good, bad or neutral?’), which is shaped by inputs needed to perform the behaviour (e.g. time, money, etc.) and the expected outcomes of the behaviour. The second construct is ‘subjective norms’, or the perceived social pressure to perform the behaviour (e.g. ‘Do people I trust agree or disagree with making changes to control JD?’), which is shaped by their perception about the social pressure they receive from individuals they perceive as important, and the strength of motivation to change their behaviour resulting from each source of social pressure. The final TPB construct is ‘perceived behavioural control’, or the perceived ability to perform the behaviour (e.g. ‘Is making on-farm changes to control JD within my control?’), which is shaped by the individual’s perception of how difficult
the behaviour is and their perception of how much is within their control (NIH, 2005; Ajzen, 1991).

The TPB has been directly applied to help explain Dutch dairy producer behaviour towards mastitis prevention and control (Kuiper et al., 2005; Jansen et al., 2010), and is a valuable theory to employ for understanding producer’s behaviour towards JD control. While the HBM has been used less frequently in an agricultural setting, it is also a valuable theory that provides an alternative approach to examining the factors that influence a producer’s behaviour. Overall, both the HBM and TPB provide useful frameworks for considering the factors that influence an individual’s decision to change their behaviour.

INFLUENCING PRODUCER BEHAVIOUR THROUGH AGRICULTURAL EXTENSION

While an understanding of the antecedents of behavioural change provides researchers with knowledge on ‘what’ to address to influence behaviour, ‘how’ to address these factors is also critical for successful behavioural change. The following section explores the role of agricultural extension and communication for change in influencing producer behaviour.

Several definitions have been used to define agricultural extension; Marsh and Pannell (1998; p. 134) suggest that agricultural extension is:

“a series of formal and informal public and private sector activities relating to technology transfer, education, attitude change, human resource development, and dissemination and collection of information”

Other definitions take a broader stance, such as the one provided by Leeuwis and van den Ban (2004; p. 27), which suggests that agricultural extension is:
“a series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations, which supposedly help to resolve (usually multi-actor) problematic situations”

The common theme underlying these definitions are that agricultural extension is a set of informal, educational, and communicative processes, which, as Andreata (2001) suggests, provides a means of offering advice, information, and knowledge to help rural communities solve problems and facilitate change within their own farming situation. The ultimate goal of agricultural extension is to effectively communicate, raise awareness, educate, motivate, support, and facilitate learning and behavioural change to address farm-level factors such as productivity, efficiency, and disease prevention and control (Black, 2000; Fulton et al., 2000; Andreata 2001; Leeuwis and van den Ban, 2004).

The changing landscape of agricultural extension

Agricultural extension, as both a process and a practice, has experienced profound change over the past 30 years. Research contributions from numerous disciplines, and changes in agricultural issues, population demographics, government funding, and the functionality and accessibility of communication technologies (e.g. wireless handheld internet devices) have altered the goals and methods used for extension today (Andreata, 2001; Coutts and Roberts 2011). Of particular importance is a shift away from linear ‘top-down’ extension strategies to the application of participatory ‘bottom-up’ approaches (Black, 2000; Fulton et al., 2000; Andreata, 2001; Coutts and Roberts, 2011).

In the 1960s and 1970s the dominant model of agricultural extension relied on the development of new technologies, knowledge, and innovations, which extension agents took to producers and promoted their adoption (Black, 2000; Andreata, 2001; Coutts and Roberts 2011). This
hierarchical model, known as the Transfer of Technology model (ToT), fundamentally places researchers above producers, as they are the ‘creators of knowledge’ who then pass down their knowledge for adoption by the producers (hence, the ‘top-down’ label). The primary communication strategy was to identify the farmers that were perceived to be ‘progressive’ or most likely to adopt the technology. This view of communication, called the Diffusion of Innovations, then assumed that other producers would follow the ‘superior’ and more advanced producers and make similar changes, which resulted in the term ‘linear adoption’ (Rogers 1983).

Criticisms of the ToT and Diffusion of Innovations models arose in the mid-1970s as the models began to fail to affect on-farm change (Coutts and Roberts, 2011). Many strongly criticized the assumption that the adoption of a practice among the most progressive farmers would diffuse down to the majority of producers (Russell et al., 1989; Dunn 1997; Andreata, 2001). Other suggested that, while it may have its place in facilitating the adoption of single techniques or technologies, it was ineffective for the adoption of more complex practices (Reeve and Black, 1998). Perhaps most importantly, critics suggested that these top-down approaches reinforced existing social inequalities between researchers and rural communities (Röling et al., 1976; Röling, 1988). Furthermore, Chambers (1983) and Russell et al., (1989) both highlighted how these models devalued the knowledge, skills and adaptive abilities of producers, as these approaches hold researchers as exclusive creators of knowledge, while producers are simply the recipients. Therefore, these linear ‘top-down’ approaches have generally fallen out of favour for facilitating the adoption of innovations among rural communities.

Alternative models have been created in response to these criticisms (Black, 2000). Central to many of these approaches is the notion of producer-centredness, or what Chambers et al. (1989) termed ‘farmer first’ approaches. More specifically, Chambers et al., (1989) emphasized the need
to start with the knowledge, problems, and priorities of the producers and their families, rather than the researchers, and highlighted the benefit of engaging producers in driving their learning, which would in turn improve adoption. These approaches (e.g. participatory action research, rapid rural appraisal, farming systems research, soft systems methodology, etc.) focus on participatory empowerment and recognize the need for engaging producers in holistic farm management and emphasizing sustainability within the rural population (Black 2000; Carberry, 2001). Often seen as direct alternatives to ToT, the emphasis of these approaches on participatory methods and producer centredness led to the label of participatory ‘bottom-up’ approaches. These approaches have continued to develop over the years, and have been successful in influencing behaviour by embracing complexity through systems thinking, integrating social psychological theories of learning and behaviour, and focusing on capacity building and community engagement (Andreata, 2001; Fulton et al., 2003; Friend et al., 2009; Coutts and Roberts, 2011). Given the success of these approaches, and their advantages over the old ToT model, the implementation of bottom-up approaches for agricultural extension are more appropriate for addressing JD control.

**Producer-centred extension**

The remainder of this review will take a closer look at one specific philosophy to ‘bottom-up’ extension called the Group Facilitation and Empowerment Model, which is outlined in detail by Coutts and Roberts (2011) and will be used throughout this thesis. This approach utilizes a facilitative framework to increase participants’ planning and decision-making capacities, through a self-directed, learner-centred process. The primary focus of this approach is to increase participants’ capacity in planning and decision making by seeking their own training and education needs. This approach relies heavily on group-based learning in the classroom and on
the farm, generally learning through open discussion and collective problem solving. This approach puts the producers at the centre of the process by allowing them to define their own problems and issues, and providing opportunities for them to seek their own solutions. The success of this model can be attributed to the fact that its underlying philosophies align with the components of adult learning theory (andragogy), action research, and experiential learning.

**Learning, education, and andragogy**

The participatory ‘bottom-up’ approaches to agricultural extension discussed here subscribe to a paradigm of learning that was established in the 1970s by two notable philosophers/social psychologists, Drs. John Dewey and Paulo Freire (Jarvis, 2001). Dewey is known for distinguishing between ‘traditional’ and ‘progressive’ education. Traditional, or subject matter education, is teacher-driven, and involves the linear transfer of information from teacher to student, where students are expected to be docile, receptive, and obedient (Dewey, 1997). In other words, educators teach using a predetermined curriculum in a non-participatory atmosphere, which tends to not value the existing knowledge, skills, attitudes, values, and perceptions of the individual recipients. Progressive education, on the other hand, employs the use of learner-centred approaches, which are typically group-oriented and embrace local knowledge, perceptions, values, skills, and experiences, and motivate individuals to take ownership of their problems and solutions (Dewey, 1997; Lawrence et al., 1999; Friend et al., 2009). Thus, progressive education provides an opportunity to improve our approaches for influencing producer behaviour towards adopting JD control practices.

Freire is best known for his explanation and criticism of the ‘banking approach’ to education (Freire, 1974). Similar to Dewey’s view of ‘traditional’ education, Freire contended that many institutions view students as empty banks of knowledge, as they do not consider the
students’ prior knowledge and experience, and that the role of educators is to deposit knowledge to improve learning (Freire, 1974). Similar to Dewey, Freire was a proponent of learner-centred approaches to education and emphasized the importance of considering a learner’s prior knowledge, and experience, and ensuring learners played an active role in their learning.

The notion of adult learning, or andragogy, was heavily influenced by the thinking of Dewey and Freire, and was created to distinguish between the characteristics of effective learning for youth and adults. According to this theory, six principles, developed by Malcolm Knowles (Knowles, 1970), must be considered when educating adults: (1) Need to Know – adults need to know the reason for learning something in the first place, (2) Experience – previous life experience is the foundation from which adults learn, (3) Self-concept – adults are self-directed and want to control how and when they learn, (4) Readiness to learn – adults are interested in learning that has immediate relevance to their lives, (5) Orientation – adults are problem-oriented and thus, want information to solve specific problems, and (6) Motivation – adults respond better to internal motivators, rather than external motivators. Agricultural extension approaches can benefit from an understanding and the practical application of the principles of learning.

**Action research and experiential learning**

The philosophies of Dewey, Freire and Knowles ultimately led to the development of action research and experiential learning (Lewin 1947; Kolb, 1984). Both of these approaches provide a practical and cyclical framework for enhancing student learning by embracing the principles of adult learning theory, and are applicable to producers learning about JD control.

Developed by Kurt Lewin, Action Research provides a stepwise and cyclical process by which learners not only engage in an experience, but they conduct a form of research, which
informs future cycles (Kemmis and McTaggart, 2007). Participants begin with Planning – where they are asked to plan an action relevant to their farm through a process of identifying on-farm problems, articulating the specific issues involved, and prioritizing them; Action – once a specific action is planned the participant engages in the action; Observation – once implemented, the participant is prompted to observe the effects of the action; Reflection – lastly, after a pre-determined amount of time, participants are asked to reflect back on the process, the impact, and the outcomes (Lewin, 1947; King et al., 2001; Kemmis and McTaggart, 2007). The goal is for participants to engage in a form learning from experience, and to systematically improve their ability by reflecting on the process and re-engaging in the process again and again.

Developed as a refinement of Action Research, Experiential Learning refers to learning from a specific experience or set of experiences. Popularized by Dr. David Kolb, the framework for experiential learning is a four-step, cyclical process, often referred to as the Kolb Cycle (Kolb, 1984). The cycle involves concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). In a JD extension context, producers would engage in learning activities (e.g. farm walk/tour, risk assessment), CE; review and reflect on each experience from various perspectives, RO; further discuss their observations, AC; and finally, explore potential applications on their own farms, AE.

These frameworks provide practical approaches for engaging producers in an explicit process that is based on sound learning theory. They have been widely adopted for use in participatory ‘bottom-up’ agricultural extension approaches, to address issues from natural resource management to feed and nutrition (Black, 2000; King et al., 2001; Andreata, 2001; Fulton et al., 2000, 2003; Friend et al., 2009; Coutts and Roberts, 2011), with positive improvements in learning and behaviour change.
Learning styles

One final consideration that must be made with respect to participatory ‘bottom-up’ approaches and learning is the concept of ‘learning styles’. An individual’s ability to learn and retain information is improved when the communication methods employed align with their learning style (Kolb 1984; Fleming and Baume 2006). The concept of ‘learning styles’ refers to a number of factors (i.e. environmental, emotional, social, psychological, and physiological stimuli) that influence an individual’s preference for gathering, interpreting, and processing information (Davis 2009; Dunn and Dunn 2010). An important component of an individual’s learning style is their ‘learning preference’, which corresponds to their specific preferences for receiving and communicating new information (e.g. visual learning versus reading and writing) (Fleming 2011). While many aspects of an individual’s learning style are static and difficult to align with communication methods (e.g. environmental and physiological stimuli), extension specialists are able to tailor communication approaches to an individual’s learning preferences (Fleming 2011). An understanding of producer learning preferences, and tailoring communication efforts to align with these preferences are proposed to be very effective in enhancing learning and promoting behaviour change (Lam et al., 2011). However, what research has been conducted on producer learning styles is cursory (Paine 1993; Gibson, 2006; McLeod, 2006; Renick, 2012), with limited analysis and small sample sizes. More research on producer learning preferences and an in-depth analysis of factors associated with these preferences are needed in order to establish the role of learning preferences and how they might be used to influence producer behaviour.
Evaluation of agricultural extension efforts for JD control

Published literature outlining agricultural extension approaches utilized for JD control strategies around the world is scarce. However, the majority of what can be found indicates that most programs typically employ linear ‘top-down’ forms of ‘traditional’ education when teaching producers about JD control. Specifically, while stakeholder education is central to all provincial JD control programs in Canada, the majority focus on the provision of information, that developers feel producers need to know, through the use of articles and fact sheets, CDs/DVDs, and oral conference/meeting presentations (Barker et al., 2012). Programs in the U.S. (USDA, 2010), the Netherlands (Benedictus et al., 2000), Denmark (Nielsen, 2007), Australia (NJDCP, 2013), U.K. (Orpin et al., 2012), and Ireland (Mullowney and Graham, 2012) report employing similar ‘traditional’ forms of extension. In general, these ‘traditional’ approaches have been shown to have a limited effect on improving compliance with desired changes in behaviour (Leeuwis and Van den Ban, 2004; Webb and Sheeran, 2006; Coutts and Roberts, 2011), mainly due to a reliance on producers’ intrinsic motivation to change, and an assumption that individuals make decisions purely on scientific rationale (Jansen et al., 2010a).

Given the shift towards participatory ‘bottom-up’ approaches to agricultural extension, and the many benefits it can have over linear forms, JD control efforts will likely benefit from the adoption of these approaches. Many examples utilizing these bottom-up approaches to improve the adoption of various on-farm practices (e.g organic husbandry practices, natural resource management, cattle feeding regimens, field preparation for planting, etc.) can be found in the literature (Lawrence et al., 1999; King et al., 2001; Fulton et al., 2003; Crawford et al., 2007; Vaarst et al., 2007; Friend et al., 2009). Furthermore, Trier et al. (2012), Groenendaal et al. (2003), and Kingham and Links (2012) have reported the implementation of small, producer-
group-based approaches to JD extension, which have been reported to be effective in improving adoption of on-farm recommendations for JD control in Danish and Dutch dairy herds, and Australian sheep flocks, respectively.

While implementation of these forms of agricultural extension may result in improved adoption, the only way to be sure that these methods are effective is to consistently monitor and evaluate their efficacy. The complexity and the numerous antecedents of behavioural change require the identification of appropriate measureable outcomes in order to adequately evaluate these programs. Measuring changes in on-farm risk and objective knowledge may be evaluated using quantitative risk assessments and formal knowledge assessments, respectively. However, given the number of intrapersonal factors influencing an individual’s behaviour, there is an inherent qualitative aspect associated with behavioural change. Thus qualitative methodologies, such as focus groups or one-on-one interviews, are needed in order to better understand the impact of extension efforts on attitudes, perceptions, and motivation. Given the need for both quantitative and qualitative methods, it is appropriate to suggest that evaluations of JD control programs use mixed-methods approaches, which are becoming increasingly popular among researchers (Garforth, 2011). The methods used to identify, measure, and assess the key antecedents of change should be implemented over time, as these factors, and behaviour, takes time to change. Pre- and post-intervention techniques are commonly used for these assessments (King et al., 2001; Jansen et al., 2010a, b) and can be useful in demonstrating the impact of agricultural extension approaches.

It is also important to note that investments in any program not only require that their efficacy be demonstrated, but that their benefits outweigh the costs. Therefore, quantitative economic approaches, such as Cost-Benefit Analysis (CBA), can be valuable in facilitating the adoption of
these agricultural extension programs by industry. Commonly used in economics, CBA allows for the consideration of future costs and benefits, which accrue over a given time period, in present day dollars by discounting future costs and benefits, at a predetermined rate, to obtain the Present Value (PV). The PV Costs and PV Benefits are calculated using the following formulas:

\[ \text{Present Value Costs} = C_1 / (1 + r)^1 + C_2 / (1 + r)^2 + \ldots + C_t / (1 + r)^t \]

\[ \text{Present Value Benefits} = B_1 / (1 + r)^1 + B_2 / (1 + r)^2 + \ldots + B_t / (1 + r)^t \]

Where \( C_t \) and \( B_t \) are the total costs and total benefits for each year (t), respectively, and \( r \) is the discount rate. The PV costs and PV benefits are then subtracted to calculate the Net Present Value (NPV), or the value of the expected future returns of an investment minus the value of the expect future costs (Boardman et al., 2010).

Interestingly, while economic analyses of the cost of JD have been conducted by a few Canadian researchers (Chi et al., 2002; Hendrick et al., 2005; Tiwari et al., 2008), no CBAs have been conducted to assess the benefits of JD control. As discussed here, a CBA may provide the necessary leverage to obtain funding for the implementation of ‘bottom-up’ approaches to effectively influence producers to implement on-farm changes for JD control.

THESIS RATIONALE

As described in this literature review, while research over the past 50 years has significantly improved our understanding of JD, the main challenge is increasing producer adoption of on-farm management practices for JD control. More specifically, little is known about Ontario dairy producers’ perceptions of the barriers to implementing on-farm management practices for JD control. Moreover, there is a need to better understand the specific motivators that influence
Ontario dairy producer behaviour in order to tailor agricultural extension strategies to properly motivate change. Information about Ontario dairy producer learning preferences and perceptions about the most useful forms of agricultural extension is also lacking, with little literature available outside of Canada to inform the creation of an Ontario specific program. Furthermore, given that ‘bottom-up’ approaches to agricultural extension have been shown in the literature to improve adoption, it would seem likely that implementation and evaluation of such an approach in the Ontario dairy industry would yield positive results. With no such approach having been implemented in Canada to date, carrying out this research is critical to improving both national and provincial JD control efforts.
RESEARCH OBJECTIVES

The research objectives of the work described in this thesis were to:

(1) Identify Ontario dairy producer and veterinarian perceptions of the barriers and motivators influencing the adoption of on-farm management practices for JD control.

(2) Implement a participatory ‘bottom-up’ education approach to improve the adoption of on-farm management practices for JD control among Ontario dairy producers.

(3) Evaluate the impact of the implemented participatory ‘bottom-up’ education approach on participating dairy producers’ perceptions, knowledge, attitude, and behaviour towards JD control in the Ontario dairy industry, and compare changes to a group of non-participating Ontario dairy producers.

(4) Describe Ontario dairy producer learning preferences and their perceptions of the factors, and information sources, which are necessary for effective agricultural extension.

(5) Create a partial-budget of the economic costs of JD to Ontario dairy producers to inform the creation of a cost-benefit analysis to economically evaluate the impact of a participatory ‘bottom-up’ education approach to JD control.
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CHAPTER TWO

A qualitative exploration of Ontario dairy producer and veterinarian perceptions of barriers and motivators to adopting on-farm management practices for control of Johne’s Disease

ABSTRACT

Recommendations for Johne’s disease (JD) control on dairy farms focus on on-farm management changes. Facilitating these changes requires knowledge of the barriers and motivators influencing producer behaviour. This study investigated Ontario dairy producers’ and veterinarians’ perceptions of the barriers and motivators influencing the adoption of JD control recommendations. Eight focus groups, six with dairy producers and two with veterinarians, were conducted and thematically analyzed. Both producers and veterinarians identified key barriers to adoption, which were categorized as physical resource barriers (i.e. time, money, infrastructure) and intrinsic barriers (i.e. perceived priority of JD, motivation, perceived practicality of JD control recommendations). While all participants recognized the importance of limited physical resources, the majority of discussions focused on producer perceptions and attitudes as barriers. Producers tended to prioritize JD control on their farm based on their lived experiences with JD, and how they viewed the public’s perception of the disease. Many agreed that recommendations about on-farm changes for JD control should focus on biosecurity more holistically, by highlighting the indirect health benefits of JD control as a result of limiting calf exposure to other fecal-orally transmitted diseases. Producers also highlighted that some recommendations for on-farm change (i.e. keeping a closed herd, or buying from low-risk herds) were unrealistic or too difficult to perform, and often disrupted their habits or routine. In contrast, veterinarians
suggested that nearly all recommendations were practical, and that they routinely recommended them. Both producers and veterinarians also identified producer motivation as a key barrier. Participants suggested both extrinsic (i.e. incentives, premiums, penalties, and regulations, extension and communication) and intrinsic (i.e. pride and responsibility) methods for motivating producers. Cash incentives and/or subsidized testing were thought to be effective for motivating change. Producers further emphasized that penalties and regulation for JD control may be required to ensure food safety standards are met, and potential links between JD and Crohn’s disease are addressed. Veterinarians highlighted the role of extension and communication, suggesting that group-based approaches were useful for motivating change. Discussions also emphasized the importance of intrinsically motivating factors, suggesting that producer pride, with respect to animal health and milk quality, and their perceived responsibility to the herd and the consumer, played an important role in producer behaviour. The results presented herein provide key insights into the perceived barriers to on-farm change for JD control, and discuss methods for increased producer motivation, which can be used to improve extension programs.

**INTRODUCTION**

Johne’s disease (JD) is a chronic wasting disease of dairy cattle and other ruminants that can result in decreased milk production, decreased fertility, and premature culling of animals (Sweeney et al., 2012). This production-limiting disease is not only important from an animal health standpoint, but from a public health perspective as well. Over the years, numerous reports have implicated the causal organism of JD, *Mycobacterium avium* subsp. *paratuberculosis* (MAP), as a potential cause of Crohn’s disease (CD) in genetically susceptible humans (Mishina et al., 1996; Naser et al., 2004; Chiodini et al., 2012; Sweeney et al., 2012). Thus, JD prevention
and control at the farm-level is of paramount importance for ensuring healthy, productive dairy herds, and producing safe dairy products for human consumption.

Current recommendations for prevention and control of JD involve a combination of periodic cow testing and implementing on-farm management practices to improve biosecurity (Sweeney et al., 2012). Numerous countries have implemented JD control programs and many utilize veterinarian-administered risk assessments (RA) (McKenna et al., 2006; Nielsen, 2007; Collins et al., 2010; Barker et al., 2012). These RAs are used to highlight high-risk management practices for dairy producers and to recommend changes in on-farm management for JD control (Sorge et al., 2010a). Given that the efficacy of these programs is ultimately dependent on a producer’s willingness to adhere to farm-specific recommendations, it is concerning that research indicates poor producer adherence in terms of JD control (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010a).

A producer’s behaviour, and subsequent decision to adhere to recommendations to change their behaviour, is influenced by numerous personal factors (e.g. attitude, perception, knowledge, opinion, beliefs, skills) and interpersonal factors (e.g. veterinarian-producer communication, agricultural extension efforts, industry outreach) (Leeuwis and van den Ban, 2004; Boxelaar and Paine, 2005; Rehman et al., 2007; Pratt and Bowman, 2008). To date, little research has been conducted to investigate dairy producer attitudes towards, and perceptions of, the barriers and motivators influencing the adoption of on-farm management practices for JD control. This information is essential to the development of effective knowledge transfer (KT) approaches that address the true perceptions, attitudes, and opinions influencing dairy producer behaviour. It is generally known that producers’ perceptions of disease risk, and the perceived practicality of recommended changes, are key factors for producers when considering changes to on-farm
management (Garforth et al., 2013). Veterinarian-producer communication also plays a central role in influencing producer behaviour. As such, veterinarians’ communication approaches, and their attitudes and perceptions of JD, are also important factors influencing on-farm change (Sorge, 2010b). Resource-based factors (e.g. money, time, staff, infrastructure, etc.) are also important for producers to consider when evaluating recommendations for on-farm change (Rehman et al., 2007). Influencing producer behaviour towards adopting on-farm practices for JD control is thus a complicated endeavour, which requires knowledge of how to effectively inform, educate, and influence, as well as an understanding of how and why producers behave in the way that they do (Garforth, 2011). The goal of this study was to investigate Ontario (ON) dairy producers’ and veterinarians’ perceptions of the barriers and motivating factors for adopting on-farm changes for JD control.

**METHODS**

Between October and December 2012, six focus groups were conducted with dairy producers residing in Ontario, Canada. Four of the six focus groups involved dairy producers who had recently participated in an active-learning extension process, in various regions across ON, that focused on JD and calf health. Four of these regions (Seaforth, New Liskeard, Winchester, and Navan, ON) were chosen for focus groups. The sampling frame for participant recruitment was comprised of a list of all participants in the extension process for each given region. The remaining two focus groups involved dairy producers who had not participated in any active extension process in the previous 12 months. Two regions (Woodstock and Napanee, ON) were chosen for these focus groups, based on a high density of farms in these regions. Using the central point of each region and the farm location coordinates and contact information from a current provincial database (Dairy Farmers of Ontario), geographic information system mapping
was used to plot the locations of farms within a 10-kilometre radius. All producers in the
sampling frames received a recruitment letter describing the details and objectives of the project.
Approximately one week later, recipients of the letters were randomly selected, using a random
number generator, and recruited via telephone. Between 9 and 10 participants were recruited for
each focus group to help ensure a minimum attendance of 6 participants.

Two additional focus groups were facilitated with bovine veterinarians, practicing in ON, who
had been involved in the active-learning extension process for JD and calf health education. The
small number of veterinarians participating in the extension process limited the number of
participants to four per focus group. These focus groups were held in Guelph, ON. An
honourarium of $50 was paid to all focus group participants for their participation.

A trained moderator led the focus group discussions, while an assistant made written notes
summarizing the discussion and group dynamics. Focus group sessions were roughly two hours
in duration, and were audio-recorded and professionally transcribed to facilitate analyses. A pre-
tested, structured questioning route was developed according to Krueger and Casey (2008), using
a combination of primary questions and probes to elicit further detail (Appendix I). Questions
were intended to elicit information about participants’ general thoughts about JD, their perceived
barriers to adopting recommendations for JD control, and opinions about how to motivate
producers to implement JD control recommendations. Face to face participant debriefing after
the focus group, debriefing between the moderator and assistant, and the field-notes and audio-
transcripts were used to maintain accuracy and reliability of the data.

Transcripts were checked against the original audio-recordings for accuracy. A coding scheme
for analysis was created by having two coders separately code one transcript line-by-line, and
then comparing and revising codes based on discussions between the two coders. One coder separately coded the remaining transcripts. Codes from all transcripts were then compiled, categorized, and thematically analyzed to generate themes and sub-themes, as described by Braun and Clarke (2006). The general perceptions, opinions, and attitudes of dairy producers who had, and had not, participated in any active extension process were very similar across all focus groups; hence, no distinction was made between these two producer categories during analysis. As a result, discussions from the six dairy producer focus groups were thematically analyzed and compared to the two veterinarian focus groups. Data cleaning, coding, and analysis were performed in ATLAS.ti© (ATLAS.ti© Scientific Software Development, Berlin, Germany). Select verbatim quotations have been included in the text as exemplars of sub-themes and have been italicized, with larger quotes indented; square brackets have been inserted in areas to provide the reader with context.

The age and gender of participants were recorded upon focus group attendance. Additionally, the herd JD status of participants’ farms was determined by retrieving each farm’s most recent JD milk enzyme-linked immunosorbent assay (ELISA) test result, if one had been performed, through the Ontario Johne’s Disease Education and Management Assistance Program (OJEMAP) database.

The Research Ethics Board of the University of Guelph approved this study (protocol #: 11AP009), and all participants provided informed, written consent.
RESULTS

Participants

A total of 39 dairy producers, 32 male and 7 female, participated in the focus groups. Producer ages ranged from 27 to 58, with an average age of 36. Among those who had a JD milk ELISA test performed within the previous 12 months (n = 35), 42.9% (15/35) had at least one test-positive cow.

A total of 8 veterinarians, 7 male and 1 female, participated in the focus groups, with ages ranging from 29 to 57.

Thematic analysis

Two key themes identified from the qualitative analysis of the dairy producer and veterinarian focus groups were: (1) barriers to adoption of JD control measures, and (2) motivation to adopt JD control measures. Figure 1 provides a thematic map, representing the themes, sub-themes, and relationships identified.

Theme #1: Barriers to adoption of JD control measures

Dairy producer and veterinarian participants perceived two major barriers to adopting JD control measures: physical resources and intrinsic barriers.

Physical resource barriers

Focus group participants were quick to point out that their time, money, and existing infrastructure were key physical resource barriers to adopting JD control practices on their farms. Producers were particularly focused on how a combination of limited time and money, and
current barn size and layout represented tangible barriers to the adoption of JD control recommendations:

“Most of these things relate back to money and time. Other than money, time is a huge factor for this stuff. I’ve only got two hands and so much time in a day, right? And I’ve only got a set amount of money to deal with a number of different issues, so they are definitely some of the main barriers... cash and time, you know?”

“Nobody wants to spend more than they have to, especially if they don’t see a benefit from it. Like [JD control] doesn’t raise your cows price if you say she’s Johne’s negative, right, so I have to consider how much time it’s going to take, how much money, and if I have the space to realistically make the changes”.

“Well, money, labour resources, time and space in the barn are top barriers, I would think. We’re always limited by these things, it’s just reality... especially cost, it’s always a balance of cost and benefit. Some of these changes, they ask me to spend more money to make changes to areas that already are tight for space, so it’s tough, you know?”

Veterinarians tended to echo the comments made by producers, often suggesting that physical resource barriers were the most common issues relayed to them regarding recommendations for JD control.

“If they don’t really want to do the change then they say, ‘oh, that sounds like it costs too much money and will probably take up too much time’, even though most of these things are pretty basic and don’t cost a lot”.

“I usually hear stuff like, ‘It’s a space issue... my facility is only so big and the layout won’t work for what you’re suggesting’, or they’ll comment on how some recommendations are just going to take too much time or even cost too much. So it’s pretty much time, money, and space, you know”.

**Intrinsic barriers**

Focus group participants discussed how perceived priority, motivation to adopt JD control measures, and perceived practicality of JD control recommendations were important barriers to adopting JD control practices.
Priority

Dairy producer opinions on how JD control should be prioritized on the farm were mixed, with some participants ranking JD control as a low priority, while others suggested it was a higher priority for them. Participants often rationalized their opinion by describing their perception of JD as a problem on their farm and their view of the public perception of JD. Many for whom JD was not a priority described how JD was not an issue on their farm, for example, “for us, it’s a really low priority... like near the bottom... we don’t see [JD] on our farm”.

Another producer explained:

“I don’t lay in bed at night thinking about how I’m going to deal with Johne’s on my farm... there are a lot of other worries before that comes through for me. It’s just not a priority you know, it’s just not an issue that we’re dealing with on our farm”.

Producers with these perceptions also tended to express less concern about the public perception of JD, often questioning the severity of JD in Canada:

“It’s much more of an American issue... you just tend to hear more from down there. The information we get here is more American than it is Canadian, so I think it’s less of an issue for us”.

“I think if it was a problem we’d hear about it more... frankly, if it was a problem then we’d have heard more about cases in Ontario, and the public would be talking about it, but I’m not hearing much, so I’m not really concerned”.

Veterinarians expressed similar opinions when discussing how they thought dairy producers prioritized JD on the farm. One veterinarian suggested, “They certainly wouldn’t put it in their top five diseases to worry about”, while another said, “a lot of things are on their minds ahead of Johne’s, except for the guys that actually have it”. However, unlike producers, veterinarians expressed more concern when discussing public perception and a potential link between JD and CD. One veterinarian expressed this well:
“You know, if a big news story, or something very public comes out, it won’t matter if ten or one hundred have it… if there’s a negative perception from the consumer, or a perception that drinking milk can be harmful to people’s health, then we’ve got a problem. So the whole MAP and Crohn’s thing could definitely turn into an issue, whether there’s a real link or not”.

Other producers considered JD to be an important priority for on-farm consideration.

These participants described personal anecdotes of JD on their farm, or had known someone who was affected:

“It’s a big concern for us… we’ve had [JD] in the past and we know others who are dealing with it. So it’s definitely something we’re concerned about on our farm and trying to manage”.

Other producers described JD control as an important issue from a more general biosecurity standpoint, explaining:

“To me it’s one of ten important issues. There’s all kinds of things you have to maintain and keep an eye on… whether it’s mastitis, Johne’s, or whatever… to me it’s one of a ten-piece puzzle to disease control. So it’s prioritized just as much as any one of a number of other diseases, you know. Because if you slip up on any one of these areas, you could be in big trouble… so it’s something we need to be worried about”.

Producers who expressed a concern for biosecurity also expressed concern for the public’s perception of JD. In particular, they were concerned about the potential link between JD and CD, and public health safety, for example:

“If the public thinks that it’s an issue, then this potential link to Crohn’s could be a big issue for us, no doubt about it. Consumers want a safe and quality product… Johne’s control is important from that point of view for sure”.

“Consumer perception of our industry, of our product is, kind of paramount. My career is producing milk, you know, so I think it’s pretty important that we do everything we can to make sure the consumer views us in a positive light”.
Motivation to adopt JD control measures

Both producers and veterinarians expressed similar views on the role of motivation in behaviour change, describing how poor motivation is a substantial intrinsic barrier to the adoption of JD control measures. One producer in particular highlighted the importance of motivation, commenting:

““You’ve got to see value in doing these things and be motivated to improve if you have any hope... it’s all about seeing a value in addressing the situation... Johne’s is no different”.

However, producers commented that many producers in the dairy industry are not motivated to make on-farm changes for JD. One producer explained:

“I think the industry has a lot of people you could ask that would be more than willing to help you out, whether it be Johne’s or whatever. But in order to do that you’ve got to be motivated to put your time into it and it goes back to those that don’t want help, you just can’t help them anyway”.

Others agreed: “Yeah, you can lead them to water but you can’t make them drink, right?”,

and: “There’s those that want to do something about it [JD], and those that don’t... it’s as simple as that. Motivation is key and when they don’t have it, that’s a barrier”.

Veterinarians tended to echo these statements,

“You know, we recommend these changes for JD control, and a lot of them involve a philosophy change... like removing calves quickly... the farmer needs to see the value in doing that. In some ways, it’s up to the farmer, I guess, to see the rationale in doing it, but some need to be motivated to attempt these things and removing that kind of motivation barrier would be a big step”.

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Perceived practicality of JD control recommendations

Producers and veterinarians stated that a producer’s perception of the practicality of JD control recommendations was a barrier to change. Many producers identified difficulty with implementing JD control recommendations. One producer simply stated:

“To me, most of them are unrealistic, and are not going to happen without a big change. You know, they’re tough to do. Vets are great for telling us what we need to do, but getting it done is another story”.

In particular, producers focused on the recommendation to keep herds closed, or buy cattle from low-risk herds:

“I mean, if you need cows, if you need the milk, you’re going to buy, right? You’re not going to start worrying about Johne’s if you need the milk, ... if you need them, you’ll buy them”.

Other producers acknowledged this barrier, and the difficulty in assessing the JD status of cows for sale, stating:

“We have to pay the bills, so we’re bringing in cows if we need them, that’s all there is to it. And when we talk about low-risk herds, well it’s not like everyone has their Johne’s tests posted at the end of the driveway”.

Other producers commented on the practicality of the recommendation to remove calves from the dam immediately after birth, explaining:

“The biggest issue is removing calves at night time for me... it’s just not practical. I’m not going to go out and take a calf away in the middle of the night, she’s going to stay with the cow”.

In contrast, the majority of veterinarians described the recommendations as practical, with comments such as:
“Oh yeah, I think probably every one of these things have been on my list of things to do for producers. They definitely seem reasonable to me”.

“Everyone’s got limitations, but most of them I think are pretty easy, you know, if the farmer is serious about reducing Johne’s disease on the farm. I think most of us are pretty realistic when giving recommendations”.

Producers and veterinarians often described how a producer’s routine and habits might impact their perception of the practicality of JD control recommendations. Producers commented:

“You know, it’s tough when you’ve got a set routine and everyone knows their role. Changing that up and taking on new tasks can be tough to do when it disrupts the flow”.

Veterinarians echoed these comments, explaining:

“It’s the way they’ve always done it and they don’t seem to have a problem with Johne’s doing things this way, so they say ‘why would I change?’ They look at the recommendations and think, ‘this is going to upset my routine, and for what?’”

Theme #2: Motivation to adopt JD control measures

Both dairy producers and veterinarians described factors that they thought would motivate producers to adopt on-farm JD control measures. These were categorized as intrinsic motivation and extrinsic motivation.

**Intrinsic motivation**

Participants identified pride and responsibility as intrinsically motivating factors, which influenced their on-farm behaviours and decisions.

**Pride**

A small number of producers felt that a producer’s pride as an animal caretaker was an important motivating factor for on-farm changes. One producer explained:
“You know, you walk through your group [of cows] and you see they’re all healthy and nice looking... you feel proud... and you think, wow, that’s because of my hard work, you know, it’s important to me and it shows, I think”.

Another producer agreed:

“You see the benefits of good management practices that come with trying to control Johne’s, because they have other benefits on the farm, like faster heifer growth and health. For me, making sure my herd is healthy is a source of pride, you know. It’s something me and my family is in control of, so seeing a healthy group makes me proud because I know I had a role to play. So preventing or controlling Johne’s is big for me”.

Responsibility

Several producers highlighted the responsibility that comes with creating a food product, for example:

“We as a Canadian milk producers, we say we have a safe product, you know, so we have to do tests and make sure we’re dealing with [JD], because otherwise consumers say ‘what’s going on with Johne’s disease?’, and a link to Crohn’s won’t be pretty”.

“Keeping the consumer comfortable with the product that we’re providing them is paramount. Like, there’s concern that there’s people linking Crohn’s and Johne’s, so we need to make sure we’re on top of this and keep the consumer safe and happy”.

While the majority of discussions on responsibilities revolved around those to the consumer, a small number of producers also acknowledged a responsibility for animal health. One producer summarized this well:

“A lot of these control measures you strive to do anyways, whether you have Johne’s or not... you want the best for your cattle, you know. Like, we have a responsibility for our animals and their health, right, so controlling Johne’s is on us”.
Extrinsic motivation

Focus group participants described incentives, premiums, penalties, and regulations, and extension and communication, as external factors that influence producers to make on-farm changes.

Incentives

Many producers described motivating incentives for adopting JD control. Free JD testing was proposed as a useful incentive, with one producer commenting:

“Well, if re-testing [for JD] came at no cost to the farmer, I’m sure a lot more farmers would be willing to do that. I would be much more willing to consider re-testing on an annual basis if the test were subsidized, that’s for sure”.

With free testing having been offered in Ontario previously, one veterinarian commented:

“The free testing helped tremendously; it’s definitely helped create awareness, which has helped with implementing some of these changes”.

Veterinarians also discussed the use of financial incentives, and subsidies for making on-farm changes, to motivate on-farm change. One veterinarian suggested:

“If [producers] don’t really want to do the change then they say, ‘oh, that sounds like it costs too much money’, even though most of these things are pretty basic and don’t cost a lot. I think if you were to provide some sort of funding, they might be a little more motivated”.

Penalties and regulations

While veterinarians did not discuss the potential impact of penalties, and regulations on adoption, producers explained how they can be an important for externally motivating change. One producer commented:
“We can motivate some guys with a premium, or some kind of cash incentive for making changes, and we motivate the rest by offering a penalty if they don’t”.

Another producer similarly stated:

“Meeting them with the carrot or the stick... either you take the carrot option or we’ll follow up with the stick, your choice”.

Many producers also focused on the potential link between JD and CD when rationalizing penalties and regulation. One producer commented:

“It’s just like the somatic cell count penalty coming down right... it’s about milk quality in that case and it’s about milk safety in this case. People aren’t going to change until it hurts, so imposing some sort of penalty is probably the next step to make sure our food products meet standards”.

Producers identified industry as the primary regulator for JD control. Several producers perceived that the Canadian Quality Milk (CQM) Program (a mandatory food-safety program) would be a logical option, with one producer stating, “It would be easier to address Johne’s if it was in the CQM program”, while another commented, “It should definitely be tied to CQM... it should be a criteria under that program somewhere”. One producer provided a good summary of these discussions:

“See, maybe they need to take it a step further and say, if you want to be a Class A milk producer these are requirements, through the CQM, that you need to do. Maybe it’s the [JD] test and doing a risk assessment or something, verified by the CQM to make sure these [protocols] are in place. Then the guys that are dragging behind and living in the dark thinking they don’t have a problem, well, then they either deal with it or maybe choose another career”.

However, there were also several producers that viewed these suggestions negatively, stating, “yeah, that’s all we need, more intrusion into our lives”, and “[regulation] is just going
to bring more restriction”. Despite these comments, many discussions revolved around a need for a structured method of penalizing and/or regulating JD control.

Producers also focused on the potential for mandatory JD testing, with comments such as:

“Mandatory bulk testing is the only way to open somebody’s eyes up because it’s the ones that say ‘ah, don’t worry, we’re not going to go testing for something we don’t have…’ those are the ones that need to open up. So...maybe we need mandatory bulk testing and if you’re positive three times, then you get a penalty”.

“I say make testing mandatory and you know what, it will maybe sharpen guys up a little bit. Maybe they won’t put their positive cows up at the sale barn and our chances of bringing it home will be a lot less”.

Extension and communication

Veterinarians commonly discussed the role of extension and communication to motivate producers, and emphasized the importance of group discussion and peer-to-peer learning. One veterinarian commented:

“The best meetings I’ve had was where there was no speaker and the farmers were just talking to each other”.

In response, another veterinarian commented:

“[Meetings with no experts] were the meetings that the farmers said they didn’t want; they almost always wanted to get another speaker in. For them it’s easier, right, they just get to sit and listen to somebody, but those sessions we had where we didn’t have a speaker, those were the meetings the farmers are still talking about, because they remember a lot of those things that they discussed amongst themselves and that really stuck”.

Producers focused more on the content that should be provided through extension and communication efforts. More specifically, they suggested that messages should highlight the negative consequences of JD, and the positive consequences of change, for example:
“If you can’t come to me and show me how changing something is going to make me produce more, improve herd health, or some small way make me more money, then, I’m probably not going to be that motivated to change it”.

“If you were to show producers what Johne’s could do to your herd, that would motivate someone to change, you know, because if Johne’s didn’t kill cows, we wouldn’t worry about it at all. But it’s the potential loss, be it cows or milk, that is going to motivate change”.

Many other producers felt that promoting calf health more holistically was a better motivator than simply recommending changes for JD control. Two producers described this idea well:

“You’re not just preventing Johne’s you know... you’re preventing scours and everything else with it. That’s an important message to motivate guys to change”.

“I wouldn’t tell someone to make these changes just for Johne’s, I think it’s important to highlight the other issues on the farm. You know, the ones they see and deal with more regularly, like scours and stuff like that. You want to talk more about standard procedures and discipline, and if that happens, you take care of Johne’s too”.

Veterinarians echoed these comments, stating:

“I approach Johne’s from a more general stance. Disease prevention in general... it’s all about preventing calf and manure contact in the first two weeks of life, you know”.

**DISCUSSION**

**Barriers to adoption of JD control measures**

The majority of participants in this study identified ‘intrinsic barriers’, such as the perceived priority of JD control and practicality of control recommendations, as well as producer motivation, as important determinants of producer behaviour with respect to JD control.
Priority

Dairy producer perceptions about the priority of JD control were varied, and were largely driven by their lived experiences with JD (i.e. current and previous on-farm JD status). Nearly 60% of producers in this study did not have a test-positive animal for JD on their most recent JD test, which likely contributed to the perception among many producers that JD was not a priority on their farm. Sorge et al. (2010a) showed similar perceptions among Canadian dairy producers, where nearly 75% of respondents reported not seeing JD as a problem for their farm. Similarly, Norton et al. (2009) reported that the majority of participating producers felt JD was of little importance to their dairy farms in New Zealand. The majority of veterinarians here also corroborated this lack of on-farm concern amongst producers. These results are similar to Sorge et al. (2010b) who reported that the majority of participating Canadian veterinarians ranked JD as the least important disease among six possible conditions (mastitis, lameness, calf diseases, metabolic peri-parturient disease, reproductive inefficiency, and JD). This perception that JD is not an on-farm problem may be attributed to the chronic nature and silent spread of the disease; JD has a prolonged incubation period (Tiwari et al., 2006), and there are few visual cues of JD infection. Leeuwis and van den Ban (2004) suggest that risk perception depends on, among other factors, visibility, magnitude, and the directness and duration of consequences. This may help explain the perceptions of JD control as a low priority reported by producers in this study: JD is caused by a microscopic bacterium, MAP, whose signs are largely absent among most infected animals (poor visibility); a relatively low number of animals are infected at one point in time (low magnitude); and JD takes years to manifest clinically (seemingly indirect and long duration). As such, it seems reasonable that many producers’ perceived risk of JD would be low. Garforth et al. (2013) similarly reported that English livestock producers viewed many of the biosecurity measures aimed at reducing the risk of the ‘silent spread’ of disease as unnecessary. Efforts to
influence adoption among producers with these negative perceptions may be more effective if they focus on the benefits of reducing the impacts of other fecal-orally transmitted diseases of cattle, such as *Escherichia coli*, *Campylobacter* spp., *Salmonella* spp., and *Cryptosporidium* spp., which can be prevented and controlled through the same approaches used to control JD. As the negative health impacts of calf infection with these latter bacteria are more readily visible than JD, producers may attribute higher risk to these diseases, and thus be more open to change. As a result, producers making changes to address these other bacteria would also have a direct positive impact on JD control, without explicitly changing their behaviour for JD control.

Interestingly, many of those who felt JD control should be a priority on the farm shared this broader perspective on disease control and biosecurity. Many producers who felt JD control was a priority commonly reported having dealt with JD personally, or knowing someone who had dealt with it. For these participants, their lived and shared experiences appeared to have resulted in an increased concern for JD control. These findings are supported by Garforth et al. (2013), who concluded that English producers’ previous experience with a given disease was one of the main factors influencing whether they would adopt a given practice. These results provide useful information for improving veterinarian-producer communication. We recommend that veterinarians ask producers to describe their prior experiences with, and perceptions of, JD, prior to making recommendations, in an effort to better understand the producer’s perspective and address the potential barriers related to a perception of low priority for JD.

A number of producers questioned the severity of JD in Canada, often suggesting it was more of a concern in the U.S. While estimates suggest that nearly 70% of all U.S. dairies have JD infected animals (USDA, 2008), roughly 30% of Canadian dairy farms have been reported to have at least 2 test-positive cows (Tiwari et al., 2009). Thus, while the prevalence of JD is
remarkably different between the U.S. and Canada, JD is nonetheless an issue for many
Canadian dairy producers. Furthermore, some producers reported that much of the information
they received was from the U.S., further reinforcing their perception that JD was not as much of
a concern in Canada. However, the Canadian Johne’s Disease Initiative (CJDI)
(www.animalhealth.ca/Programs/), implemented in 2010, prompted the creation of provincial-
based JD control programs, each with an explicit KT component. The results presented here
suggest, however, that current KT initiatives are not effectively reaching all members of their
target audiences. Extension efforts should focus on providing Canadian producers with
contextually relevant information, through various KT channels (e.g. provincial dairy magazines,
mail-out flyers, dairy websites, regional meetings, conference presentations, etc.) to improve
producer exposure. Consistent and regular communication on JD as it relates to the Canadian
dairy industry may also facilitate the formation of informed perceptions of JD risk for Canadian
dairy producers.

Producers’ prioritization of JD control also appeared to be related to their concerns about
the public perceptions of JD and the potential link between JD and CD. These concerns were
similar to findings from Sorge et al. (2010a), who found the potential association between JD
and CD to be a significant motivator for Canadian dairy producers to join a JD control program.
While evidence for this link is controversial, Sweeney et al. (2012) suggests that there is
moderately strong evidence of a causal relationship between MAP and CD in genetically
susceptible individuals. A change in milk consumption or demand of milk products, as a result of
a perceived threat from JD, would affect all dairy producers, regardless of on-farm JD status.
This message may serve as a powerful motivator to influence change among those that do not
feel JD is a problem on their particular farm.
Perception of the practicality of JD control recommendations

The perceived practicality of JD control recommendations was another barrier to change identified in this study. Many producers who felt that JD prevention was not a priority tended to question the practicality of some recommendations, often in terms of time and money. Garforth et al. (2013) reported that perceived practicality was an important factor influencing adoption of biosecurity recommendations, and that perceptions of disease risk are often directly linked to perceptions of the specific recommendations. In this study, many producer criticisms referred to the participants’ limited time or level of control over the specific practice. Sorge et al. (2010a) reported similar results, concluding that one of the main reasons for non-compliance among Canadian dairy producers was the perception that practices were unnecessary, or too challenging to implement. A producer’s assessment of how the practices would impact their habits, or routine, was also an important factor influencing their perceived practicality in this study. Many producers placed value in having a set routine and felt that breaking of this routine could be a barrier to adopting new practices for some. Sorge et al. (2010a) also concluded that habits hindered adoption of JD control recommendations for Canadian producers. However, Garforth et al. (2013) suggested that habitual behaviour was not a strong driver of the use, or non-use, of specific practices, and that producers were willing to be convinced to use practices they currently did not. Thus, an unwillingness to break routine likely stems from a lack of perceived value of the practice in question. Interestingly, most veterinarians perceived JD control recommendations as reasonable and feasible, and suggested that the main barrier to adoption was producer attitude. These findings highlight that producers and veterinarians have conflicting perceptions on the practicality of JD control measures. It is therefore important to inform both producers and veterinarians of these differences and focus on effectively communicating the value of making
on-farm changes for JD control, whether the focus is on the control of JD specifically, or improving biosecurity to prevent and control a variety of other calf diseases.

**Motivation to adopt JD control measures**

In this study, participants described how both extrinsic factors (i.e. incentives, penalties, and regulation, and extension and communication) and intrinsic factors (i.e. pride and responsibility) served as important motivators of change.

**Incentives**

Producers’ perceived that free JD testing would motivate the adoption of JD control management practices. This coincides with the identification of money as a barrier to adoption as well, suggesting that free testing might eliminate financial barriers. Many of the provincial JD control programs in Canada, and programs worldwide, have implemented some form of subsidized testing (Barker et al., 2012; Harrison 2013). However, many producers declined these opportunities, even when fully subsidized. For example, only 52% of 4158 eligible dairy herds in ON took advantage of free JD testing offered by their JD control program (OJEMAP 2013). Furthermore, as might be expected, many of the world’s control programs have experienced a drop-off in routine JD screening as subsidies were removed and the cost of testing was put back on the farmer (Harrison 2013). The lack of participation in free testing, and the subsequent drop-off in participation upon the removal of testing subsidies, suggests that, generally, producer behaviour changed without a change in attitude. When this occurs, behaviours are generally short-lived (Pike 2008; Sasaki, 2012), which ultimately compromises the long-term efficacy of these programs. Therefore, the provision of incentives such as free testing opportunities may be insufficient to facilitate sustained behaviour change.
**Penalties and regulation**

Dairy producers in this study felt that financial premiums for ‘MAP-free’ milk, and penalties for milk containing MAP, would serve as strong motivators for producers to adopt recommendations for JD control. The use of premiums and penalties to motivate producers has been widely utilized and researched in the context of mastitis control (Valeeva et al., 2007; Nightingale et al., 2008), and offers useful insights into the potential impact for JD control. Jansen et al. (2009) reported that Dutch farmers felt that receiving premiums for low bulk tank somatic cell counts (BTSCC) motivated the uptake of on-farm control measures; however, Valeeva et al. (2007) suggested that Dutch farmers were more motivated by a price decrease for poor quality milk (high BTSCC), opposed to a price increase for high quality milk. Further evidence suggests that the combination of a penalty program for low quality milk (high BTSCC) and a premium program for high quality milk (low BTSCC) provided a strong incentive for American farmers to improve on-farm mastitis management (Nightingale et al., 2008). Thus, there appears to be value in the use of premiums and/or penalties to motivate producers to change. It is important to note however, that, similar to incentives, this type of extrinsic motivation does not directly aim to influence producer attitudes and/or perceptions. Furthermore, given the chronic nature of JD, its persistence in the environment, and other inherent differences between JD and mastitis, further research is needed to examine whether the creation and implementation of a premium-penalty program for JD control would be feasible and/or effective.

Some producers also rationalized the need for monitoring and regulating JD in Canada given the potential food safety issues related to CD and human health. They further expressed interest in incorporating this into an existing monitoring program, called the Canadian Quality Milk Program (CQM). The CQM uses a Hazard Analysis Critical Control Points approach to
food safety, which focuses on preventing and minimizing the risk of food safety hazards (DFC, 2013). While not currently designed to assess JD specific risks, programs like the CQM may provide viable opportunities to monitor and/or enforce JD-related practices, such as testing and culling protocols. It may be more likely, however, that any industry-driven push to monitor and regulate JD would come in the form of an independent certification program. Nielsen et al. (2011) reported that Danish producers expressed a desire for a JD certification program; however, challenges in declaring a herd ‘free of MAP infection’ has led countries like Canada (CAHC 2006) and Denmark (Sergeant et al., 2008) to shy away from establishing a national certification program. While some countries, including Australia, the Netherlands, and U.S., have implemented herd certification programs for JD (JIC 2010), further evaluation of the voluntary JD control programs currently in place in Canadian provinces is needed before further monitoring, regulation and/or certification can be considered (CAHC, 2006).

Extension and communication

Veterinarians in this study regarded group discussion and peer-to-peer learning as valuable motivators for change. Agricultural extension research suggests that bottom-up approaches, which utilize producer-centred, participatory group approaches are more effective in influencing change among farmers (Andreata, 2001; Fulton et al., 2003). The ability of these approaches to address the social factors influencing behavioural change has resulted in greater levels of adoption of on-farm mastitis control practices in Denmark (Vaarst et al., 2002), and JD control practices in Denmark (Trier et al., 2012) and Australia (Kingham and Links 2012). Therefore, group approaches can be instrumental in motivating on-farm change for JD control. Veterinarians could be more effective motivators by fostering, and participating, in these
producer-led groups, in combination with providing clear and consistent communication about JD.

**Pride and responsibility**

The findings suggest that producers pride and perceived responsibility are motivating factors for change. For some, these intangible, or intrinsic, factors were important considerations in their decision to adopt JD control measures. Interestingly, Valeeva et al. (2007) reported that, for Dutch dairy farmers, non-monetary factors, such as internal esteem and taking pleasure in healthy animals on the farm, were equally as motivating as monetary factors to improve mastitis management. Producers in this study also felt they were responsible for producing safe food products and maintaining animal health. Ellis-Iversen et al. (2010) similarly reported that nearly all English and Welsh cattle farmer respondents believed they had a social responsibility to produce safe products and control zoonoses on their farms. Awareness of animal welfare has also been reported to be an important motivator for adopting JD control practices for dairy producers (Hop et al., 2011). JD control programs, monitoring, and regulatory decisions in particular, can benefit by addressing these intrinsic motivations, as they have been shown to both motivate and inhibit producer participation. For example, Hood and Seedsmann (2004) reported that producers in an Australian JD control program expressed lowered self-esteem when their herds were identified as being infected with JD. Consequently, producers may be wary of participating in future JD control programs for fear of a negative stigma associated with a JD positive herd status. In contrast, participation in JD control programs may result in increased self-esteem and pride among farmers who realize improved herd health as a result of making on-farm changes (Benjamin et al., 2010). Producers taking pride in herd health may also be more motivated to make changes to maintain, or to achieve, a JD negative status and improve overall herd health.
(Gunn et al., 2008). Therefore, future control programs should focus on communicating with producers about their pride and perceived responsibility with respect to their herd and the impact of disease. By focusing on these intrinsic motivators control programs may be able to influence more sustainable change among producer populations.

This study provides important contributions to the current understanding of dairy producer and veterinarians perceptions of the barriers and motivators that influence the adoption of on-farm management changes for JD control. A particular strength of this study is the use of qualitative methods to obtain a rich, in-depth understanding of the wide range of perceptions and attitudes that influence behaviour. A limitation of this study is the number of focus groups conducted for each of the populations of interest (i.e. producers and veterinarians), which were limited based on budgetary constraints. Without such limitations, focus groups would ideally have been carried out until saturation of the data had been achieved. Lastly, dairy producer participants may have been hesitant to discuss their personal on-farm issues with respect to JD due to concern over what other group members might think. As a result, it is possible that producers in this study may have deliberately biased their responses by providing socially desirable answers to questions about on-farm disease status and/or prevention and control practices. In consideration of this bias, every effort was made to ensure mutual respect and equality among participants by clarifying that all focus group discussions were to remain private and confidential, that there were no right or wrong answers, and that all perceptions, attitudes, and opinions could be expressed free from judgment. Future studies may also consider contacting participants individually after the focus group to discuss these issues, or consider holding one-on-one interviews to reduce the potential bias associated with socially desirable responding.
CONCLUSION

This study investigated ON dairy producer and veterinarian perceptions of the barriers and motivators influencing the adoption of JD control recommendations. While a lack of physical resources (i.e. time, money, and infrastructure) was considered an important barrier to on-farm change, participants also identified the significance of several intrinsic barriers, which related to their perceived priority of JD, their motivation, and their perception of the practicality of JD control recommendations. The lived and shared experiences of producers, with respect to JD, tended to influence their perception of JD as an on-farm problem, with many of those who had not personally dealt with JD generally unconcerned about the disease. Future communication with producers about on-farm changes for JD control should take a more holistic stance on biosecurity by highlighting the indirect health benefits of JD control as a result of limiting calf exposure to other fecal-orally transmitted diseases. Furthermore, the perception among some producers that JD is not an issue for them, and thus is not worth changing for, may be influenced by emphasizing the potential consequences of a link between JD and CD, and how even a negative public perception of milk safety might impact the entire dairy industry, regardless of JD status.

Producers and veterinarians described the importance of both extrinsic (i.e. incentives, premiums, penalties, regulation, and extension and communication) and intrinsic (i.e. pride, responsibility) forms of motivation. While incentives and premiums, penalties, and regulation can be useful for influencing producer behaviour, these methods often do not address producer attitudes towards JD and are often coercive, rather than motivational, leading to unsustainable change. Motivating change through group-based extension and communication, and considering how JD control impacts producer pride and perceived responsibility, may serve as opportunities to intrinsically
motivate producers to change. Veterinarians should focus on understanding each producer’s own perspective on JD and its control, and aim to motivate change by tailoring their recommendations, and the information they provide, based on that perception. In doing so, producers will be more likely to engage in sustainable change as a result of their own perception that on-farm management practices for JD control are meaningful.
REFERENCES


Figure 1 | Thematic map produced from the thematic analysis of data on perceived barriers and motivators for the on-farm adoption of JD control recommendations, collected during six dairy producer and two veterinarian focus groups, conducted in Ontario, Canada (October to December 2012). Bolded themes and subthemes are discussed within the text.
CHAPTER THREE

The Ontario Focus Farm approach to improving the adoption of on-farm management practices for Johne’s disease control in the Ontario dairy industry

ABSTRACT

This study describes a conceptual and practical framework for implementing a producer-centred extension model, Ontario Focus Farms (FF), and reports on the implementation and evaluation of FF to improve the adoption of on-farm management practices for Johne’s disease (JD) control in Ontario, Canada. Six focus groups were carried out, four with dairy producers and two with veterinarians, to assess participant perceptions about the usefulness of FF as an extension model. A post-FF intervention questionnaire was also administered to investigate the impact of FF on producer knowledge, attitudes, and behaviours towards JD control. Conceptually, FF is participatory, self-directed, and collaborative; emphasizes honest communication and a trusting environment; promotes planning, action, and implementation of on-farm changes; and engages participants in reflective practice for learning. Practically, 7-12 producers form a FF group, which is facilitated by a trained veterinarian. Each group commits to a minimum of 4 meetings in a 12-month period. Each meeting is comprised of a half-day on-farm and a half-day in a meeting room, where groups discuss their self-identified issues using a variety of active-learning techniques (e.g. risk assessment, farm tours). Overall, 176 dairy producers participated in 1 of 14 FF groups. Thematic analysis of focus group data revealed that a facilitator-moderated, producer-centred environment, which utilized a variety of active-learning techniques (e.g. farm tours, risk assessments), were the key characteristics in making FF a useful extension method. Producers and facilitators also suggested that the lack of dairy specific context and the broad scope of the
facilitator training, and the limited time producers have in the harvesting season, were the main barriers to running FF efficiently. Over two-thirds of respondents reported increases in awareness, confidence, knowledge, and positive attitude towards JD control, and 81% of producers reported making at least one on-farm management change for JD control as a result of FF. Thus a producer-centred process that incorporate a collaborative learning approach, appears to be perceived by producers/veterinarians as an effective method for agricultural extension and may increase producer adoption of on-farm management practices for JD control.

INTRODUCTION

Johne’s disease (JD) is an important production-limiting disease affecting cattle, and other ruminants, in many countries worldwide (Sweeney et al., 2012). In addition to decreased milk production, decreased fertility, and premature culling of subclinical animals, clinically affected animals typically develop chronic diarrhea and waste away over time (Tiwari et al., 2006; Sweeney et al., 2012). In Canada, studies show 10% to 40% of dairy herds have at least two seropositive cows (Tiwari et al., 2006; 2009), with annual economic losses estimated at over CAD$15 million (McKenna et al., 2006). Of increasing concern is the evidence suggesting that the causal organism, Mycobacterium avium subsp. paratuberculosis (MAP), plays an important role in causing Crohn’s disease (CD) in genetically susceptible humans (Feller et al., 2007; Waddell et al., 2008; Chiodini et al., 2012; Sweeney et al., 2012). A causal-link between MAP and CD, or even a perception among consumers that MAP exposure (through the consumption of dairy products) is a health risk, could have devastating financial impacts on the Canadian dairy industry.
As there is no cost-effective treatment for JD, prevention and control is recommended through a combination of periodic cow testing and by implementing management changes to improve farm hygiene and biosecurity (Sweeney et al., 2012). Typically, a veterinarian-administered risk assessment (RA) is used to identify management practices on the farm that increase risk of MAP transmission. Over the past decade, RA-based control programs have been implemented in Australia (Kennedy and Allworth, 2000), Denmark (Nielsen, 2007), the Netherlands (Benedictus et al., 2000; Groenendaal et al., 2003), United States (Collins et al., 2010), and Canada (Sorge et al., 2010; OJEMAP, 2009). Although RA-based control programs have been widely implemented, producer compliance ultimately determines the efficacy such programs. Most importantly, several studies examining the uptake of recommended changes in on-farm management practices to control JD have reported poor producer compliance (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010).

A producer’s behaviour and willingness to adopt recommendations are influenced by a complex set of relationships among factors such as communication, attitude, perception, knowledge, beliefs, and skills (Boxelaar and Paine, 2005; Rehman et al., 2007). From an agricultural extension perspective, the linear, top-down transfer of information (e.g. knowledge holder (i.e. veterinarian) instructing knowledge user (i.e. producer)), which is a persuasive form of extension often associated with RA-based control programs, has had limited effects on changing behaviour (Leeuwis and Van den Ban, 2004; Coutts and Roberts, 2011). More effective forms of agricultural extension to induce behaviour change involve participatory, bottom-up approaches, which embrace ‘systems thinking’, theories of adult education, and action learning principles, to address the social factors influencing change (Andreata, 2001; Fulton et al., 2003; Friend et al., 2009).
Beginning in 2010, the Ontario Johne’s Disease Working Group began a three-year, voluntary, RA-based JD control program, called the Ontario Johne’s Education and Management Assistance Program (OJEMAP) (OJEMAP, 2009). The program was comprised of voluntary whole-herd testing, a veterinarian-administered on-farm RA, and an education component. The major focus of the education component was identifying, designing, and implementing an extension model with documented success in improving the adoption of on-farm management practices. In particular, Focus Farms, a participatory, practice-based extension approach, developed in Australia and New Zealand, was identified as a viable option (Andreata, 2001; Nelson 2007a, b). Focus Farms is a self-directed process, which employs collaborative learning methods (Nelson 2007b). A Focus Farm is a learning tool, around which group and individual learning activities are devised, to address individual and common issues. Thus, the Focus Farm is used as a place to gather for discussions, to plan changes, and to discuss performance. The overall goal of this approach is to engage participants in an active-learning process focusing on identifying, planning, and implementing changes on participants’ farms (Nelson, 2007a, b).

Using this Focus Farm framework, the Ontario Focus Farm process (FF) was developed to contribute to the education component of OJEMAP.

**Ontario Focus Farms**

Conceptually, FF can be categorized under the Group Facilitation and Empowerment Model (Andreata, 2001), which utilizes a facilitative framework to increase participants’ planning and decision-making capacities, through a self-directed, learner-centred process (Coutts and Roberts, 2011). Within this model, FF relies on the principles of adult education (Knowles, 1970) and experience-based learning theories, such as experiential learning and participatory action research/learning (Lewin, 1947; Kolb, 1984; Kemmis and McTaggart, 2007). Overall, FF
embraces four main principles, based on these theories, for the creation of an effective learner-centred process:

1. Participatory, self-directed, and collaborative

FF is a learner-centred process, where dairy producers engage in active-learning strategies in a highly participatory and collaborative environment. The process revolves around the producers, and through goal setting, prioritization, and discussion, each group self-directs their learning. This approach offers producers the ability to pursue their own learning agenda to acquire knowledge about a specific issue, rather than one that is imposed upon them. Furthermore, it generates pragmatic and contextually meaningful solutions by using producers’ pre-existing knowledge and experiences. FF embraces the individuality of learners and provides an opportunity for producers with different backgrounds, values, and experiences to work collaboratively in an effort to address their own on-farm issues.

To effectively maintain a learner-centred environment, a trained facilitator moderates each group. The facilitator’s job is to work with group members to put their expectations, wants, and needs at the centre of the process. They guide, support, and foster discussion, while emphasizing learning and change. Facilitators embrace unanswered questions, divergent opinions, and perceived needs to promote discussion. Overall, producers drive their learning and actively engage in a variety of activities, which appeal to a variety of learning styles, to improve their knowledge and address their prioritized issues.

2. Honest communication and trust

The FF process emphasizes a need for participants to be honest and open when sharing their issues, attitudes, and opinions. Without honest discussion of the issues facing participants (e.g. disease status, on-farm challenges), meaningful learning, which translates into practical
solutions for on-farm change, cannot occur. This emphasis is paramount to instilling a level of mutual trust and respect among participants to create and maintain a learner-centred environment. Facilitators encourage participants to actively share their views, listen to others patiently, and explore their curiosities collectively. Facilitators recognize and embrace the varying levels of knowledge and ability among participants by promoting an environment that is free from hierarchy and judgment. Establishing the need for honesty, openness, and acceptance as a ground-rule promotes sincere dialogue that is true to the issues, attitudes and opinions held by individual participants.

3. Planning, action, and implementation

The two principles discussed above place an emphasis on specific aspects of adult education theory. This principle focuses on the cyclical nature and shared aspects of experience-based learning theories, such as experiential learning and participatory action research/learning. Focus Farms embraces the steps of the Kolb Cycle for experiential learning (concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), active experimentation (AE)) (Kolb, 1984). Producers engage in learning activities (e.g. farm walk/tour, risk assessment), CE; review each experience from various perspectives, RO; further discuss their observations, AC; and finally, explore potential applications on their own farms, AE. Complementing this approach, FF embraces the steps of action research/learning by facilitating the identification, articulation, and prioritization of individual on-farm issues, and engages producers in a process of planning, implementing, observing and reflecting (King et al., 2001; Kemmis and McTaggart, 2007).

Throughout this process of learning and on-farm change, Focus Farm groups are used as a support network to facilitate and enhance the steps of the learning cycles. Moreover, producers work collaboratively to help identify goals, plan, and discuss impacts of on-farm changes.
Overall, producers engage in the active implementation of learned concepts/information, and learn from one another’s experiences and observations.

4. Reflection

The FF approach promotes internal reflection among individual participants and external reflection among the group as a whole. Producers are prompted to critically think about, and question, their planning process, changes made, and the resulting positive and negative outcomes. Individually, facilitators provide end of meeting questions and/or tasks, and have between-meeting follow-ups to promote internal reflection. As a group, facilitators prompt external reflection through farm walks, sharing farm-specific pictures, and open discussions. In many ways, individual reflection prepares the producers to engage in collective reflection. As the group improves in its ability to collectively reflect and/or share individual reflections, producers can, with the aid of the facilitator, effectively identify ‘teachable moments’. These moments allow producers to identify the value of various changes/solutions, which ultimately facilitates the creation of new knowledge, and practical, contextually appropriate solutions.

The first objective of the present study was to describe the implementation of a ‘pilot’ version of FF with Ontario (ON) dairy producers in an attempt to improve the adoption of on-farm management practices for JD control. The second objective was to evaluate FF with respect to participant and facilitator perceptions about its usefulness as an extension model, and to provide preliminary information on its impact on producer knowledge, attitudes and behaviours towards JD control.
MATERIALS AND METHODS

Implementing Ontario Focus Farms

A pilot version of FF was implemented to address issues surrounding JD control. In line with a learner-centred approach, producers were prompted to explore and discuss all issues of interest over the course of the process, and to consider the relationships of these issues to JD control. Eight regions of ON were used for Focus Farm establishment (Figure 1). Two cohorts, of 8 groups each, were expected to hold 4 full-day meetings within a 12-month time frame. The first cohort took place between November 2010 and November 2011, while the second took place from December 2011 to December 2012.

In the first group meeting, an experienced facilitator explicitly outlined the FF concept, expectations, and encouraged the group to engage in discussions and learning activities in an attempt to create a comfortable, supportive, and trusting learning environment. Subsequent meetings were self-directed by producers, with a facilitator present to moderate discussions and coordinate learning activities based on group-identified priorities and goals. The base structure for these meetings tended to be a combination of a half-day of on-farm tours and activities, and a half-day of round-table discussions and indoor activities. Finally, ‘cross-over’ meetings between Cohorts 1 and 2 for each region were planned so participants of Cohort 1 could communicate their experiences with FF to members of Cohort 2. These meetings took place between November and December 2011.

Participant recruitment

Bovine veterinarians were recruited to act as FF facilitators via email and mail-out letters to veterinary clinics, and articles in provincial dairy magazines. A pre-established working
relationship with producers, extensive knowledge of JD and calf health management issues, and a keen interest in improving on-farm disease management made veterinarians ideal candidates for FF facilitators. Interested veterinarians were briefed on the concept of FF and expectations of them as facilitators through a 1-hour talk and the provision of a FF overview document (Figure 2). Upon consent, veterinarians were registered to participate in a three-day, professional facilitator-training program (Leadership Strategies: The Facilitation Company). This training took place in September 2010, and incorporated lecture from a professional facilitator, active role-playing and group simulations, and numerous educational materials in the form of a facilitator-training handbook. Lessons and activities focused on the development of critical facilitation skills, such as generating energy, facilitating group discussion, building consensus, keeping groups on task/focused, and managing dysfunction.

Facilitators recruited a Focus Farm, via phone or in-person, that was owned and operated by a willing producer who was: ready to actively participate, discuss, and listen; ready to open their farm for others to observe, discuss, and evaluate; and, who had a farm that was easily accessible for a group. Facilitators contacted additional producers through clinic newsletters, email, phone, and in-person. During recruitment, facilitators explained the concept of FF, the producer’s role, and the expectation of active participation in group discussions and activities.

**Data collection and analysis**

The evaluation of FF with respect to producer and facilitator perceptions about its usefulness as an extension model was comprised of separate post-FF intervention focus groups with producers and facilitators. A post-FF intervention questionnaire was also administered to participating dairy
producers to assess the impact of FF on respondents’ knowledge, attitudes, and behaviour with respect to JD control.

**Focus groups**

Between October and December 2012, four focus groups with were carried out with producers who had participated in the FF process. Among the eight regions in which FF groups were established, four regions were chosen for focus groups (Seaforth, New Liskeard, Winchester, and Navan, ON) to gain a wide geographic spread of FF participants. The sampling frame for participant recruitment was comprised of a list of all participants in the FF process for each given region. All producers in the sampling frames received a recruitment letter describing the details and objectives of the focus group. Approximately one week later, recipients of the letters were randomly selected, using a random number generator, contacted, and recruited via telephone. Between 9 and 10 participants were recruited for each focus group to help ensure a minimum attendance of 6 participants.

Two additional focus groups were carried out with FF facilitators. The small number of veterinarians participating in FF limited the number of participants to four per focus group. These focus groups were held in Guelph, ON. A $50 honorarium was paid to all focus group participants for their participation.

A trained moderator led the focus group discussions, while an assistant made written notes describing the discussion and group dynamics. Focus groups were roughly two hours in duration. Audio recordings of the focus group sessions were professionally transcribed to facilitate analyses. A pre-tested, structured questioning route was developed according to Krueger and Casey (2008), using a combination of primary questions and probes to elicit further detail (Appendix I). Questions sought information on participants’ perceptions of FF; specifically,
the perceived advantages, disadvantages, areas for improvement, and perceptions of FF as an extension model. Participant debriefing after the focus group, debriefing between the moderator and assistant, and the field-notes and audio-transcripts were used to maintain accuracy and reliability of the data.

Transcripts were checked against the original audio-recordings for accuracy. A coding scheme for analysis was created by having two coders separately code one transcript line-by-line, and then comparing and revising codes based on discussions between the two coders. One coder separately coded the remaining transcripts. Codes from all transcripts were then compiled, categorized, and thematically analyzed to generate themes and sub-themes, as described by Braun and Clarke (2006). Data cleaning, coding, and analysis were carried out using ATLAS.ti© (ATLAS.ti© Scientific Software Development, Berlin, Germany). Verbatim quotations in the text are italicized, with larger quotations indented; square brackets have been inserted in areas to provide the reader with context.

**Questionnaire**

Producers’ perceptions about changes in their awareness, knowledge, attitude, and behaviour, with respect to JD control, were assessed using a self-report post-FF intervention questionnaire (Appendix II). These were administered to Cohort 1 producers in December 2011, and to Cohort 2 producers between December 2012 and January 2013. The questionnaire was comprised of 14 open-ended questions, 14 dichotomous (yes/no) questions, and 2 questions using Likert scales ranked from 1 to 5 (where 1 represented ‘very little on-farm risk’ or ‘very little concern of JD’) corresponding to respondent demographics, usefulness of FF, impact of FF on awareness, knowledge, attitude and behaviour, and perception of risk of JD and overall concern about JD.
Respondents with a missing answer for a particular variable (including ‘refused’ responses) were excluded from the analysis of that variable. Responses to open-ended questions were individually reviewed, categorized based on response similarities, and tallied to provide frequency counts. All other questions were analyzed descriptively; data cleaning, screening, and analyses were conducted in STATA/IC 12 for Mac (StatCorp, Texas, USA).

The Research Ethics Board of the University of Guelph approved this study (protocol #: 11AP009), and all participants provided informed, written consent.

RESULTS

Implementing Ontario Focus Farms

In total, Cohort 1 was made up of 8 FF groups and comprised 105 dairy producers, while Cohort 2 included 6 FF groups and an additional 71 producers; two facilitators were unable to contribute to Cohort 2 due to a lack of time attributed to an increase in work-related commitments. The typical meeting size ranged from 7 to 12 producers, and due to interest and resources, all groups held a minimum of 5 meetings, while 7 groups met 6 times in total. In addition, 6 groups worked with their facilitator to write applications for additional funding for more FF meetings through an agricultural funding organization (details not discussed here).

While the specific content of each group meeting focused on various issues surrounding JD and JD control, common themes included: maternity pen management and design, cow-calf separation and feeding, manure management, testing and purchasing animals, managing a JD positive animal and/or herd, calf feeding and housing, transition cow management, lameness, and heat stress. The specific learning activities employed in each meeting were unique to each group, but common activities included: exemplar farm tours, meeting with technical/content experts (as
requested by groups), round-table group discussions, participant presentations on their farm-specific issues, group work/learning activities (e.g. ‘think-pair-share’, ‘JD jeopardy game’), test result interpretation, demonstrations and discussions of various on-farm management practices (e.g. maternity pen management, calf housing, transition cow management, etc.), and planning/brainstorming sessions focusing on problems common to the group and on producer-specific issues.

**Perceptions of the usefulness of Ontario Focus Farms**

Thematic analysis of focus group data from producers and facilitators resulted in the identification of several important themes relating to FF and its impacts, many of which corresponded to the principles upon which FF is based. Figure 3 provides a thematic map, representing the themes, sub-themes, and relationships identified. Given the specific goal of the present study to evaluate the utility of FF, two important themes are discussed further: (1) Characteristics of the FF learning environment, and (2) Areas for improving the FF process.

**Theme #1: Characteristics of the Focus Farms learning environment**

The characteristics of the learning environment for FF were comprised of several sub-themes. Specifically, producer-centredness, honest and open communication, the use of multiple learning activities, and presence of a FF facilitator, were identified as essential components of an effective learning environment. These components are described further, from both producer and facilitator perspectives, below.

*Producer-centredness*

Overall, many producers felt that the opportunity to actively participate, self-direct, and customize the meetings based on their needs was valuable for their learning. Many identified that
they “felt in control of how the meetings were set up and what was talked about”, and that they were in control of their learning by being able to “evolve” and “change” the process as their questions, concerns, and interests changed. One participant stated,

“[The facilitator] was always asking us which way we wanted to go, so we were the ones suggesting the topics, which was great, you know, ‘cause we controlled it”.

Another acknowledged the level of producer control, stating,

“It was clear that we were the ones leading, and because we were always being asked what we wanted to zero in on, we got to spend our time talking about, or seeing, the issues we wanted to address”.

Similarly, the facilitators perceived that a major success of FF was “giving the participants the reigns” and, “providing them with the opportunity to customize their learning to meet their needs”. One facilitator felt strongly about this focus: “They just took far more ownership of the meetings and that made a difference”. A number of facilitators described the importance of giving each producer a voice to discuss their own on-farm issues:

“This process just gives them an opportunity to talk about their own farm, you know, whereas at a producer meeting, where you’ve got 100 clients in the room, they’re just sitting there listening to the speaker, but here they got to talk about their farm, their issues, and their interests”.

Another facilitator described,

“[Producers] identified the topics… I was shocked to see some of the issues they came up with, and it made me see some of the similarities in interests and the obvious gaps in knowledge among the group”.

Many producers expressed positive views towards the fact that there was minimal one-way communication and that, unless otherwise requested, they predominantly engaged in open discussions with one another. For example, one producer commented,
“It doesn’t always work when you have someone speaking to all of us, when we are experts at what we do. It works better when we as a group kind of collectively say ‘yea, I have questions’, you know? Or ‘I’m curious about this’, and it seemed to work better here because we weren’t spoken to”.

Further comments such as, “we weren’t being preached at” or, “we weren’t being told what to do and think” further evidenced these feelings. One additional comment captured this well:

“We all manage our farms and we’re all experts in our field... when a speaker comes, it’s nice that he/she brings information you can draw from, but what I liked is I had no one speaking to me... you know, we were all speaking, we all kind of brought our expertise and took it in, and I think [FF] was a better format because of that, because we weren’t being spoken to, we were speaking”.

Several facilitators also identified that the producer-centred nature of the process was unique, and something they had not previously dealt with in other extension programs. One participant captured this thinking well:

“This process gave us a chance to allow producers to dictate what they want. Other extension programs try to teach through newsletters, big dairy events, or meetings, but it’s always about us, us, us [the veterinarians] and not them [the producers], so I think this process helped focus things back on them and their needs”.

Furthermore, many facilitators felt that the absence of lecturing and traditional ‘teaching’ was a unique and effective aspect of producer education.

“[FF] is about self-teaching rather than someone standing and talking, you know, for two or three hours and just lecturing. This was about a group of dairymen talking to each other about their own issues and how they deal with it on their own particular farm”.

“I think how it differs from other extension programs is that it’s less about someone at the front teaching... more than 75 percent of the time it’s just producers asking and answering each other’s questions, and I love that”.
**Honest and open communication**

Several producers identified the importance of honesty, openness, and trust amongst participants and suggested that these qualities are “imperative if we’re gonna help one another and learn from each other”. Additionally, many felt that, “[their] issues aren’t worth lying about”, that, “hearing others share their problems/issues gives you a feeling that you’re not alone”, and that, “others shouldn’t be afraid to talk about [their issues]”. Elaborating on this, one producer commented:

“It’s good to know other people’s problems around your area too, and maybe you have the same problem… then you can discuss with those guys and get local help. I found that very helpful”.

Similarly, many producers felt that the honesty and openness of the Focus Farm owner during the farm tours set an example that defined the expectations for how group members should be: “They had to be honest when we could see the good and the bad right in front of us on their farm”. However, they still acknowledged that some producers were not as open at times: “Not everyone is always 100% transparent”; “some guys were more honest about their opinions of others issues, and not always their own”.

Many facilitators were surprised at the high degree of honesty and openness on the part of the producers discussing their issues. Some suggested that producers were “brutally honest with their opinions”, that, “their comments weren’t sugar-coated”, and that “[they] weren’t afraid to tell it like it is”. One comment in particular highlighted this sentiment:

“I was surprised how open a lot of the farmers were. I thought I would really have to push them to identify issues, but they just opened up and said, ‘yeah we have a group problem with this’, and they would critique their operations in front of a room full of farmers. I never expected that, it was fantastic! And you know, other producers would comment on that and say, ‘gee, I thought I was the only one’, so it was farmers teaching farmers and was a real highlight for me”.

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Multiple learning activities

Producers routinely discussed their enjoyment of the combination of farm tours and round-table discussions packaged into a meeting; “The meetings were a good length, and broke the day up a little bit with the farm tour and meeting combo”. The opportunity to see other producers’ farms, to see practices in action, and to ask pertinent questions was seen as a tremendous positive among the majority of producers.

“It’s easier to picture things when you’re actually on farm and to talk about different problems when you’re looking at calves and facilities”.

“On farm, you’re in the environment... a picture is worth a thousand words – well being on farm, all you have to do is move your head! So partly for me it’s not just hearing about what others do, but seeing exactly how it’s done in the environment”.

Another participant focused more on the ability to ask questions:

“I liked that we could discuss how it worked on the farm, you know, instead of just hearing the information or seeing it on a slide, and then going back home by yourself and then you’re thinking, ‘yea, would that work here?’ Just having someone to bounce ideas off of while you’re trying to work out if it will work for you was good”.

Many felt the classroom/meeting room portion was useful for brainstorming new ideas, and relating what they had seen back to their farm. This was well-captured by one comment:

“On the farm you’re visually assessing, but having to talk about it afterwards, not at the farm, that made things more clear for me. We took a break and then got into discussion in the right environment where I felt like talking... especially when we had [JD] test results for the group and a chance to talk about taking what I saw earlier and trying it on my farm”.

The facilitators enjoyed the opportunity to engage with producers through both formal and informal learning methods:
“We would have less than 25% of every meeting using PowerPoint, and that kind of thing, and then we focused on getting them up and moving, changing seats, so they’re not with the same guy, and they’re working on different activities together”.

“I liked having a day set aside where I could have a bunch of producers come together and interact, there was no pressure, and they benefitted from it because often times the conversation at lunch was just as valuable to them as the formal activities we had planned. They saw real value in learning from each other”.

**Relationship of veterinarian facilitators with producers fostered open communication**

The majority of producers perceived that having their veterinarian facilitate the FF process was useful for their participation and engagement.

“Well he’s our vet too, so like I mean, we had more of a relationship with him, I guess from the start, and it helped me feel like it was going to be worthwhile from day one”.

“The fact that my vet was the facilitator showed me he genuinely cared, I don’t think it’s a job to him. He seemed to want people to do well, he cares, and I could tell he wanted to learn too… that motivated me to improve”.

“[The facilitator] challenged and pushed us a little bit, but it wasn’t him ‘strong-arming us’, it was just a push to make us think about things from another point of view, which made me want to keep thinking about how to make things a little bit better”.

Facilitators were curious about their impact on producer honesty and openness through the process. One facilitator offered, “I wonder how much producers were affected by the fact that we were standing in the room and knowing that we know the true story”, while another facilitator stated:

“I wasn’t sure how producers would respond when discussing their personal issues, but they seemed to be pretty honest… I wonder if that was because of my presence in the room”.

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Many producers acknowledged that knowing that the facilitator had knowledge of their farm (and everyone else’s) served as a motivator to be honest and open about their problems. One participant described this well, commenting:

“I knew that [my facilitator] knew what was going on specifically on my farm, so it seemed kind of silly for me to not be honest about what’s going on”.

All facilitators discussed that their involvement in FF greatly improved their confidence in facilitation, and that it was a valuable tool for them to have; “It was a great learning process for me”; “[facilitation] is another tool in the toolbox”; “this [process] was great... and down the line this may become something that gets incorporated into my practice as a way to differentiate myself and add value”. Overall, all facilitators agreed that the facilitation process was a useful learning experience, and that it seemed to change their perspective on client communication and knowledge extension.

“As I’ve gone through this process I’ve seen the value in this producer-driven extension. I’m trying to have fewer speakers in other activities I do, and instead, foster more discussion, because I feel that these guys can learn more from each other rather than just bring in somebody every time”.

“I think this is the kind of thing I need to be focusing more of my time on... it seems to be a better way to connect with producers and get at their specific issues. Their involvement throughout the process has been something I’ve really enjoyed”.

A few facilitators commented that transitioning from a veterinarian role to a facilitator role was a struggle for them. One participant in particular explained this in detail:

“I felt that this type of process does diminish the role of the veterinarian somewhat, because even though you’re a veterinarian, you’re trying to be a facilitator, you can’t provide expertise, right, even though you can try and direct farmers in the right direction. You basically have to put everything you know aside, and that’s been the most difficult part for me. Some of the time I could have
probably jumped in, helped, given advice, but you know, you can’t do that as a facilitator, and so in that respect I’ve seen my role somewhat diminished”.

While a few other facilitators agreed with this comment, one participant responded,

“I think veterinarians are the best choice [to facilitate] here. I think we have a good grasp of a lot of the topics that are being discussed, so we can ask probing questions... we can help moderate the discussions probably better than, you know, a lot of other people if they were to be facilitators”.

Theme #2: Areas for improving Ontario Focus Farms

Timing of Ontario Focus Farms

One area of improvement that both producers and facilitators identified was the difficulties surrounding producers’ schedules during the ‘planting and harvesting’ seasons (mid-April through September). One producer commented:

“Timing is a major thing in terms of fieldwork, and even if I may want to be here, things can happen on a given day, or the weather will suddenly change, and I need to be on the farm”.

Another producer confirmed this feeling, stating:

“We’re in the business where time is really, really a factor. Every day is a different day and every day is something to do... unfortunately that leaves little time for meetings during the summer months”.

A few facilitators reported having held summer meetings, but found that the uncertainty of participation and attendance limited their efficacy. One facilitator commented:

“I had a June meeting this year, I thought it was going to be a great meeting, but I just didn’t have the crowd I would have liked and it seemed to be hard to get everyone motivated”.
Similarly, other facilitators commented: “The summer was definitely a slow point, I felt like I lost traction over the summer... starting back up in the fall was a little slower than I would’ve liked”.

*Facilitator training*

Another identified area for improvement related to facilitator training. Facilitators perceived that the training they received prior to implementing FF was not specific enough. One producer commented that the training was “too broad”, while another suggested “we could’ve had more opportunities to address group dynamics and work on promoting discussion”. Another facilitator commented:

“The facilitator training threw me a little... I kept trying to follow the model they taught us and instead I should’ve gone with a more customized approach for my group. Their model seemed to be more about conflict resolution, and made me feel like there was only one ‘right’ way to facilitate a meeting”.

Additionally, a few facilitators felt that the training was “too basic” and that it was not tailored to meet the characteristics of FF specifically, indicating “It was more about consensus building in a business environment, and less about collective understanding”. Similarly, another facilitator suggested, “[The training] could have been shorter and more focused on the actual process we would go through in [FF]”.

**Post-Ontario Focus Farm intervention questionnaire**

In total, 39.8% (70/176) of producers who participated in FF completed a post-process questionnaire. Approximately 81% (57/70) of respondents reported implementing at least one on-farm management change to address JD control as a result of FF. Of these respondents, 17.5% (10/57) made one, 29.8% (17/57) made two, 28.1% (16/57) made three, and 24.6%
(14/57) made four changes. The three most commonly implemented changes were: calves removed more quickly from maternity pens (n = 23), feeding calves four liters of colostrum as soon as possible (n = 19), and maternity pens cleaned after each calving (n = 11). Table 1 provides a list of all the on-farm changes producers reported making as a result of FF.

Sixty-six percent (46/70) and 87% (61/70) of respondents reported that they felt their attitude and confidence towards managing JD on the farm had improved as a result of FF, respectively; 91% (42/46) and 89% (55/61) of which also reported making at least one on-farm management change. Approximately 90% (63/70) and 89% (62/70) of respondents reported that their awareness and knowledge of JD control measures had increased through FF, respectively; 87% (55/63) and 87% (54/62) of which reported making at least one on-farm management change. Lastly, 88.6% (62/70) of respondents reported that they would be interested in continuing with FF.

**DISCUSSION**

As the education component of OJEMAP, FF was implemented in response to poor producer adherence with veterinarian recommendations, observed by Sorge et al. (2010), and the resulting recommendation that future programs have improved education and communication strategies. Although stakeholder education is central to all provincial JD control programs in Canada, the majority primarily employ ‘traditional’ forms of extension, such as articles and fact sheets, CDs/DVDs, and oral conference/meeting presentations (Barker et al., 2012). Similarly, programs in the U.S. (USDA, 2010), the Netherlands (Benedictus et al., 2000), Denmark (Nielsen, 2007), Australia (NJDCP, 2013), U.K. (Orpin et al., 2012), and Ireland (Mullowney and Graham, 2012) report employing primarily ‘traditional’ forms of extension.
‘Traditional’ extension approaches tend to be teacher-driven and involve a linear, or ‘top-down’, form of education, which aims to persuade behavioural change through information delivery (Dewey, 1997; Parks et al., 2005). Moreover, these approaches have been shown to have a limited effect on improving adherence with desired changes in behaviour (Leeuwis and Van den Ban, 2004; Webb and Sheeran, 2006; Coutts and Roberts, 2011), mainly due to a reliance on producers’ intrinsic motivation to change, and an assumption that individuals make decisions purely on scientific rationale (Jansen et al., 2010a). Furthermore, these approaches tend to not value the existing knowledge, skills, attitudes, values, and perceptions of the individual recipients, which are critical factors in an individual’s decision to change (Leeuwis and Van den Ban, 2004; Boxelaar and Paine, 2005; Friend et al., 2009).

Recently, aspects of JD control programs in Canada (Barkema et al., 2012), the U.S. (Lambert, 2011), Ireland (Mullowney and Graham, 2012), and Italy (Crovato et al., 2012) have begun to incorporate more participatory learning strategies (primarily on-farm meetings and stakeholder workshops). Similarly, other programs are focused on implementing interactive software programs, such as the simulation game, JD Consult, in the U.S. (McDonald et al., 2012), or the online RA and herd-tracking database in the U.K., www.myhealthyherd.com (Orpin et al., 2012). However, many of these approaches still involve a teacher/researcher-driven approach, which may not adequately address and/or change the perceptions and attitudes producers have about JD in the first place. Therefore, a change in the approaches used among JD control programs to influence producer behaviour towards more progressive and participatory forms of education is needed.

‘Progressive’ extension approaches tend to be learner-centred, focus on collective learning and information sharing, employ dialogic processes, and utilize active-learning strategies (Dewey,
1997; Parks et al., 2005; Friend et al., 2009). Such ‘bottom-up’ approaches are typically group-oriented, embrace local knowledge, perceptions, values, skills, and experiences, and motivate individuals to take ownership of their problems and solutions (Lawrence et al., 1999; Friend et al., 2009). These approaches also tend to use multiple learning strategies to address individual perceptions, motivators, and attitudes, which several studies have shown to be key factors in improving adoption of on-farm practices (Valeeva et al., 2007; Jansen et al., 2010a, b). Many examples utilizing these models to improve the adoption of various on-farm practices can be found in the literature (Lawrence et al., 1999; King et al., 2001; Fulton et al., 2003; Crawford et al., 2007; Vaarst et al., 2007; Friend et al., 2009), and there appears to be a growing trend in agricultural extension towards employing them (Andreata, 2001; Fulton et al., 2003; Coutts and Roberts, 2011). Furthermore, Trier et al. (2012), Groenendaal et al. (2003), and Kingham and Links (2012) have reported the implementation of small, producer-group-based approaches to JD extension, which have improved compliance with on-farm recommendations for change in Danish and Dutch dairy herds, and Australian sheep flocks, respectively.

The main objectives of this study were to describe the implementation of FF and evaluate the participant perceptions of the usefulness of FF and preliminary impacts on their knowledge, attitudes and behaviours. In this study, the producer-centred nature of FF was seen as an essential characteristic of a positive learning environment. Producers highlighted the participatory and collaborative nature of FF as a major positive, and embraced the opportunity to self-direct the content and context of their own learning. In addition, many producers felt the process kept them honest and that they built a level of trust with one another, which helped focus meetings on the key issues facing producers. Facilitators echoed these comments acknowledging the significant benefits of the flexibility, openness, and producer-focused nature of FF. These findings are
consistent with, and build on, the learner-centred approach of other studies dealing with training in agricultural issues, which has shown increased participant engagement, motivation, and interest as a result of employing learner-centred methods (Simeral and Hogan, 2001; King et al., 2001; Fulton et al., 2003; Vaarst et al., 2007; Friend et al., 2009). In this study, producers were engaged, motivated and took ownership in the FF process as a result of its producer-centred nature.

Producers and facilitators in this study also acknowledged the importance of using multiple different types of learning activities/techniques. Producers appreciated the opportunity to learn from one another in a setting that used both formal (e.g. classroom/meeting room) and informal (e.g. farm tours) activities. Similarly, many facilitators perceived that producers enjoyed learning through a variety of activities that involved gaining experiences, and making, and discussing, on-farm changes. The use of multiple learning methods in this type of approach is characteristic of the Group Facilitation and Empowerment Model of extension, as outlined by Coutts and Roberts (2011). The methods employed here were similar to methods reported in other studies, such as field days, workshops, farm tours, and farmer discussion groups (Andreata, 2001; King et al., 2001; Crawford et al., 2007). The use of multiple learning activities can be particularly useful when facilitating producers to engage in the cycles of experience-based learning. Producers in this study appreciated the opportunity to discuss, ‘set up’, and debrief the issue in a classroom setting, use schematics and pictures to aid their discussions, and go on-farm to physically see and address the issue in-person. It is also important to consider that individuals have different preferences for learning new information (e.g. visual, oral, read/write, kinesthetic) (Fleming, 2011). Given these differences, the use of activities that appeal to multiple preferences provides a better chance for participant engagement and meaningful learning among the group of learners.
(Gottesdiener, 2002). Similarly, producers may require different forms of communication based on their perceptions, attitudes, and motivations towards a given issue or behaviour. Jansen et al. (2010b) described that farmers are not a homogeneous group, and that different types of farmers must be approached in different ways, using different communication strategies based on their specific needs. Therefore, it is important when developing training programs to consider the variety, and type, of learning activities that are being utilized in agricultural extension programs to ensure producer engagement, and enhance the likelihood that effective learning takes place.

Lastly, producers in this study highlighted the significance of a facilitator being present in the group and often perceived that they drove the supportive nature of the FF process. The role of facilitators in these types of processes are to establish rapport with participants, manage dialogue, guide and support, encourage participants to take ownership, and to foster and motivate effective learning (Laessøe, 2008). In addition, in our study we found that some producers and facilitators already had a prior professional relationship and that this relationship positively contributed to establishing a supportive environment throughout the FF process. Other studies have also reported that participants enjoyed dealing with someone who guided the process, and allowed them to be active, collaborative, and critical with one another (King et al., 2001; Vaarst et al., 2007; Crawford et al., 2007). This evidence suggests that the use of an effective facilitator is a key aspect for the establishment of an effective extension process. A similar finding was concluded by Vaarst et al. (2007), who reported that eliminating the role of an expert, and establishing a facilitator was crucial for the success of the process.

Interestingly, a few facilitators described their struggle in transitioning from a veterinarian role, where their job is to advise and consult, to a facilitator role, where their job is to be impartial and supportive. Given their role as veterinarians outside of FF, it is not surprising that limiting the
urge to teach and address questions was a struggle for some. Nelson et al. (2007a) described a similar situation where producers had expected the facilitator to not only give guidance, but also lead the groups’ thinking and direction. Interestingly, in their process called ‘Stable Schools’, Vaarst et al. (2007) used facilitators that were originally cattle production advisors. They noted that the experience of shifting from an advisory role, to a facilitator role, was “profound”. Given these experiences, it is reasonable to question whether someone with so much technical expertise on the issue is appropriate to facilitate this process. Andreata (2001) suggests that where too much expertise lies within the facilitator, meetings quickly turn from a discussion group to a consulting session. While facilitators and producers here both felt that the process was producer-driven and that facilitators conducted their roles well, future programs must carefully consider whom they use as facilitators, ensure thorough training, and emphasize the importance of following the guidelines.

Facilitators reported an improvement in their confidence and understanding of the facilitator role over the course of this project. In addition, they perceived that they effectively established their role as a facilitator and maintained an effective learning environment. These findings are not surprising, as it is expected that facilitators will grow and become more confident with practice. Furthermore, additional training and opportunities to have facilitators work together and engage in ‘train the trainer’ programs are likely to contribute to further development of these facilitation skills. Several studies have shown that these competencies are essential to successful facilitation of small-groups (Davis, 2003). Interestingly, many facilitators discussed how the facilitation process, and the skills they obtained, led them to reconsider how they communicate with the clients as veterinarians. In more recent years, schools for veterinary medicine have placed more value on facilitation skills, and are embracing the development of non-technical competencies.
through increased emphasis on communications (Burns et al., 2006; Magrath, 2006). Thus, an unexpected positive outcome of FF, was the impact on the facilitators, which seemed to change their perspective and behaviour towards client education and communication.

**Producer knowledge, attitudes and behaviours towards Johne’s disease control**

In this study, 81% of participants, who participated in a post-FF survey, reported making an on-farm change to address JD as a result of FF. Furthermore, the majority of changes reported corresponded to important areas for JD control (OJEMAP, 2013) and to the top 10 recommendations made by Canadian veterinarians (Sorge et al., 2010). The level of adoption evidenced in this study is higher than the level observed in JD control studies employing traditional approaches (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010). Importantly, other studies, using similar ‘bottom-up’ approaches for influencing on-farm JD control behaviours as those described here, have reported similar improvements in adoption. Specifically, preliminary results from a Danish approach to JD control, which employs small, producer-directed on-farm meetings, showed that nearly 90% of participants improved their calving procedures to address JD, and the majority of participants reported improvements in their knowledge of JD management (Trier et al., 2012). Similarly, Kingham and Links (2012) reported a marked upsurge in the use of an ovine JD vaccine in Australia among participants involved in a group-based learning process. Our results contribute to these findings and provide a more comprehensive look at the positive impact of learner-centred approaches to JD control.

The impact of social factors, such as attitudes, perceptions, and knowledge, on behavioural change cannot be overstated. Health behaviour theories, such as the Health Belief Model (Rosenstock, 1974) and the Theory of Planned Behaviour (TPB) (Ajzen, 1991) have highlighted
the roles and relationships that these factors play in behavioural change. In this study, over two-thirds of producers reported that their attitude towards making on-farm changes to address JD improved as a result of FF. Similarly, nearly 90% of producers reported increases in their confidence, knowledge, and awareness of on-farm JD control measures. Furthermore, a high proportion of those that reported improvements in these factors also reported making on-farm changes for JD control. Based on these preliminary findings, FF was successful in addressing some of the key social factors associated with behavioural change. Other studies have also demonstrated that addressing these factors can increase the adoption of specific on-farm practices. For example, Jansen et al. (2010c) observed changes in attitudes and knowledge among Dutch dairy farmers participating in a national mastitis control program, which resulted in increased compliance with control recommendations. Similarly, Llewellyn et al. (2005) addressed the attitudes and perceptions of Australian grain growers and showed increased adoption of integrated pest management practices as a result. Thus, the increases in on-farm adoption observed in this study may be attributed to the positive changes in these social factors. Furthermore, this attitudinal shift and ‘willingness to experiment’ with on-farm changes evidences motivation to change among study respondents, and as a result, may be a primer for continued change moving forward. Given their roles in behavioural change, addressing the attitudes, motivations, and perceptions of producers should be a key goal of future JD extension programs.

Areas for improving Focus Farms

Both producers and facilitators acknowledged that through the summer months there was a loss of momentum in the FF process, due to an inability to meet, as producers were typically tied up with their daily duties, fieldwork, and ongoing construction projects. A lengthy period between
meetings would likely result in a loss of momentum in terms of participation and engagement, and should be avoided, if possible. Some facilitators opted to try summer meetings, with limited success. Due to the length of meetings and producers’ schedules in the summer, a full-day meeting is likely not realistic, and as such, it may be best to prompt groups to engage in ‘twilight meetings’ during the summer months. These meetings could be short (e.g. 1 to 3 hours), informal get-togethers on group member farms, scheduled at the end of the day. Rather than becoming a formal meeting, they can be left open, as an informal social gathering, which will help maintain relationships, allow participants to discuss progress and maintain the momentum of group discussion.

When discussing the training that facilitators received, all facilitators perceived that they were adequately prepared with the main tools required for the job. However, as they reflected on the process, they frequently commented that the training provided was broad, and really only covered the main aspects of facilitation. Moving forward, we recommend facilitators be given more opportunity to role play and simulate the environment in which these meetings typically occur. Furthermore, if veterinarians are to be used as facilitators a stronger emphasis on the distinction of roles between facilitators and veterinarians, and the importance of maintaining a neutral position and fostering group discussion, is crucial to the success of the process.

A limitation of this study is the absence of a comparison or control group, which would be a group of producers not actively engaging in this type of learning process. The results reported here provide only a preliminary look at the outcomes of FF, and a more rigorous evaluation of the impacts of this process on producer knowledge, attitudes, perceptions, and behaviour, with the use of a control group, is needed. This will provide a more comprehensive understanding of the impacts of FF. Additionally, the use of self-reporting to assess adoption may be unreliable if
respondents are not truthful about, or perhaps exaggerate, the on-farm changes made. While limitations of time and money prevented additional on-farm auditing to confirm self-reports, future studies should attempt to evaluate the accuracy of self-reported behaviour change.

**CONCLUSIONS**

FF engaged dairy producers in a producer-centred learning process that motivated, and ultimately facilitated, the adoption of on-farm management practices effective in the control JD. This approach is built upon the principles of adult education and experience-based learning, and as a result, can be widely applicable to a range of complex issues. Our findings indicate that successful FF should be participatory, self-directed, and collaborative; emphasizing honest communication and a trusting environment; promotes planning, action, and implementation; and engages participants in reflective practice for learning. Importantly, substantial changes in producer attitude, and increases in confidence, knowledge, and awareness of JD control were observed as a result of FF, and the majority of producers reported making on-farm management changes to control JD. Thematic analysis of producer and facilitator focus groups showed that both groups felt a facilitator-moderated, producer-centred environment, which utilized a variety of active-learning techniques, were the key characteristics in making FF a useful extension process to influence producer behaviour. A successful JD control program should focus on addressing these factors to improve the uptake of on-farm practices moving forward. The framework of FF has been shown to be an effective approach for agricultural education and communication and would likely be useful to address other issues in a variety of agricultural sectors.
REFERENCES


Table 1 | Categorization of the on-farm management changes implemented as a result of Ontario Focus Farms to control JD, as reported by 57 dairy producers between 2011 and 2013.

<table>
<thead>
<tr>
<th>Management Change</th>
<th>Frequency Among Focus Farm Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># (%)(^1)</td>
</tr>
<tr>
<td>Improved on-farm hygiene</td>
<td></td>
</tr>
<tr>
<td>Maternity pen cleaned after each calving</td>
<td>11 (19.3)</td>
</tr>
<tr>
<td>Separation of equipment for feeding and manure handling</td>
<td>8 (14.0)</td>
</tr>
<tr>
<td>Purchased new equipment (e.g. skid steer, buckets, etc.)</td>
<td>6 (10.5)</td>
</tr>
<tr>
<td>Cleaning calf housing area routinely</td>
<td>6 (10.5)</td>
</tr>
<tr>
<td>General on-farm cleanliness improved</td>
<td>6 (10.5)</td>
</tr>
<tr>
<td>Building of a new barn or maternity pen</td>
<td>6 (10.5)</td>
</tr>
<tr>
<td>Boots washed more frequently</td>
<td>4 (7.0)</td>
</tr>
<tr>
<td>Adding more bedding in calving area</td>
<td>2 (3.5)</td>
</tr>
<tr>
<td>Improved record keeping</td>
<td>2 (3.5)</td>
</tr>
<tr>
<td><strong>Total changes</strong></td>
<td><strong>51</strong></td>
</tr>
<tr>
<td>Calf management</td>
<td></td>
</tr>
<tr>
<td>Calves are removed from maternity pen within 3 hours</td>
<td>23 (40.4)</td>
</tr>
<tr>
<td>Feeding 4 liters of colostrum as soon as possible</td>
<td>19 (33.3)</td>
</tr>
<tr>
<td>Change in colostrum management (i.e. switch to artificial colostrum)</td>
<td>10 (21.1)</td>
</tr>
<tr>
<td>Focusing on cleaner feedings (milk and/or colostrum)</td>
<td>7 (12.3)</td>
</tr>
<tr>
<td>Change in feeding of calves (i.e. switch to milk replacer)</td>
<td>6 (10.5)</td>
</tr>
<tr>
<td>Overall calf care is better</td>
<td>5 (8.8)</td>
</tr>
<tr>
<td>Freezing colostrum from low-risk animals</td>
<td>4 (7.0)</td>
</tr>
<tr>
<td>Started the use of hutches</td>
<td>3 (5.3)</td>
</tr>
<tr>
<td><strong>Total changes</strong></td>
<td><strong>77</strong></td>
</tr>
<tr>
<td>Johne’s disease (JD)</td>
<td></td>
</tr>
<tr>
<td>Testing for JD routinely</td>
<td>8 (14.0)</td>
</tr>
<tr>
<td>More aware of JD and managing JD-positive cows</td>
<td>5 (8.8)</td>
</tr>
<tr>
<td>JD+ cows are culled more quickly</td>
<td>2 (3.5)</td>
</tr>
<tr>
<td>Rendering JD-positive animals instead of selling for beef</td>
<td>2 (3.5)</td>
</tr>
<tr>
<td>Asking about JD status when buying animals</td>
<td>1 (1.8)</td>
</tr>
<tr>
<td>Stopped buying animals/closed the herd</td>
<td>1 (1.8)</td>
</tr>
<tr>
<td>Stopped spreading manure on hayfields</td>
<td>1 (1.8)</td>
</tr>
<tr>
<td><strong>Total changes</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

\(^1\) Multiple responses per respondent permitted
Figure 1 | (Top left) Map of Canada, with the province of Ontario (ON) highlighted. (Bottom left) Map of ON, with the region of the province where Focus Farm (FF) meetings occurred, highlighted. (Right) Area of ON within circle in bottom left image. Specific locations of FF groups, from 2010-2013 highlighted: (A) Seaforth, (B) Kirkton, (C) Listowel, (D) Tavistock, (E) New Liskeard, (F), Napanee, (G) Winchester, and (H) Navan, ON (Images obtained from www.maps.google.ca).
Figure 2 | Ontario Focus Farm meeting 1 structure (adapted from Nelson, (2007b)).
Focus Farm walk & tour
Owner takes group on a full tour of the Focus Farm. Group members individually conduct on-farm risk assessment to assess JD management and risk factors on the farm.

Discussing the disease management priorities
Focus Farm owner discusses his/her specific disease management priorities and expected strategies. Discussion is then opened up to all group members and priorities are listed on chart paper.

Planning future meetings
With the lists created from discussions through the day, and based on the needs and interests of the group, members decide on content, activities, and timing, for the next meeting.

Participants learn about the farm system and see it first hand; allows them to put the morning discussions into context. Disease management issues are highlighted — Focus Farm owner talks about issues and how they’ve been (or are planning on being) addressed. The risk assessment prompts group members to ask pertinent questions and engage in rich discussion. More importantly, discussions on the farm system, cow/calf management, reproduction management, and disease mitigation are held in context.

After seeing the on-farm operation group members learn about what is priority for the owner. This is followed by open discussion, which lets members compare the owner’s priorities to what they thought were priorities. The owner benefits by discussing the group’s thoughts, impressions, and suggestions for tackling the issues. Opening up the discussion focuses on disease management on each individual farm. Listing the self-identified priorities of the group for everyone to see where the interest lie and will facilitate the identification of future meeting topics.

The process of allowing group members to decide on what, where, when, and how they move forward puts the process in their hands. Facilitators show they are there to guide and support, rather than teach and lecture. Group members customize the process to meet their needs so they can get the most out of the process.

Figure 2 (continued) | Ontario Focus Farm meeting 1 structure (adapted from Nelson, (2007b)).
Figure 3 | Thematic map of themes and sub-themes identified in the analysis of focus group data, from Ontario Focus Farm (FF) dairy producer participants, and veterinarian facilitators, on their perceptions about the usefulness of FF as an extension model (October – December 2012; Ontario, Canada). Bolded themes are discussed within the text.
CHAPTER FOUR

Evaluating Focus Farms’ impact on Ontario dairy producer knowledge, perceptions, attitudes and behaviour towards Johne’s disease control

ABSTRACT

This study evaluated the impact of a participatory-based, experiential learning program, Ontario Focus Farms (FF), which aimed to improve the adoption of on-farm management practices for Johne’s disease (JD) control in Ontario, Canada. The goals were to (1) assess the impact of FF on participating dairy producers’ perceptions, knowledge, attitudes, and behaviour with regard to JD control, (2) compare changes in these factors among FF participants to changes among a group of non-participating dairy producers, and (3) describe the characteristics of producers who made at least one on-farm management change. Pre- and post-FF intervention questionnaires were used to collect data on 70 FF and 62 control respondents’ perceptions, knowledge, attitudes, behaviour, herd production and demographic information; pre- and post- JD risk assessments were used to assess respondents’ on-farm risk of JD transmission. The proportion of FF participants who reported making at least one on-farm change (81%) was significantly higher than that of control respondents (38%). Overall, FF respondents significantly changed their risk score in 4 out of 5 risk areas and had an average reduction of 13 points in their overall risk score between pre and post risk assessments. Control respondents’ risk assessment scores did not significantly change during the study period. In an objective knowledge assessment, FF and control respondents exhibited a moderate level of knowledge on JD prior to the intervention period, with median scores of 75.9% (22/29) in each group. FF respondents significantly improved their score at the post-intervention assessment, with a median of 82.8% (24/29);
control respondent scores did not significantly change. Both FF and control respondents held strong positive attitudes towards JD control and felt a moderate amount of social pressure from veterinarians and industry organizations to make on-farm changes. However, they questioned their ability to effectively control JD on the farm. Lastly, participating in FF, having a moderate herd management score, a positive perception about the practicality of on-farm recommendations, and having a singular learning preference were associated with increased odds of making an on-farm change. Overall, the FF process was effective in influencing the adoption of on-farm management practices for JD control. Future JD control programs should consider implementing learner-centred FF extension processes to improve producer adoption of on-farm recommendations.

INTRODUCTION

The prevention and control of dairy cattle diseases are keys to producing safe, high quality milk products for consumers. Johne’s disease (JD), an enteric disorder caused by *Mycobacterium avium* subsp. *paratuberculosis* (MAP), is an important production limiting disease, affecting cattle in many countries worldwide (Sweeney et al., 2012). In Canada, 10% to 40% of dairy herds have at least two seropositive cows (Tiwari et al., 2006). Of increasing concern is the evidence suggesting that MAP plays a role in Crohn’s disease (CD) (Chiodini et al., 2012; Sweeney et al., 2012). A causal-link between MAP and CD, or even consumer perception that dairy products pose a health risk, could be devastating for the Canadian dairy industry.

With no cost-effective treatment available, JD control is recommended through periodic testing of cows and implementing management changes to improve farm biosecurity (Sweeney et al., 2012). As a result, many national JD control programs utilize risk assessments (RA) to identify
and modify high-risk on-farm management practices and influence producer behaviour to adopt JD control measures (Kennedy and Allworth, 2000; Groenendaal et al., 2003; Nielsen, 2007; Collins et al., 2010; Barker et al., 2012). While RA-based JD control programs have been widely implemented, their efficacy is largely dependent on producer compliance (Sorge et al., 2010a). Several studies examining the uptake of on-farm management practices to control JD have reported poor producer compliance (Wraith et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010a). This is likely due to the inability of the RA to address the social factors associated with behavioural change (Sorge et al., 2010a). Social psychological theories suggest that behavioural change is influenced by a complex set of social factors, including communication, attitude, perception, knowledge, beliefs, learning preferences, and skills (Boxelaar and Paine, 2005). One such theory is the Theory of Planned Behaviour (TPB), which identifies a set of constructs that influence behavioural intentions and actual behaviour (Ajzen, 2006). The TPB suggests that producer behaviour is influenced by, (1) attitudes toward the behaviour, (2) subjective norms (i.e. perceived social pressure to perform the behaviour), and (3) perceived behavioural control (i.e. perceived ability to perform the behaviour). Therefore, in order to effectively influence dairy producer behaviour, these antecedents of behavioural change need to be addressed.

In Canada, JD control is coordinated nationally, however each province is responsible for creating and administering their own control program (Barker et al., 2012). Beginning in 2010, Ontario (ON) implemented a three-year, voluntary JD control program, called the Ontario Johne’s Education and Management Assistance Program (OJEMAP) (OJEMAP, 2009). The program was comprised of an education component, a veterinarian administered on-farm RA and voluntary, whole-herd testing. The education component of OJEMAP focused on the
development of an extension model to improve the adoption of on-farm management practices to control JD. The resulting model, Ontario Focus Farms (FF), is a self-directed, learner-centred process that aims to influence producer behaviour by addressing their knowledge, attitudes, perceptions, and opinions (Chapter 3). Conceptually, FF utilizes the principles of adult education and experiential/participatory learning theory. Practically, FF is implemented as a series of small group meetings, which are facilitated by professionally trained veterinary practitioners. The meetings are self-directed based on group-identified priorities.

The first objective of this study aimed to evaluate the impact of FF on participating dairy producers’ perceptions, knowledge, attitudes, and behaviour with regard to JD control. The second objective was to compare changes in these factors among FF participants to changes among a group of non-participating ON dairy producers. The final objective was to investigate and describe the characteristics of producers who made at least one on-farm management change to control JD.

**METHODS**

**Ontario Focus Farms**

The FF process consisted of two cohorts which took place between November 2010 and November 2011 (cohort 1) and December 2011 and December 2012 (cohort 2). As reported in Chapter 3, cohort 1 consisted of 8 groups and 105 dairy producers, while cohort 2 included 6 groups and 71 producers. Each group consisted of 7 to 12 dairy producers, and held a minimum of 5 meetings.
Participant recruitment

Participant recruitment for this study has been previously described (Chapter 3). Briefly, bovine veterinarians from eight regions of ON (Seaforth, Kirkton, Listowel, Tavistock, New Liskeard, Napanee, Winchester, Navan) were recruited, via email and provincial dairy magazines, to participate in FF as facilitators. In September 2010, all recruited veterinarians completed a professional facilitator-training program. Each facilitator was responsible for establishing one FF group per cohort in their respective regions. Facilitators recruited dairy producers in-person, through clinic newsletters, email, and phone.

For comparison purposes, another sample of ON dairy producers was recruited in April 2011, via email and postal mail, to form a control group. A random number generator was used to select 400 dairy producers from the ON milk marketing board (Dairy Farmers of Ontario) database, which holds current contact information for all ON producers. The inclusion criteria for participation were: being an owner or co-owner of a dairy herd in ON for at least 12 months, and being willing to refrain from participating in other formal, active extension programs during the study period. In addition, potential participants were excluded if they had participated in any JD research within the past 12-months.

Data Collection

As further described below, data about producer perceptions, knowledge, attitudes and behaviour were collected using pre- and post-intervention questionnaires; data pertaining to on-farm risk of JD transmission were collected using pre- and post-intervention JD RA’s.
Pre-intervention questionnaire

A pre-intervention questionnaire (Q1; Appendix III) was administered (paper copy or online) to cohort 1 participants between October and November 2010, while cohort 2 participants, and control producers, received it between November and December 2011. Data on producers’ perceptions about their awareness, attitude, knowledge, and behaviour, with respect to JD, were collected using open- and closed-ended questions, as well as 10 statement items, the latter of which respondents rated using a 5-point Likert scale (1 to 5) according to their level of agreement (e.g. ‘strongly disagree’ to ‘strongly agree’).

Respondents’ level of knowledge of JD was also measured using an objective JD assessment, which was adapted from a previously existing JD knowledge assessment (Johne’s Information Centre, 2010). The assessment tool was comprised of 29 multiple choice questions and assessed producer knowledge of JD with respect to: signs and symptoms, rates of transmission, on-farm risk factors, susceptibility, testing, culling protocols, and methods of on-farm prevention and control. Each question was scored as correct or incorrect, resulting in a maximum possible score of 29.

Respondent learning preferences were assessed using the 16-item Visual, Auditory, Read/Write, Kinesthetic (VARK) questionnaire (v. 7.1; Fleming, 2011), which identifies an individual’s preference(s) for receiving new information. The VARK instrument classifies individuals as having a singular preference or a preference for some combination of delivery modes (e.g. bimodal (V, A), trimodal (V, A, R), or multimodal (V, A, R, K)).

Respondents were also asked to report their demographic characteristics (i.e. age, gender, ethnicity, income, education level). Lastly, respondents were asked to provide access to their CanWest Dairy Herd Improvement (DHI) farm-level data including: herd size, herd turnover rate,
and the averages for 305-day milk production/cow (kg), fat production (kg), protein production (kg), somatic cell count, calving interval (days), dry period (days), number of days at first breeding, days open, and number of breedings/cow/year (CanWest DHI, 2009).

**Post-intervention questionnaire**

A post-intervention questionnaire (Q2; Appendix II) was administered to cohort 1 participants between November and December 2011, while cohort 2 participants, and control producers, received the questionnaire between December 2012 and January 2013. The Q2 duplicated the Q1 questions on respondents’ perceptions and behaviours, and included the same JD knowledge assessment. In addition, respondents were asked to report whether they had made on-farm changes to address JD during the intervention period, and specifically, what changes they had made. FF respondents’ also answered dichotomous (yes/no) questions corresponding to perceived changes in their ability to manage JD, as well as whether FF facilitated making on-farm changes.

An indirect measure TPB instrument, which was developed according to the TPB manual provided in Francis et al. (2004), was also included in Q2. The 36-item instrument measured the belief-based measures of respondents’ behavioural intentions, attitudes, subjective norms, and perceived behavioural control towards making an on-farm change to control JD. Behavioural intention was measured with two statements relating to making an on-farm change to control JD, which respondents rated on a 5-point Likert scale (1 to 5) according to their level of agreement. Attitudes were measured using 7 item-pair statements, where each pair consisted of a behavioural belief statement (i.e. beliefs about the consequences of the behaviour) rated from 1 to 5 (‘strongly disagree’ to ‘strongly agree’), and an outcome evaluation statement (the positive or negative judgments about each statement) rated from -2 to +2 (‘very unimportant’ to ‘very
important’). Specifically, attitudes towards the financial, cow health, and human health impacts of JD, prevention and control of disease, efficacy of management practices, and impacts on herd health were investigated. Subjective norms were measured using 5 item-pair statements, where each pair consisted of a normative belief statement (i.e. the positive and negative judgments of the social pressure they received from individuals they perceived as important), rated from -2 to +2 (‘strongly disagree’ to ‘strongly agree’), and a motivation to comply statement (i.e. the strength of motivation to change their behaviour resulting from each source of social pressure), rated 1 to 5 (‘not at all’ to ‘very much so’). Specifically, respondents addressed the amount of social pressure they felt from fellow producers, veterinarians, industry organizations, and consumers to make on-farm changes. Finally, perceived behavioural control (PBC) was measured using 5 item-pair statements, where each pair consisted of a control belief statement (i.e. beliefs about factors that inhibit or facilitate performing the behaviour), rated from 1 to 5 (‘strongly disagree’ to ‘strongly agree’), and a power statement (i.e. the power of a given factor to influence the behaviour), rated -2 to +2 (‘much less likely’ to ‘much more likely’).

Specifically, respondents addressed the influence of various factors on their perception of control, including: time commitments, financial cost and practicality of changes, presence of clinical signs of disease, and test accuracy. An overall measurement for behavioural intention was obtained by calculating the mean of the two intention questions. An overall measurement for each of the remaining constructs was computed using an expectancy-value equation (TPB construct $\propto \Sigma b_i e_i$), as outlined by Ajzen (2006). A score for each item-pair (comprised of a belief statement ($b_i$) and an outcome statement ($e_i$)) was calculated by multiplying the belief statement by its corresponding outcome statement. The final score for each construct was then obtained by summing the products from all corresponding item-pairs.
**Pre-Intervention Johne’s disease Risk Assessment and Management Assistance Plan**

A pre-intervention JD Risk Assessment and Management Assistance Plan (RAMP) (OJEMAP, 2012; Appendix IV) was used to collect information about specific on-farm risk factors for JD transmission. Cohort 1 participants had received pre-intervention RAMPs (RAMP1) completed between September and November 2010; cohort 2 participants, and control producers between October and December 2011. In total, the veterinarian-administered RAMP contained 23 items focused on specific management practices. Items were scored as a 1, 4, 7, or 10, where a higher score represents a higher level of risk of JD transmission (OJEMAP, 2010). There were 5 sections in total: (1) cattle addition risks (/60), (2) calving area risks (/80), (3) heifers – pre-weaned risks (/70), (4) heifers – weaned to first calving risks (/40), and (5) cows – risks (/50). Item scores were summed within each section to provide section scores, which were then summed to provide an overall risk score (/300).

**Post-Intervention Johne’s disease Risk Assessment and Management Assistance Plan**

Post-intervention RAMPs (RAMP2; Appendix IV) were administered for cohort 1 participants between November and December 2011, and for cohort 2 participants, and control producers between December 2012 and January 2013.

The Research Ethics Board of the University of Guelph approved this study (protocol #: 11AP009), and all participants provided informed, written consent.

**Data analysis**

All data entry, cleaning, and screening were completed using Microsoft® Excel 2011 for Mac (version 14.3.8), while all statistical analyses were conducted in STATA/IC 12.1 for Mac© (StataCorp, Texas, USA). Unless otherwise indicated, the significance level for all statistical
tests was set at $p < 0.05$. Demographic and farm-level characteristics were compared between FF and control respondents using Fisher’s exact tests; differences between individual subcategories of variables were assessed using a Binomial test for proportions. Respondent answers to open-ended questions regarding the specific on-farm changes made were reviewed, categorized based on similarities, and tallied to assess the frequency, and type, of on-farm changes reported. Within-group comparisons (i.e. FF and control groups) between Q1 and Q2 JD knowledge assessment scores, and respondent answers regarding their perceptions (i.e. awareness, attitude, knowledge, and behaviour, with respect to JD), were compared for FF and control groups using Wilcoxon signed-rank tests; within-group RAMP1 and RAMP2 scores were compared using a paired t-test. Between-group comparisons, with respect to Q1 and Q2 JD knowledge assessment scores, and TPB responses, were made using Wilcoxon-Mann-Whitney rank sum tests; RAMP1 and RAMP2 scores between FF and control producers were compared using t-tests. Gain scores were calculated by subtracting pre-intervention scores from post-intervention scores, to assess changes between Q1 and Q2 knowledge assessments, and RAMP1 and RAMP2 scores. Comparisons between gain scores were made using t-tests.

A multivariable logistic regression model was used to investigate the characteristics associated with a respondent making an on-farm management change to control JD. All variables unconditionally associated with the outcome at a significance level of 20% (Dohoo et al., 2009) or less were initially included in the model. A manual stepwise, backward elimination procedure, using likelihood ratio tests, was used to construct the main effects model. The significance level for all final analyses was set at $p < 0.05$. Spearman rank correlation coefficients were used to assess collinearity, with a cut-off of 0.8. Confounding was assessed by observing a change of 30% or more in model coefficients when a variable was removed; identified confounders were
forced into the model. All biologically plausible, two-level interaction terms of the final main effects were tested. Model fit was assessed using a Hosmer-Lemeshow goodness of fit test. Plots of residuals and leverage points were used to assess outliers and influential observations in the final model, and delta-beta values were used to assess the effect of each covariate pattern on the model coefficients (Dohoo et al., 2009).

RESULTS

Pre- and post-intervention questionnaires

Approximately 52% (91/176) of FF participants responded to Q1. Prior to administering Q2, 5 respondents dropped out of FF (left dairy industry (n=2), health reasons (n=2), unknown (n=1)). Among the remaining 86 respondents, 70 completed Q2, yielding a response rate of 81.4% (70/86). A total of 357 (/400) dairy producers were eligible as control participants in this study, of which 62 responded to Q1, yielding a response rate of 17.4% (62/357). After accounting for one respondent leaving the dairy industry prior to administering Q2, 85% (52/61) of control group respondents completed Q2. Statistical comparisons between the herd size, DHI management score, learning style preference(s), and demographic characteristics of FF (n = 70) and control (n = 52) respondents who completed Q1 and Q2 are shown in Table 1. Overall, FF respondents were more likely to be younger, have larger herds, and have higher DHI management scores than control respondents.

Approximately 97% (68/70) FF and 90% (47/52) of control respondents had farm-level production information available through CanWest DHI. Comparisons between the farm-level production data for FF and control respondents are shown, along with the production
characteristics for all ON DHI herds (n = 3090), in Table 2. There were no significant differences between FF and control respondents’ herds.

In Q2, 89% (62/70) of FF respondents indicated that the FF process facilitated the implementation of on-farm changes. In addition, 87% (61/70) reported that FF increased their ability to implement on-farm changes. As reported in Chapter 3, 81% (57/70) of respondents reported implementing at least one on-farm management change to address JD as a result of FF. Of these respondents, 18% (10/57) made one, 30% (17/57) made two, 28% (16/57) made three, and 25% (14/57) made four changes (Chapter 3). Significantly fewer (p<0.001) control respondents made on-farms changes; 38% (20/52) reported implementing at least one on-farm management change. Of these respondents, 50% (10/20) made one, 35% (7/20) made two, and 15% (3/20) made three changes. The most commonly reported change by both FF (n = 23) and control respondents (n = 11) was the removal of calves from the maternity pen within three hours after birth. Table 3 provides a categorized list of on-farm changes reported by FF and control respondents (Chapter 3).

Q1 and Q2 comparisons among FF and control respondents, with respect to their perceived knowledge of the ‘general facts of JD control’, their perceived level of on-farm risk of JD, and their overall concern about JD on their farm, are shown in Table 4. Among those who perceived an increase in their JD knowledge between Q1 and Q2, 83% (29/35) of FF and 50% (2/4) of control respondents reported making at least one on-farm management change. In addition, 87% (20/23) of FF and 14% (1/7) of control respondents who perceived a decrease in the level of on-farm risk of JD, from Q1 to Q2, reported making at least one on-farm management change. Lastly, among those who reported an increase in their overall concern about JD on their farm
between Q1 and Q2, 80% (16/20) of FF and 33% (5/15) of control respondents reported making at least one change.

Among FF respondents, Q1 JD knowledge assessment scores ranged 10 to 27, with a median score of 75.9% (22/29). Q1 scores among control respondents ranged from 14 to 26, with a median score of 75.9% (22/29). The distributions of the Q1 JD knowledge assessment scores among FF and control respondents were not significantly different ($p = 0.145$).

The Q2 JD knowledge assessment scores, among FF respondents, ranged from 16 to 27, with a median score of 82.8% (24/29). Among control respondents, the Q2 scores ranged from 17 to 25, with a median score of 75.9% (22/29). The distributions of the Q2 JD knowledge assessment scores between FF and control respondents were significantly different ($p < 0.001$).

Changes in FF respondent scores between the Q1 and Q2 assessments were statistically significant ($p = 0.002$), while changes in control respondent scores were not ($p = 0.206$). In addition, the JD knowledge assessment gain scores (Q2 score – Q1 score) among FF respondents ranged from -3 to +12, with an average of 1.33 and a standard deviation of 3.19. The gain scores among control respondents ranged from -5 to +6, with an average of -0.44 and a standard deviation of 2.70. The differences between average FF and control respondent gain scores were statistically significant ($p = 0.002$). Among those with positive gain scores, 73% (29/40) of FF and 50% (8/18) of control respondents reported making an on-farm change.

The results of the Q2 TPB assessment are shown in Table 5. Differences in TPB measures between FF and control respondents, with respect to each item-pair and overall construct score, were not statistically significant ($p > 0.05$). Additionally, no significant differences in TPB
constructs ($p > 0.05$) were observed between those that reported making an on-farm change and those that did not.

**Pre- and post-intervention Johne’s disease Risk Assessment and Management Assistance Plans**

Overall, 90% (82/91) of FF respondents had RAMP1 completed by their herd veterinarian, while 91% (78/86; 5 dropouts during intervention period) of remaining respondents had RAMP2 completed. Among control respondents, 76% (47/62) had RAMP1 completed, while 53% (32/61; 1 dropout during intervention period) of remaining respondents had RAMP2 completed.

Comparisons of RAMP1 and RAMP2 scores, within and between FF and control respondents, are shown in Table 6. Comparing RAMP1 and RAMP2 scores among FF respondents, the overall RAMP score (/300), and 4 of 5 section scores, significantly decreased ($p < 0.05$), indicating lower risk. RAMP scores among control respondents did not change significantly.

Among FF respondents that reported making at least one on-farm management change (n = 50; 7 were excluded due to missing RAMP1 or RAMP2 score), RAMP gain scores ranged from -75 to +24, with an average of -16.56 and a standard deviation of 23.19. Among control respondents that reported making an on-farm change (n = 17; 3 were excluded due to missing RAMP1 or RAMP2 score), RAMP gain scores ranged from -48 to +42, with an average of -4.10 and a standard deviation of 33.57. Gain scores, among FF and control respondents who reported making at least one on-farm management change to address JD, were significantly different ($p = 0.049$).
Characteristics associated with making on-farm changes

The final multivariable model assessing respondent characteristics associated with making an on-farm management change to address JD was statistically significant (LR chi2(11) = 56.98, \( p < 0.00001 \)) and included four predictor variables: producer group (FF or control), DHI management score, perceived practicality of recommendations for JD control (a PBC measure; categorized as neutral [0], slightly negative [-1 to -2] and moderately negative [-3 to -4]), and VARK learning preference(s) (Table 7). In addition, herd size was forced into the model to account for a potential confounding relationship between DHI management score and the outcome. The model results show that the odds of making an on-farm change among FF respondents were 33.7 times greater than those making a change among control respondents.

With respect to DHI management score, the odds of making a change among herds with moderate overall performance (500-750) were 14.8 times greater than those with low overall performance (<500), while the odds among respondents with a score >750 were 13.4 times greater than those with a score of <500. The odds of making a change among respondents with a neutral perception of the practicality of on-farm recommendations were 2.5 and 14.1 times greater than the odds among respondents with a slightly negative and moderately negative perception of recommendations, respectively. Lastly, compared to respondents with multimodal learning preferences, the odds of making an on-farm change were greatest among respondents with a singular preference for aural (e.g. lecture), kinesthetic (e.g. farm tour), and read/write learning (e.g. fact sheet), respectively. In addition, respondents with a preference for two and three modes of learning (i.e. V, A or V, A, R) had greater odds of making an on-farm change over those with multimodal preferences.
DISCUSSION

On-farm change and Johne’s disease risk

One of the key objectives of the evaluation of the FF process in this study was the ability of FF to influence the adoption of on-farm management changes for JD control. Overall, 81% of FF respondents reported making at least one on-farm management change to address JD, as compared to only 38% of control respondents. More than 50% of those FF respondents that made at least one management change reported making more than two on-farm changes to address JD, compared to only 15% of control respondents. The number of changes implemented per respondent in this study is higher than a previous Canadian report, where only 60% of respondents implemented one on-farm recommendation (Sorge et al., 2010a). The majority of the changes implemented by producers in this study are key areas of concern in the RAMP, with many respondents focusing on calf management in particular. Specifically, respondents commonly reported removing calves more quickly after birth, and feeding colostrum sooner and in larger quantities. Furthermore, many of the changes made correspond to some of the most common recommendations made by Canadian dairy veterinarians for JD control (Sorge et al., 2010a). Hence, the changes made by study respondents are expected to be useful in preventing further on-farm spread of MAP.

The average RAMP1 score among FF and control respondents did not significantly differ, and represented a medium level of risk (116/300) with respect to on-farm JD transmission. These values were only marginally lower (i.e. representing lower risk) than the average ON RAMP score (120/300) obtained from over 2000 completed RAMPs between 2010 and 2013 (L. Pieper, University of Guelph, Guelph, Ontario, personal communication). Thus, they appear to reflect
the scores of the general ON population. The average RAMP2 score among FF respondents significantly decreased from the average RAMP1 score, and represented a low level of risk (104/300) with respect to on-farm transmission. There was no change in RAMP scores amongst control respondents. Furthermore, 88% of FF respondents who made an on-farm change decreased their RAMP2 score. Therefore, the changes that were made by respondents were deemed by the veterinarian to reduce the risk of on-farm transmission of JD, resulting in a reduced RAMP score. Several other studies have observed similar relationships when comparing two sequential RAMPs (Sorge et al., 2010b; Raizman et al., 2006; Wells et al., 2008), indicating that compliance with recommendations is correlated with a decrease in the on-farm risk of JD. Additionally, FF respondents significantly decreased their RAMP2 score in nearly every sub-section of the assessment; the one section that did not significantly change was related to the purchase of animals in the past five years. Given the RAMP marking scheme, and the temporal proximity of the two RAMPs, even if purchasing behaviour changed between RAMPs, the section score for a producer who had purchased an animal within the previous five years would not have changed during this study period, as it was less than five years. Importantly, a significant decrease in all section areas suggests that FF respondents addressed their individual high-risk areas; an important step in decreasing their risk of on-farm transmission.

**The antecedents of on-farm change**

Another key objective to the evaluation of FF was to assess the impact of FF on respondents’ perception, knowledge, and attitude with respect to JD control. Over 50% of FF respondents perceived that their level of knowledge about JD control had increased to at least a moderate level, 83% of which reported making a change to address JD on their farm. These results suggest that this perception may have played a role in influencing respondent behaviour. Similar findings
were reported by Jansen et al. (2010a), who identified that an increase in perceived level of knowledge of mastitis was positively associated with a decrease in bulk milk somatic cell count. It is important to consider, however, that measures of perceived level of knowledge, termed ‘subjective knowledge’, typically reflect an individual’s level of self-confidence with respect to performing a given behaviour (Chiou, 1998). Furthermore, Chapter 3 showed that 87% of FF respondents reported increased confidence in dealing with JD on their farm as a result of the FF process, 90% of whom also reported making at least one change. Thus, the influence of perceived increases in ‘subjective knowledge’ on JD control may have more to do with an increase in respondents’ level of self-confidence to control JD, rather than an explicit increase in their level of knowledge.

Based upon the objective knowledge assessment, the knowledge level of FF respondents significantly increased during the study period, while the knowledge level of control respondents did not. Furthermore, 70% of FF respondents who reported making an on-farm change exhibited a better knowledge of JD control at Q2. However, both FF and control respondents displayed a moderate to good level of knowledge of JD control prior to any intervention. This suggests that, while there was room for improvement, the majority of respondents possessed sufficient knowledge to effectively control JD prior to the intervention. As a result, knowledge may not have played a significant role in influencing the increased adoption observed among FF respondents in this study. Similar conclusions were made by Kuiper et al. (2005), who found that a lack of general knowledge and problem awareness were not the key factors explaining the adoption of management practices to control mastitis among Dutch dairy farmers. Lam et al. (2011) expressed similar views regarding knowledge and behaviour, suggesting that knowledge is not the barrier in improving udder health among Dutch dairy farmers. Therefore, while the
improvements in objective knowledge observed in this study are important, we expect that it may not have been a significant driver of change among study respondents. The majority of FF respondents’ perceptions changed over the course of the intervention period. A larger proportion of FF respondents exhibited a greater level of concern regarding JD on their farm at Q2 compared to Q1. This change may represent a favorable trend, as those who express a greater level of concern may be more inclined to make changes to their behaviour. In addition, 80% of those who expressed a greater level of concern also reported making an on-farm management change. Similar to level of concern, a larger proportion of FF respondents expressed a lower perceived risk of JD on their farm at Q2 compared to Q1. This might be explained by the fact that 87% of those who held this perception also reported making an on-farm management change. Thus, we might expect that respondents implemented on-farm changes and, as a result, their perception of their farm’s level of risk decreased. Jansen et al. (2009) identified similar associations between perceptions and attitudes among Dutch dairy farmers, and bulk milk somatic cell count. Furthermore, Jansen et al. (2010a) observed positive changes in farmer perception and attitude with respect to problem and satisfaction levels with bulk milk somatic cell count, which they suggested could influence future response to mastitis problems. Therefore, the favorable changes in perception observed in this study may be an important contributor to the adoption of on-farm management practices to control JD. The TPB assessment showed that both the FF and control groups displayed similar behavioural intent, attitudes, subjective norms, and perceived behavioural control. While these groups did not significantly differ from one another, the strength of various components of the TPB constructs provides useful results to inform future extension approaches. Both groups possessed a moderate to strong positive attitude towards controlling JD. The most influential attitude, with respect to
making changes to control JD, was that controlling JD was an important aspect in improving herd health. This was followed by a strong attitude that preventing and controlling JD makes respondents good managers of herd health. Thus, it appears that respondents were most driven to address JD because they valued managing and improving herd health. Typically, JD extension focuses on producer awareness of the production, financial and human health impacts of JD to motivate change. Interestingly, attitudes towards these factors tended to have the weakest positive influence on making on-farm changes for JD control. These findings suggest that communicating JD control as part of a holistic approach to improving herd health will be an effective method for influencing producers to change.

Both FF and control respondents also perceived a moderate amount of social pressure to make on-farm changes to control JD. Both groups felt herd veterinarians were highly influential in their decision to make changes. As one of the primary sources of reliable information and advice on disease management, veterinarians are in a position to play a central role in influencing farmer behaviour (Kuiper et al., 2005; Jansen et al., 2009; Lam et al., 2011). However, the veterinarians’ ability to influence behaviour is largely dependent on the communication approaches they employ (Vaarst et al., 2007). Lam et al. (2011) suggest that effective producer communication requires veterinarians to account for different producer learning styles, take a pro-active approach towards prevention, personalize messages, and provide a realistic frame of reference for producers with regard to disease problems. Further supporting evidence of this is the finding reported here, that producer learning style preferences were significantly associated with increased odds of making an on-farm change in this study. Overall, these findings suggest that JD control programs will benefit from employing the use of veterinarians to influence producer behaviour, and should consider the efficacy of the communication methods employed,
and their alignment with specific learning preferences, as these considerations have important ramifications with respect to producer behaviour.

Both groups of respondents also felt that producer organizations highly influenced their decision to make changes. This is an important consideration, as communication efforts from industry-led initiatives provide the opportunity to influence change from a population level. Lam et al. (2011) suggest that a key to effective communication at this level is that all organizations in the farmer’s social environment articulate the same message, which will avoid confusion, and maintain trust and motivation in the sources of the information. Thus, industry-led initiatives need to ensure they are conveying the same message with respect to JD implications, control recommendations, and expectations. Coordinating outreach at both the veterinarian and organization level, and focusing on the considerations discussed herein, is therefore likely to be effective for JD control. Interestingly, Jansen et al. (2010b) showed that the combination of two different routes of communication, one through veterinarians and another through an industry-wide mass-media campaign, was effective in disseminating knowledge and changing on-farm practices to address mastitis among Dutch dairy farmers. While communication at both of these levels is relatively commonplace among ON dairy outreach programs, the focus moving forward must be on effectively communicating the message of long-term control. Future extension programs will be strengthened by considering the social factors that influence producers, and ensuring that the sources of information are relaying the same message in a clear and consistent way.

FF and control respondents exhibited a slightly negative perception of their ability to effectively control JD on their farm, which was influenced by the perceived practicality of on-farm recommendations. Furthermore, the odds of making an on-farm change increased as the perception of the practicality of on-farm recommendations increased from negative to positive.
Therefore, producers who felt that management practices for JD control were practical were more likely to adopt those management practices. Similar findings were identified by Garforth et al. (2013), who showed that the perceived practicality and efficacy of on-farm management practices strongly influenced whether English sheep and pig farmers made an on-farm change. The chronic nature of JD and a prolonged sub-clinical phase, three to six years in many cases (Tiwari et al., 2006), also seemed to negatively impact the producers’ perceived ability to control JD. Furthermore, the accuracy of JD tests has been shown to vary (Tiwari et al., 2006), which appeared to be another influential factor for study respondents. Many studies have shown that PBC was a useful predictor of both behavioural intention and behavioural change (Armitage and Conner, 2001). Furthermore, both Jansen et al. (2010a) and Kuiper et al. (2005) reported that PBC was a key factor affecting the uptake of mastitis control practices among Dutch dairy producers. Thus, we might expect a negative perception of one’s ability to effectively control JD on the farm to result in few changes being implemented. However, many respondents in this study reported making on-farm changes to address JD, which showed that even those who made changes questioned their ability to effectively control JD on their farms. This negative perception could stem from the fact that the effects of management changes on JD prevalence will generally not be realized for several years, due to the chronic nature and long incubation period of JD. This delayed impact may result in producers questioning whether the changes have had, or will have, a positive impact. Given these results, the practicality and efficacy of on-farm management practices for JD control must be consistently communicated to producers to improve their perception that they can get control of JD on their farm. In addition, it must be emphasized that JD control requires that producers be vigilant and ‘stay the course’ in order to effectively combat this chronic disease. Producers with a negative perception of their ability to control JD may be
easier to influence by promoting a more holistic approach to calf health and farm biosecurity, as making changes to improve these issues are essential for raising productive dairy cows. With this approach in mind, highlighting the immediate benefits that these on-farm changes have been shown to have on other fecal-oraly transmitted diseases, such as *Escherichia coli*, *Campylobacter* spp., *Salmonella* spp., and *Cryptosporidium* spp. (McKenna et al., 2006), may serve to more drastically influence producers’ behaviour.

When considering the relationship between TPB factors and behaviour change, it appears that PBC, on its own, was not as influential in this population as it has been shown to be in other dairy producer populations (Jansen et al., 2009, 2010a; Kuiper et al., 2005). We might therefore expect that the positive attitudes towards JD control, and moderate amount of social pressure perceived among study respondents, played a larger role than PBC in the uptake observed in this study. However, these factors were not significantly different among FF and control groups, nor were they significantly different among those who made changes and those who did not. One explanation for the observed difference in adoption is that there may be differences between these two populations with respect to factors that were not measured (i.e. motivation). Producer motivation has been shown to be an important factor influencing behaviour (Lam et al., 2011), and is influenced by internal factors, such as management style, perceptions, and attitudes (Jansen et al., 2009), as well as external factors, such as penalties and incentives (Valeeva et al., 2007). Lam et al. (2011) reported that influencing internal motivation leads to more lasting change, and that it can be influenced through reasoned opinions, which are shared in producer study groups and individual discussions with veterinarians. Thus, participation in FF may have resulted in changes in respondents’ internal motivation to address JD, and as a result, account for the difference in adoption observed between FF and control respondents.
The role of Ontario Focus Farms

FF appears to be effective in changing producer perceptions about JD and JD control favorably, as a higher proportion of FF respondents reported changes in their perception, compared to control respondents. Furthermore, a significant increase in knowledge assessment scores among FF respondents, and no change among control respondents, indicates that FF was effective in increasing the objective knowledge of participants with respect to JD control. FF was also effective in increasing the level of perceived knowledge (i.e. subjective knowledge) among respondents, which as suggested, may provide insight into respondents’ self-confidence. Given these results, FF appears to have been successful in addressing, and positively changing, many of the antecedents of on-farm change.

It is difficult to observe the effect FF had on the TPB construct measures without a pre- and post-intervention comparison; however, FF may not have had a dramatic impact on these factors given that they did not significantly differ among FF and control respondents at the end of the intervention. Despite this, preliminary findings on the effects of FF showed that 66% of FF participants reported a change in attitude towards making on-farm changes to control JD (Chapter 3). Thus, the power of this study to detect differences between these groups may have been limited due to a small sample size, and as a result, true differences in TPB constructs may have been missed. Furthermore, the TPB instrument may not have addressed all of the factors that contributed to observed changes in behaviour. While the measurement of the TPB constructs provide valuable insights into the various perceptions and attitudes of respondents, future studies should aim to address as many pertinent factors as possible in TPB instruments, and conduct a pre-post assessment to evaluate the impact of interventions on these measures.
Overall, the significant increase in the adoption of on-farm management practices observed among FF respondents, as compared to control respondents, suggests that FF was effective. The level of adoption observed here was larger than other studies focusing on JD adoption (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010a). Pratt and Bowman (2008) suggest that actual behavioural change occurs when the cognitive, social, psychological, and emotional dimensions of the behaviour are addressed. Thus, the increase in adoption among FF respondents may be attributed to the fact that FF addressed, and in many cases significantly changed, some of the key antecedents of change (i.e. knowledge, perceptions and attitudes). Pratt and Bowman (2008) also suggest that if behaviour change is the goal, then extension programs must include personally relevant, problem-focused, experiential, active learning practices focused on skill building. Given this recommendation, and the demonstrated improvement in the adoption evidenced in this study, the participatory, collaborative learning methods, which FF employs, appear to be effective in facilitating on-farm change. Furthermore, Trier et al. (2012) and Kingham and Links (2012) have showed that similar approaches were effective in improving on-farm change to control JD among Dutch dairy farmers and Australian sheep farmers, respectively. Thus it would appear that these participatory-based approaches, which embrace collaborative and experiential learning processes, are directly applicable for JD control.

Given that FF respondents were asked to report on their perceptions, and the impact, of FF by the administrators of FF, it is important to acknowledge that respondents may have deliberately biased their responses to provide socially desirable answers. Further, as a comparison group, control respondents were meant to represent the ‘typical’ ON dairy producer; however, the low response rate (17%) for the Q1 control group may have contributed to selection bias, in the form of non-response bias, in this study. As there are currently no reliable data on all ON dairy
producer demographic characteristics, we were not able to assess representativeness from this perspective. However, based on demographic comparisons between FF and control groups, FF respondents were more likely to be younger, have larger herds, and have higher DHI management scores than control producers. Comparisons between FF and control groups showed no significant differences with respect to herd level production and reproduction characteristics. However, FF respondents tended to have slightly better production and reproduction than control respondents. Moreover, both FF and control respondents tended to have slightly better production and reproduction than all CanWest DHI herds. These differences are similar to other studies, which identified higher production among participants than non-participants (Raizman et al., 2006; Sorge et al., 2010b). Therefore, the participants in this study may be more progressive and informed than the overall ON dairy population, and as a result, some caution may need to be applied in the generalizing of these findings to the broader population.

CONCLUSIONS

This study highlights the importance of the social factors underlying dairy producers’ on-farm behaviours. Although study respondents perceived JD control as important, and perceived moderate pressure from veterinarians and industry organizations to make on-farm changes, they questioned their ability to effectively control JD. It is important that extension and outreach efforts continue to routinely, and consistently, communicate the importance of JD control at both producer and industry levels. Future communication with dairy producers must also focus on the efficacy of recommended changes with respect to the immediate impacts on many fecal-orally transmitted diseases and the long-term persistence needed to effectively control JD. By targeting these perceptions, attitudes, and opinions, communication efforts are more likely to influence producer behaviour. This study showed that the participatory-based, experiential learning
approach employed by FF was an effective method for improving the adoption of on-farm management practices for JD control. Participants in the FF process reported improvements in attitude and perception towards JD control, exhibited improved ‘subjective’ and ‘objective’ knowledge levels, and a significant proportion made on-farm changes for JD control. These changes in perception, knowledge, attitude and behaviour were more significant among FF respondents, compared to control respondents, suggesting that the conceptual framework and practical approach of FF is effective in influencing change among producers. Other RA-based JD control programs should consider the implementation of self-directed, learner-centred processes, such as FF, in order to target and effectively influence the antecedents of behavioural change and ultimately improve the success of industry-wide JD control efforts.
REFERENCES


Table 1 | Comparisons between 70 Ontario Focus Farm (FF) and 52 Control respondents with respect to age, gender, education level, ethnicity, cohort, herd size, and DHI management score (October 2010 – December 2011; Ontario, Canada).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FF respondents</th>
<th>Control respondents</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># (%)</td>
<td># (%)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 35</td>
<td>21 (30.0)</td>
<td>9 (17.3)</td>
<td>0.051</td>
</tr>
<tr>
<td>35 to 44</td>
<td>22 (31.4)</td>
<td>10 (19.2)</td>
<td></td>
</tr>
<tr>
<td>45 to 54</td>
<td>19 (27.1)</td>
<td>20 (38.5)</td>
<td></td>
</tr>
<tr>
<td>55 to 64</td>
<td>7 (10.1)</td>
<td>12 (23.1)</td>
<td></td>
</tr>
<tr>
<td>&gt; 65</td>
<td>0 (0.0)</td>
<td>1 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (1.4)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>60 (85.7)</td>
<td>44 (84.6)</td>
<td>0.866</td>
</tr>
<tr>
<td>Female</td>
<td>10 (14.3)</td>
<td>8 (15.4)</td>
<td></td>
</tr>
<tr>
<td>Education level</td>
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<td></td>
<td></td>
</tr>
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<td>Grade School</td>
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<td>Some high school</td>
<td>3 (4.3)</td>
<td>2 (3.8)</td>
<td></td>
</tr>
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<td>High school</td>
<td>20 (28.6)</td>
<td>14 (26.9)</td>
<td></td>
</tr>
<tr>
<td>College/trade school</td>
<td>35 (50.0)</td>
<td>22 (42.4)</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>12 (17.1)</td>
<td>12 (23.1)</td>
<td></td>
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<td>Unknown</td>
<td>0 (0.0)</td>
<td>1 (1.9)</td>
<td>0.601</td>
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<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>58 (82.9)</td>
<td>45 (86.5)</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>9 (12.9)</td>
<td>6 (11.6)</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>2 (2.8)</td>
<td>1 (1.9)</td>
<td></td>
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<td>Belgium</td>
<td>1 (1.4)</td>
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<td>Net Farm Income</td>
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<td>&lt; $50,000</td>
<td>0 (0.0)</td>
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<td>$50,000 to $99,999</td>
<td>15 (21.4)</td>
<td>17 (32.7)</td>
<td></td>
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<td>$100,000 to $149,999</td>
<td>10 (14.3)</td>
<td>8 (15.4)</td>
<td></td>
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<td>$150,000 to $199,999</td>
<td>17 (24.3)</td>
<td>14 (26.9)</td>
<td></td>
</tr>
<tr>
<td>&gt; $200,000</td>
<td>28 (40.0) a</td>
<td>11 (21.2)</td>
<td>0.109</td>
</tr>
<tr>
<td>Unknown</td>
<td>0 (0.0)</td>
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<tr>
<td>Focus Farm Cohort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohort 1 - Dec. 11’ to Dec. 12’</td>
<td>41 (58.6)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Cohort 2 - Dec. 12’ to Dec. 13’</td>
<td>29 (41.4)</td>
<td>NA</td>
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</tr>
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</table>

a Proportion in that subcategory is significantly different ($p < 0.05$) between FF and Control respondents.
Table 1 (continued) | Comparisons between 70 Ontario Focus Farm (FF) and 52 Control respondents with respect to age, gender, education level, ethnicity, cohort, herd size, and DHI management score (October 2010 – December 2011; Ontario, Canada).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Focus Farm respondents</th>
<th>Control respondents</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td></td>
<td># (%)</td>
<td># (%)</td>
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<tr>
<td><strong>Herd Size</strong></td>
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<tr>
<td>&lt; 51</td>
<td>11 (15.7)</td>
<td>21 (40.4)</td>
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<tr>
<td>51 to 150</td>
<td>50 (71.4)</td>
<td>28 (53.8)</td>
<td></td>
</tr>
<tr>
<td>&gt; 150</td>
<td>9 (12.9)</td>
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<td>0 (0.0)</td>
<td>0.007</td>
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<tr>
<td><strong>DHI Management Score</strong></td>
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<tr>
<td>&lt; 500</td>
<td>7 (10.0)</td>
<td>12 (23.1)</td>
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<tr>
<td>500 - 750</td>
<td>42 (60.0)</td>
<td>21 (40.4)</td>
<td></td>
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<tr>
<td>&gt; 750</td>
<td>19 (27.1)</td>
<td>14 (26.9)</td>
<td></td>
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<td>Unknown</td>
<td>2 (2.9)</td>
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<td>Visual</td>
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<td>0 (0.0)</td>
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<tr>
<td>Aural</td>
<td>7 (10.0)</td>
<td>7 (13.5)</td>
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<td>Read/Write</td>
<td>9 (12.9)</td>
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<td>Kinesthetic</td>
<td>20 (28.6)</td>
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<td>0.130</td>
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</tbody>
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* Proportion in that subcategory is significantly different (p < 0.05) between FF and Control respondents
Table 2 | Comparisons between Ontario Focus Farm (FF) herds (n = 68), Control herds (n = 47), and all Ontario (ON) CanWest Dairy Herd Improvement (DHI) herds (n = 3090) for production and reproduction data obtained between April 2012 and April 2013.

<table>
<thead>
<tr>
<th>Production Characteristic</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>FF-Control p-value</th>
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</thead>
<tbody>
<tr>
<td><strong>Average 305 day milk production/cow (kg)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Focus Farm Herds</td>
<td>9813.26</td>
<td>1285.21</td>
<td>6269.00</td>
<td>12718.00</td>
<td>0.116</td>
</tr>
<tr>
<td>Control Herds</td>
<td>9424.33</td>
<td>1503.14</td>
<td>5903.00</td>
<td>12770.00</td>
<td></td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>8894.48</td>
<td>1625.99</td>
<td>4571.00</td>
<td>13675.00</td>
<td></td>
</tr>
<tr>
<td><strong>Average fat production (kg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>377.75</td>
<td>41.45</td>
<td>307.00</td>
<td>500.00</td>
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<tr>
<td>Control Herds</td>
<td>367.57</td>
<td>49.19</td>
<td>219.00</td>
<td>485.00</td>
<td>0.204</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>343.88</td>
<td>59.51</td>
<td>178.00</td>
<td>529.00</td>
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<tr>
<td><strong>Average protein production (kg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>316.36</td>
<td>35.54</td>
<td>235.00</td>
<td>399.00</td>
<td></td>
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<tr>
<td>Control Herds</td>
<td>303.39</td>
<td>42.25</td>
<td>190.00</td>
<td>396.00</td>
<td>0.060</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>286.10</td>
<td>49.48</td>
<td>148.00</td>
<td>434.00</td>
<td></td>
</tr>
<tr>
<td><strong>Average somatic cell count (x1000)</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Focus Farm Herds</td>
<td>214.05</td>
<td>79.60</td>
<td>87.00</td>
<td>457.00</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>226.96</td>
<td>66.15</td>
<td>93.00</td>
<td>407.00</td>
<td>0.322</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>243.69</td>
<td>97.83</td>
<td>76.00</td>
<td>1043.00</td>
<td></td>
</tr>
<tr>
<td><strong>Average of the actual calving interval (days)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>415.55</td>
<td>23.58</td>
<td>379.00</td>
<td>483.00</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>419.00</td>
<td>27.32</td>
<td>372.00</td>
<td>485.00</td>
<td>0.444</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>426.85</td>
<td>44.05</td>
<td>372.00</td>
<td>542.00</td>
<td></td>
</tr>
<tr>
<td><strong>Average dry period (days)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>68.92</td>
<td>13.93</td>
<td>47.00</td>
<td>119.00</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>67.59</td>
<td>16.53</td>
<td>45.00</td>
<td>138.00</td>
<td>0.621</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>72.96</td>
<td>22.78</td>
<td>40.00</td>
<td>154.00</td>
<td></td>
</tr>
<tr>
<td><strong>Number of days at first breeding</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>80.53</td>
<td>14.43</td>
<td>63.00</td>
<td>134.00</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>82.83</td>
<td>13.59</td>
<td>63.00</td>
<td>123.00</td>
<td>0.369</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>86.67</td>
<td>18.94</td>
<td>57.00</td>
<td>150.00</td>
<td></td>
</tr>
<tr>
<td><strong>Average days open</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>133.55</td>
<td>23.58</td>
<td>97.00</td>
<td>201.00</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>137.00</td>
<td>27.32</td>
<td>90.00</td>
<td>203.00</td>
<td>0.444</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>146.03</td>
<td>35.50</td>
<td>90.00</td>
<td>260.00</td>
<td></td>
</tr>
<tr>
<td><strong>Number of breedings/cow/year</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>2.15</td>
<td>0.34</td>
<td>1.00</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>2.03</td>
<td>0.37</td>
<td>1.06</td>
<td>3.00</td>
<td>0.075</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>2.07</td>
<td>0.49</td>
<td>1.00</td>
<td>3.44</td>
<td></td>
</tr>
<tr>
<td><strong>Herd turnover rate (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Farm Herds</td>
<td>42.48</td>
<td>10.70</td>
<td>9.82</td>
<td>64.36</td>
<td></td>
</tr>
<tr>
<td>Control Herds</td>
<td>40.62</td>
<td>13.30</td>
<td>11.99</td>
<td>73.50</td>
<td>0.365</td>
</tr>
<tr>
<td>All ON DHI Herds</td>
<td>42.86</td>
<td>16.13</td>
<td>12.55</td>
<td>98.78</td>
<td></td>
</tr>
</tbody>
</table>
Table 3 | Categorization of the on-farm management changes implemented to control Johne’s Disease (JD) during the intervention period, as reported by 57 Ontario Focus Farm and 20 control respondents (November 2011 – January 2013; Ontario, Canada) (Adapted from Chapter 3).

<table>
<thead>
<tr>
<th>Management Change</th>
<th>Frequency Among Focus Farm Respondents # (%)</th>
<th>Frequency Among Control Respondents # (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternity pen cleaned after each calving</td>
<td>11 (19.3) ^a</td>
<td>1 (5.0)</td>
</tr>
<tr>
<td>Separation of equipment for feeding and manure handling</td>
<td>8 (14.0) ^a</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Purchased new equipment (e.g. skid steer, buckets, etc.)</td>
<td>6 (10.5) ^a</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Cleaning calf housing area routinely</td>
<td>6 (10.5)</td>
<td>2 (10.0)</td>
</tr>
<tr>
<td>General on-farm cleanliness improved</td>
<td>6 (10.5)</td>
<td>1 (5.0)</td>
</tr>
<tr>
<td>Building of a new barn or maternity pen</td>
<td>6 (10.5)</td>
<td>3 (15.0)</td>
</tr>
<tr>
<td>Boots washed more frequently</td>
<td>4 (7.0)</td>
<td>2 (10.0)</td>
</tr>
<tr>
<td>Adding more bedding in calving area</td>
<td>2 (3.5)</td>
<td>2 (10.0)</td>
</tr>
<tr>
<td>Improved record keeping</td>
<td>2 (3.5)</td>
<td>1 (5.0)</td>
</tr>
<tr>
<td><strong>Total changes</strong></td>
<td><strong>51</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

Calf management

<table>
<thead>
<tr>
<th>Management Change</th>
<th>Frequency Among Focus Farm Respondents # (%)</th>
<th>Frequency Among Control Respondents # (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves are removed from maternity pen within 3 hours</td>
<td>23 (40.4)</td>
<td>11 (55.0)</td>
</tr>
<tr>
<td>Feeding 4 liters of colostrum as soon as possible</td>
<td>19 (33.3)</td>
<td>3 (15.0)</td>
</tr>
<tr>
<td>Change in colostrum management (i.e. switch to artificial colostrum)</td>
<td>10 (21.1)</td>
<td>4 (20.0)</td>
</tr>
<tr>
<td>Focusing on cleaner feedings (milk and/or colostrum)</td>
<td>7 (12.3)</td>
<td>3 (15.0)</td>
</tr>
<tr>
<td>Change in feeding of calves (i.e. switch to milk replacer)</td>
<td>6 (10.5)</td>
<td>4 (20.0)</td>
</tr>
<tr>
<td>Overall calf care is better</td>
<td>5 (8.8)</td>
<td>4 (20.0)</td>
</tr>
<tr>
<td>Freezing colostrum from low-risk animals</td>
<td>4 (7.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Started the use of hutches</td>
<td>3 (5.3)</td>
<td>3 (15.0)</td>
</tr>
<tr>
<td><strong>Total changes</strong></td>
<td><strong>77</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

Johne’s disease (JD)

<table>
<thead>
<tr>
<th>Management Change</th>
<th>Frequency Among Focus Farm Respondents # (%)</th>
<th>Frequency Among Control Respondents # (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing for JD routinely</td>
<td>8 (14.0)</td>
<td>2 (10.0)</td>
</tr>
<tr>
<td>More aware of JD and managing JD-positive cows</td>
<td>5 (8.8) ^a</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>JD-positive cows are culled more quickly</td>
<td>2 (3.5)</td>
<td>2 (10.0)</td>
</tr>
<tr>
<td>Rendering JD-positive animals instead of selling for beef</td>
<td>2 (3.5)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Asking about JD status when buying animals</td>
<td>1 (1.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Stopped buying animals/closed the herd</td>
<td>1 (1.8)</td>
<td>1 (5.0)</td>
</tr>
<tr>
<td>Stopped spreading manure on hayfields</td>
<td>1 (1.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td><strong>Total changes</strong></td>
<td><strong>20</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>

^a Proportion in that subcategory is significantly different (p < 0.05) between FF and Control respondents

1 Multiple responses per respondent permitted
Table 4 | Pre- and post-survey comparisons of respondents’ current level of understanding of Johne’s Disease (JD), their farm’s current level of risk of JD, and their overall concern about JD on their farm, among 70 Ontario (ON) Focus Farm and 52 Control respondents (October 2010 – January 2013; ON, Canada).

<table>
<thead>
<tr>
<th>Focus Farm Respondents</th>
<th>Control Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How would you rate your current level of understanding of the 'general facts' on JD control?</strong></td>
<td><strong>How would you rate your farm's current level of risk for getting JD?</strong></td>
</tr>
<tr>
<td></td>
<td>Pre-Survey Response</td>
</tr>
<tr>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>Pre-Survey Response</td>
<td>Complete</td>
</tr>
<tr>
<td>Very high</td>
<td>-</td>
</tr>
<tr>
<td>Moderate</td>
<td>1</td>
</tr>
<tr>
<td>Little</td>
<td>-</td>
</tr>
<tr>
<td>None</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
</tr>
</tbody>
</table>

*p < 0.0001

| | | | p = 0.017 |

<p>| How would you rate your farm's current level of risk for getting JD? |</p>
<table>
<thead>
<tr>
<th>Pre-Survey Response</th>
<th>Post-Survey Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very high</td>
</tr>
<tr>
<td>Pre-Survey Response</td>
<td>Very high</td>
</tr>
<tr>
<td>High</td>
<td>-</td>
</tr>
<tr>
<td>Moderate</td>
<td>-</td>
</tr>
<tr>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Very low</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
</tr>
</tbody>
</table>

*p = 0.435

*p = 0.136
Table 4 (continued) | Pre- and post-survey comparisons of respondents’ current level of understanding of Johne’s Disease (JD), their farm’s current level of risk of JD, and their overall concern about JD on their farm, among 70 Ontario (ON) Focus Farm and 52 Control respondents (October 2010 – January 2013; ON, Canada).

<table>
<thead>
<tr>
<th>Focus Farm Producers</th>
<th>Control Producers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall, how concerned are you about JD on your farm?</strong></td>
<td><strong>Post-Survey Response</strong></td>
</tr>
<tr>
<td>Pre-Survey Response</td>
<td>Very concerned</td>
</tr>
<tr>
<td>Very concerned</td>
<td>-</td>
</tr>
<tr>
<td>Concerned</td>
<td>3</td>
</tr>
<tr>
<td>Neither concerned nor unconcerned</td>
<td>-</td>
</tr>
<tr>
<td>Unconcerned</td>
<td>-</td>
</tr>
<tr>
<td>Very unconcerned</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 5 | Comparisons between the item-pair responses used to indirectly measure the Theory of Planned Behaviour constructs (Behavioural Intention, Attitude, Subjective Norms, Perceived Behavioural Control) among 65 Ontario Focus Farm (FF) respondents and 52 Control respondents (November 2011 – January 2013; Ontario, Canada).

<table>
<thead>
<tr>
<th>Behavioural Intention Statements</th>
<th>Focus Farm Respondents</th>
<th>Control Respondents</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1 to 5 scale)</td>
<td>Med Min Max Mean SD</td>
<td>Med Min Max Mean SD</td>
<td></td>
</tr>
<tr>
<td>It is expected of me to make changes in management to prevent and control JD on my farm</td>
<td>4 1 5 4.39 0.83</td>
<td>4.5 2 5 4.31 0.85</td>
<td>0.896</td>
</tr>
<tr>
<td>I intend to make changes in management to prevent and control JD on my farm</td>
<td>4 1 5 4.28 0.82</td>
<td>4 2 5 4.02 0.94</td>
<td>0.131</td>
</tr>
<tr>
<td>Total Intention Score</td>
<td>4.5 1 5 4.31 0.74</td>
<td>4 2 5 4.16 0.71</td>
<td>0.120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attitude Statements</th>
<th>Focus Farm Respondents</th>
<th>Control Respondents</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioural Belief Statement (1 to 5 scale); Outcome Evaluation Statement (-2 to +2 scale)</td>
<td>Med Min Max Mean SD</td>
<td>Med Min Max Mean SD</td>
<td></td>
</tr>
<tr>
<td>I am concerned about the health effects of JD on my herd; Being concerned about the health effects of JD on my herd is:</td>
<td>5 -2 10 5.97 3.43</td>
<td>7 0 10 6.69 3.28</td>
<td>0.234</td>
</tr>
<tr>
<td>I am concerned about the financial costs of JD; Minimizing the financial costs of JD is:</td>
<td>5 -2 10 5.82 3.64</td>
<td>6 -3 10 6.52 3.39</td>
<td>0.358</td>
</tr>
<tr>
<td>I am concerned about the possible human health risks of JD; Being concerned about the possible human health risks of JD is:</td>
<td>5 -2 10 5.58 3.71</td>
<td>6 -2 10 5.98 3.79</td>
<td>0.570</td>
</tr>
<tr>
<td>I currently use many of the recommended prevention and control strategies for JD on my farm; Preventing and controlling JD on my farm is:</td>
<td>8 -4 10 6.31 3.33</td>
<td>7 -3 10 6.42 3.08</td>
<td>0.859</td>
</tr>
<tr>
<td>Prevention and control strategies for JD are very effective; Having effective prevention and control strategies for JD is:</td>
<td>8 -4 10 6.46 3.23</td>
<td>6 0 10 6.29 2.97</td>
<td>0.692</td>
</tr>
<tr>
<td>Preventing and controlling JD makes me a good manager; Being a good manager of herd health is:</td>
<td>8 -6 10 6.77 3.19</td>
<td>8 0 10 7.00 2.79</td>
<td>0.841</td>
</tr>
<tr>
<td>Preventing and controlling JD improves herd health; Improving herd health on my farm is:</td>
<td>10 -2 10 7.57 3.09</td>
<td>10 0 10 7.73 2.85</td>
<td>0.872</td>
</tr>
<tr>
<td>Total Attitude Score</td>
<td>43 -22 70 44.48 19.23</td>
<td>45.5 14 70 46.63 16.12</td>
<td>0.627</td>
</tr>
</tbody>
</table>
Table 5 (continued) | Comparisons between the item-pair responses used to indirectly measure the Theory of Planned Behaviour constructs (Behavioural Intention, Attitude, Subjective Norms, Perceived Behavioural Control) among 65 Ontario Focus Farm (FF) respondents and 52 Control respondents (November 2011 – January 2013; Ontario, Canada).

<table>
<thead>
<tr>
<th>Subjective Norms Statements</th>
<th>Focus Farm Respondents</th>
<th>Control Respondents</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normative Belief Statement (-2 to +2 scale); Motivation to Comply Statement (1 to 5 scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My fellow producers think it's important to prevent and control JD; What my fellow producers think is important matters to me</td>
<td>3</td>
<td>-3</td>
<td>10</td>
</tr>
<tr>
<td>My fellow producers made changes to prevent and control JD; What my fellow producers do on their farm matters to me</td>
<td>1</td>
<td>-3</td>
<td>10</td>
</tr>
<tr>
<td>My herd vet thinks it's important for me to prevent and control JD; What my herd vet thinks I should do matters to me</td>
<td>8</td>
<td>-10</td>
<td>10</td>
</tr>
<tr>
<td>ON dairy organizations think it's important for me to control JD; What ON organizations think is important matters to me</td>
<td>8</td>
<td>-4</td>
<td>10</td>
</tr>
<tr>
<td>Dairy consumers think it's important for me to prevent and control JD; Consumer approval of my management matters</td>
<td>4</td>
<td>-6</td>
<td>10</td>
</tr>
<tr>
<td>Total Subjective Norm Score</td>
<td>22</td>
<td>-19</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perceived Behavioural Control Statements</th>
<th>Focus Farm Respondents</th>
<th>Control Respondents</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Belief Statement (1 to 5 scale); Power Statement (-2 to +2 scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing to control JD is too time consuming; When changing is time consuming I am (more-less likely) to change</td>
<td>0</td>
<td>-6</td>
<td>0</td>
</tr>
<tr>
<td>Changing to prevent and control JD is too expensive; When changing is expensive I am (more-less likely) to make them</td>
<td>0</td>
<td>-6</td>
<td>0</td>
</tr>
<tr>
<td>Recommendations to control JD aren't realistic; When they aren't realistic I am (more-less likely) to change</td>
<td>-2</td>
<td>-6</td>
<td>0</td>
</tr>
<tr>
<td>Preventing and controlling JD is difficult since I can't see signs or symptoms of it being present; When signs and symptoms of disease aren't visible I am (more-less likely) to make changes.</td>
<td>0</td>
<td>-8</td>
<td>6</td>
</tr>
<tr>
<td>The tests for JD don't provide me with accurate enough results to make changes; When tests aren't accurate I am (more-less likely) to make changes.</td>
<td>0</td>
<td>-10</td>
<td>8</td>
</tr>
<tr>
<td>Total Perceived Behavioural Control Score</td>
<td>-5</td>
<td>-17</td>
<td>8</td>
</tr>
</tbody>
</table>
Table 6 | Comparisons between RAMP1 and RAMP2 section scores, total scores, and gain scores among Ontario Focus Farm (FF) and Control respondents (October 2010 – January 2013; Ontario, Canada).

<table>
<thead>
<tr>
<th>RAMP Section (score)</th>
<th>FF Respondents</th>
<th>Control Respondents</th>
<th>FF-Control p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Survey</td>
<td>Post-Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Focus Farm Respondents</strong></td>
<td><strong>Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Section 1: Cattle Addition Risks (/60)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey</td>
<td>82</td>
<td>33.70</td>
<td>22.62</td>
</tr>
<tr>
<td>Mean</td>
<td>32.59</td>
<td>23.19</td>
<td>23.44</td>
</tr>
<tr>
<td>SD</td>
<td>41</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Med.</td>
<td>60</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>60</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.478</td>
<td>0.471</td>
<td>0.812</td>
</tr>
<tr>
<td><strong>Section 2: Calving Area Risks (/80)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey</td>
<td>82</td>
<td>31.30</td>
<td>10.84</td>
</tr>
<tr>
<td>Mean</td>
<td>28.49</td>
<td>9.00</td>
<td>13.75</td>
</tr>
<tr>
<td>SD</td>
<td>82</td>
<td>26</td>
<td>33</td>
</tr>
<tr>
<td>Med.</td>
<td>47</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Min</td>
<td>11</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Max</td>
<td>68</td>
<td>47</td>
<td>74</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.141</td>
<td>0.804</td>
<td>0.018</td>
</tr>
<tr>
<td><strong>Section 3: Heifers – Pre-weaned Risks (/70)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey</td>
<td>82</td>
<td>19.77</td>
<td>9.64</td>
</tr>
<tr>
<td>Mean</td>
<td>17.38</td>
<td>8.66</td>
<td>17.13</td>
</tr>
<tr>
<td>SD</td>
<td>78</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Med.</td>
<td>49</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Min</td>
<td>16</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Max</td>
<td>46</td>
<td>49</td>
<td>74</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.008</td>
<td>0.700</td>
<td>0.880</td>
</tr>
<tr>
<td><strong>Section 4: Heifers – Weaned to First Calving Risks (/40)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey</td>
<td>82</td>
<td>16.55</td>
<td>7.93</td>
</tr>
<tr>
<td>Mean</td>
<td>14.41</td>
<td>7.57</td>
<td>17.03</td>
</tr>
<tr>
<td>SD</td>
<td>78</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Med.</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Min</td>
<td>34</td>
<td>31</td>
<td>34</td>
</tr>
<tr>
<td>Max</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.641</td>
<td>0.924</td>
<td>0.107</td>
</tr>
<tr>
<td><strong>Section 5: Cows – Risks (/50)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey</td>
<td>82</td>
<td>15.04</td>
<td>8.09</td>
</tr>
<tr>
<td>Mean</td>
<td>13.87</td>
<td>7.85</td>
<td>15.03</td>
</tr>
<tr>
<td>SD</td>
<td>78</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Med.</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Min</td>
<td>38</td>
<td>35</td>
<td>32</td>
</tr>
<tr>
<td>Max</td>
<td>38</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.026</td>
<td>0.218</td>
<td>0.491</td>
</tr>
<tr>
<td><strong>Total Score (/300)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Survey</td>
<td>82</td>
<td>116.35</td>
<td>31.50</td>
</tr>
<tr>
<td>Mean</td>
<td>106.74</td>
<td>32.89</td>
<td>32.07</td>
</tr>
<tr>
<td>SD</td>
<td>78</td>
<td>114.38</td>
<td>32.07</td>
</tr>
<tr>
<td>Med.</td>
<td>114</td>
<td>39</td>
<td>116</td>
</tr>
<tr>
<td>Min</td>
<td>38</td>
<td>39</td>
<td>116</td>
</tr>
<tr>
<td>Max</td>
<td>189</td>
<td>188</td>
<td>186</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.001</td>
<td>0.861</td>
<td>0.268</td>
</tr>
<tr>
<td><strong>Gain Scores</strong></td>
<td>71</td>
<td>-13.13</td>
<td>25.67</td>
</tr>
<tr>
<td>Mean</td>
<td>23</td>
<td>-4.35</td>
<td>-8</td>
</tr>
<tr>
<td>SD</td>
<td>-11</td>
<td>36.06</td>
<td>-78</td>
</tr>
<tr>
<td>Med.</td>
<td>-75</td>
<td>-59</td>
<td>60</td>
</tr>
<tr>
<td>Min</td>
<td>-23</td>
<td>-23</td>
<td>-78</td>
</tr>
<tr>
<td>Max</td>
<td>-13.13</td>
<td>25.67</td>
<td>60</td>
</tr>
<tr>
<td>Pre-Post p-value</td>
<td>0.001</td>
<td>0.861</td>
<td>0.268</td>
</tr>
</tbody>
</table>
Table 7 | Final logistic regression model assessing the factors associated with making an on-farm change to address Johne’s Disease among 70 Ontario Focus Farm and 52 Control respondents (October 2010 – January 2013; Ontario, Canada). n = 98 farms, LR chi2(11) = 56.98, Prob > chi2 = 0.0000, Pseudo $R^2 = 0.4602$.

<table>
<thead>
<tr>
<th>Predictor Variable (Likelihood Ratio Test p-value)</th>
<th>Odds Ratio</th>
<th>Standard Error</th>
<th>t-test</th>
<th>p-value</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer group</td>
<td>Control (referent)</td>
<td>Focus Farm</td>
<td>33.72</td>
<td>29.38</td>
<td>4.04 &lt;0.0001</td>
</tr>
<tr>
<td>Herd size&lt;sup&gt;2&lt;/sup&gt;</td>
<td>&lt; 500 (referent)</td>
<td>Focus Farm</td>
<td>1.01</td>
<td>0.01</td>
<td>1.44 0.149</td>
</tr>
<tr>
<td>DHI management score (p = 0.036)</td>
<td>&lt; 500 (referent)</td>
<td>500 - 750</td>
<td>14.84</td>
<td>15.95</td>
<td>2.51 0.012</td>
</tr>
<tr>
<td>Perceived practicality of recommendations for JD control (p = 0.041)</td>
<td>Neutral (0) (referent)</td>
<td>Slightly negative (-1 to -3)</td>
<td>0.41</td>
<td>0.67</td>
<td>-0.55 0.585</td>
</tr>
<tr>
<td>VARK learning preference(s) (p = 0.034)</td>
<td>Multimodal preference (i.e. V, A, R, K) (referent)</td>
<td>Aural preference</td>
<td>95.02</td>
<td>164.63</td>
<td>2.63 0.009</td>
</tr>
<tr>
<td>Model constant</td>
<td>Bimodal preference (i.e. V, A)</td>
<td>2.98</td>
<td>3.68</td>
<td>0.88 0.378</td>
<td>0.26 33.59</td>
</tr>
<tr>
<td></td>
<td>Trimodal preference (i.e. V, A, R)</td>
<td>2.77</td>
<td>3.36</td>
<td>0.84 0.402</td>
<td>0.26 29.89</td>
</tr>
</tbody>
</table>

<sup>1</sup> Significance of categorical variables (p < 0.05) based on likelihood ratio tests

<sup>2</sup> Herd size forced into model as confounder
ABSTRACT

Purpose: To explore Ontario (ON) dairy producers’ (i) perceptions of the factors, and information sources, that are necessary for effective agricultural extension in the ON dairy industry, and (ii) VARK learning preferences and related respondent demographics.

Design/Methodology/Approach: A questionnaire, comprised of rank-order and open-ended questions, and the Visual, Aural, Read/write, Kinesthetic (VARK) instrument, was administered to 153 ON dairy producers between October 2010 and December 2011.

Findings: Respondents wanted their time to be valued, and to receive practical recommendations from trusted sources. While producer preferences were highly varied, nearly 68% (104/153) ranked veterinarians as their top information source. Approximately 58% (86/149) of respondents exhibited a singular preference for one of the VARK learning modes (44.2% K (38/86); 34.9% R (30/86); 20.9% A (18/86); 0.0% V (0/86)), while 18%, 15%, and 9% preferred a combination of two, three, or four modes, respectively. Respondents’ VARK learning preferences significantly differed by age ($p = 0.013$) and education level ($p = 0.035$).

Practical Implications: Veterinarians and extension specialists should aim to identify their clients’ preferences for learning new information through learning preference instruments, such as the VARK, and tailor their communication approaches accordingly. The ON dairy industry will reach producers by communicating through veterinarians and magazines, but multiple...
approaches are required to reach all producers. Information presented for the kinesthetic and read/write learner will be most effective for ON dairy producers.

*Originality/Value:* This study contributes to the knowledge of producer perceptions of extension methods and provides insights into the value of using learning preference instruments to create a tailored communication approach.

**INTRODUCTION**

Agricultural extension, as both a theory and a practice, has drastically changed over the past 30 years. Research contributions from numerous disciplines, and changes in agricultural issues, population demographics, government funding, and the functionality and accessibility of communication technologies (e.g. wireless handheld internet devices) have altered the goals and methods used for extension today (Coutts and Roberts 2011). Agricultural extension aims to effectively communicate, raise awareness, educate, motivate, support, and promote behavioural change to address farm-level factors such as production/yields, efficiency, and disease prevention and control (Andreata 2001; Lam et al. 2011). Although each extension program has unique goals and delivery methods, a common challenge is effective communication among key stakeholders (e.g. farmer, veterinarian, industry personnel, etc.) to achieve desired program outcomes (i.e. learning and change).

Learning and behavioural change are influenced by numerous factors, including the demographic characteristics, knowledge, and perceptions among the target population, as well as the communication strategies employed (Andreata 2001; Boxelaar and Paine 2005). Theories of behavioural change, such as the Health Belief Model (HBM; Rosenstock 1974) and the Theory of Planned Behaviour (Ajzen 1991), highlight the importance of both internal personal factors
(i.e. knowledge, perceptions and attitudes) and external pressures (i.e. extension and communication) in influencing an individual’s behaviour. Understanding the specific perceptions and attitudes that influence a given behaviour is thus important for tailoring extension strategies to promote and motivate behaviour change. Furthermore, extension and communication approaches are equally as important for influencing behaviour. In order for these external pressures to influence behaviour, they must be consistently, and effectively, communicated in a manner that results in its uptake (Jansen, Renes, and Lam 2010a).

An individual’s ability to learn and retain information is improved when the communication methods employed align with their learning style (Kolb 1984; Fleming and Baume 2006). The concept of ‘learning styles’ refers to a number of factors (i.e. environmental, emotional, social, psychological, and physiological stimuli) that influence an individual’s preference for gathering, interpreting, and processing information (Davis 2009; Dunn and Dunn 2010). An important component of an individual’s learning style is their ‘learning preference’, which corresponds to their specific preferences for receiving and communicating new information (e.g. visual learning versus reading and writing) (Fleming 2011a). While many aspects of an individual’s learning style are static and difficult to align with communication methods (e.g. environmental and physiological stimuli), extension specialists are able to tailor communication approaches to an individual’s learning preferences (Fleming 2011a). Although producers’ learning preferences have been documented in other parts of the world, such as New Zealand (Paine 1993; Gibson 2006; McLeod 2006) and the United States (Renick 2012), limited research has been conducted in Canada. Identification of Ontario dairy producers’ learning preferences can provide researchers, extension specialists, and veterinarians with valuable information for increasing the efficacy of communication strategies through learning preference alignment.
The Visual (V), Aural (A), Read/write (R), Kinesthetic (K) (VARK) questionnaire, is a popular questionnaire-based instrument used to classify individuals’ learning mode preferences (i.e. V, A, R, K) (Fleming 2011a). Visually-oriented individuals prefer graphic or symbolic representations of information (e.g. diagrams, maps, charts, graphs, etc.); aurally-oriented individuals prefer verbal communication (e.g. lecture, tutorial, discussions, etc.); read/write-oriented individuals prefer text-based communication (e.g. PowerPoint, lists, etc.); kinesthetic-oriented individuals prefer methods emphasizing experience, practice, and context (e.g. case studies, field trips, simulations, etc.). Individuals may also express a preference for more than one mode (Fleming 2011b). The VARK can thus be used to facilitate improvements in personal learning, staff development, one-on-one communication, and informing future extension strategies (Fleming and Baume 2006).

This study aimed to explore and describe Ontario (ON) dairy producers’ (i) perceptions of the factors, and information sources, that are necessary for effective agricultural extension in the ON dairy industry, and (ii) VARK learning preferences and demographics.

METHODS

Participant recruitment

Participant recruitment for this study has been previously described (Chapter 3). Briefly, in September 2010, bovine veterinarians in eight regions of ON (Seaforth, Kirkton, Listowel, Tavistock, New Liskeard, Napanee, Winchester, Navan) were recruited via email, personal communication, and advertisements in provincial dairy magazines, to act as facilitators in a voluntary educational intervention, aimed at ON dairy producers. Each recruited veterinarian was then responsible for recruiting dairy producers within their region to participate via clinic
newsletters, email, phone, and in-person communication. The intervention, called ON Focus Farms (FF), focused on increasing the adoption of management practices to control Johne’s disease (JD) and improve calf health on ON dairy farms (Chapter 3). Two 12-month cohorts of FF were conducted; cohort 1 (November 2010 to November 2011) participants were recruited in October 2010, while cohort 2 (December 2011 to December 2012) participants were recruited in November 2011.

For comparison purposes, another sample of ON dairy producers were recruited in April 2011, via email and postal mail, to form a control group. A random number generator was used to select 400 dairy producers from the ON milk marketing board (Dairy Farmers of Ontario) database, which holds current contact information for all ON producers. The inclusion criteria for participation were: being an owner or co-owner of a dairy herd in ON for at least 12 months, and being willing to refrain from participating in other formal, active extension programs during the study period. In addition, potential participants were excluded if they had participated in any JD research within the past 12-months.

**Data collection**

Data collection procedures for this study have been previously described (Chapter 3). Prior to the FF intervention, a questionnaire (Appendix III) was administered (paper copy or online) to cohort 1 participants between October and November 2010, while cohort 2 participants and control producers received it between November and December 2011. A portion of this questionnaire prompted respondents to answer rank-order questions corresponding to their preferences for, and perceptions of, various information sources (veterinarians, magazines, other producers, extension personnel, producer organizations, internet, scientific journals), used to
access farm-related information. Respondents ranked each information source from 1 to 7, using each number once (‘1’ being the most useful). Open-ended questions were also included to gain a more in-depth understanding of respondent perceptions of these information sources. In addition, respondents’ learning preferences were assessed using the VARK questionnaire (v. 7.1; Fleming 2011c), which is comprised of 16 multiple-choice statements, each of which describes a scenario with 4 potential actions. Respondents indicate their preference for one or more of the actions provided. Each action corresponds to a given learning mode (i.e. V, A, R, K) and upon completion, the number of actions corresponding to each learning mode is tallied and scored to identify the individual’s mode preference(s). Users of the VARK are assigned with either a singular preference or a combination of two (bimodal), three (trimodal), or four preferences (multimodal). Lastly, respondents were asked to provide demographic information (i.e. age, gender, education level, herd size).

Data analysis

As reported in Chapter 3, the pre-intervention questionnaire yielded a response rate of 54.1% (91/176) and 17.4% (62/357; 43 producers contacted were ineligible or no longer in the dairy industry) for FF and control producer groups, respectively. Given the objectives of the current study, FF and control group responses were collated, resulting in one pool of respondents (n =153).

To facilitate VARK learning preference analyses, the specific mode preferences of bimodal, trimodal, and multimodal respondents were separated and added to frequency counts for each mode accordingly. This provided a count of all respondents that had a preference for each given mode regardless of whether that preference is singular, or part of a combination of preferences.
Therefore, bimodal respondents are represented twice in frequency counts (once for each specific preference (e.g. V and A)); trimodal respondents are represented three times, and multimodal respondents, four times. For additional analysis of these data, the VARK learning preferences of another random sample of individuals who completed the VARK questionnaire online (www.vark-learn.com) between September and December 2012 were obtained as a reference population (Fleming 2011d) to compare with the study population.

Respondents with a missing answer for a particular variable (including ‘refused’ responses) were excluded from the analysis of that variable. Responses to open-ended questions were individually reviewed, categorized based on response similarities, and tallied to provide frequency counts. Statistical comparisons between categorical variables were conducted using Fisher’s exact tests, while differences between subcategories were assessed using a Binomial test for proportions. A significance level of \( p < 0.05 \) was used for all analyses. Data cleaning, screening, and analyses were conducted in STATA/IC 12 for Mac© (StataCorp, Texas, USA).

**RESULTS**

**Factors for effective communication**

In total, 92.2% (141/153) of respondents answered an open-ended question that asked them to report up to five factors that, in their opinion, were the most important for effective communication with producers. Individual factors were grouped together based on their similarities, and further placed into one of three broad categories: (1) program characteristics, (2) information characteristics, and (3) information sources. The specific factors listed, and their reported frequencies, are shown in Table 1.
When asked to rank the usefulness of various information sources, veterinarians were perceived to be the most useful, with 67.9% (104/153) of respondents ranking them first. The rank-order for the usefulness of the remaining information sources was highly variable among respondents (Figure 1).

**VARK learning preferences**

The VARK questionnaire was completed by 97.4% (149/153) of respondents. In total, 57.8% (86/149) of respondents exhibited a preference for one specific delivery mode. Among the 42.2% (63/149) of respondents preferring a combination of modes, 42.9% (27/63) were classified as ‘bimodal’, 34.9% (22/63) as ‘trimodal’, and 22.2% (14/63) as ‘multimodal’. Statistical comparisons between the VARK learning preferences of study respondents and a VARK reference population (Fleming 2011d) revealed a wide range of learning preferences and are shown in Table 2.

When the specific modes comprising the bimodal, trimodal, and multimodal preferences of respondents were separated and incorporated into the frequency counts for each specific delivery mode (i.e. V, A, R, and K), 61.1% (91/149) of respondents reported a preference for kinesthetic learning. Read/write was the second most common preference (48.3%; 72/149), followed by aural (46.3%; 69/149) and visual (19.5%; 29/149). Figure 2 shows the proportion of respondents that had a preference for each delivery mode, categorized by whether that preference is singular or part of a combination of preferences (i.e. bimodal, trimodal, or multimodal).
Association of VARK learning preferences with respondent demographics

Most respondents were male (86.9%; 133/153), between the ages of 35 and 54 (55.9%; 85/152), college/trade school educated (47.0%; 71/151), and had a dairy herd between 50 and 150 cows (64.0%; 98/153).

The individual VARK learning preferences were stratified by demographic characteristics (age, gender, education, herd size) and compared (Table 3). Respondents’ learning preferences significantly differed by age ($p = 0.013$); the vast majority of younger participants ($\leq 45$ years) preferred kinesthetic modes of learning (89.5%; 68/76), while participants between 45 and 65 held a wider variety of preferences, with read/write being the most popular mode (45%; 40/89). Respondents’ preferences also significantly differed by education level ($p = 0.035$); the majority of non-university educated respondents tended to prefer kinesthetic learning (62.7%; 74/118), while most university educated respondents preferred read/write modes of learning (60.0%; 18/30). Respondents did not significantly differ by gender ($p = 0.599$) or herd size ($p = 0.186$).

DISCUSSION

Factors for effective communication

This study explored ON dairy producers’ perceptions of key factors for effective agricultural extension. Respondents reported program characteristics, information characteristics, and information sources as being important. For program characteristics, respondents wanted an extension approach that: makes good use of the time they invest in participating, involves knowledgeable speakers and organizers, is convenient to access and participate in, makes organizers accountable for the process by following-up on participant questions and information needs, motivates the participants, and provides a forum for networking. In terms of information
characteristics, respondents expressed a desire for pragmatic information, clear and concise recommendations, information on farm economics and profitability, unbiased opinions, and evidence-based knowledge. Franz et al. (2010) qualitatively explored rice, beef, tobacco, dairy and organic fruit and vegetable farmers’ preferences for educational experiences in Louisiana, Tennessee, and Virginia, United States, and reported similar findings to the results reported in this study. Specifically, producers wanted extension specialists to: help with interpreting information, provide knowledge, build relationships, value their time, and focus on farm economics. Researchers, extension specialists, and veterinarians should thus provide practical information in a supportive setting to enhance the learning process for many producers.

Respondents also indicated that veterinarians were the most important source of information for their learning. This preference was further evidenced by respondents’ ranks on the usefulness of various information sources, where 80% of respondents ranked veterinarians first or second. This ranking was not unexpected, as veterinarians provide farm-specific service, and with the decline of public extension officers in ON over the past decade (Milburn, Mulley, and Kline 2010), veterinarians represent one of few opportunities for producers to obtain specific, one-on-one information from a professionally trained source. This preference for veterinarians has been documented elsewhere; Jansen et al. (2009) reported that Dutch dairy producers considered their veterinarian as the most important source of knowledge on udder health. Furthermore, Lam et al. (2011) reported that the personal relationship veterinarians have with their clients, and the knowledge of each client’s management and animal health situation, puts veterinary practitioners in an ideal situation to educate and motivate change among producers. Therefore, the utilization of veterinarians is crucial to the success of producer education efforts and must be considered a
central part of all communication approaches to effectively extend information to the producer population.

Respondents also considered magazines a useful source of information in this study, with 54% ranking them in their top three most useful sources. Print media has long been a traditional form of mass media extension, and other studies have documented similar producer perceptions towards this method of communication. For example, Russell and Bewley (2011) investigated Kentucky dairy producers’ perceptions of various information sources (magazines, newsletters, meetings, factsheets, on-farm, television, internet); 81% of producers reported that printed farm magazines were effective. Additionally, Jansen et al. (2010b) described the characteristics of Dutch dairy farmers that were deemed ‘hard to reach’ by their veterinarians; all study respondents felt farm magazines were their most important source for general information about udder health.

While the choice of delivery method(s) for a given extension program is influenced by a number of factors (e.g. content, the objectives (i.e. awareness vs. behaviour change), time, funding, etc.), it is important to consider the specific preferences of the target audience. Perhaps the most important result from respondent rankings reported here was that the perceptions of the usefulness of various information sources were diverse. Each option received ranks ranging from most useful (i.e. 1) to least useful (i.e. 7), indicating that respondents hold a wide array of preferences for specific information sources. Given the common preferences for veterinarian communication and magazines, the ON dairy industry will benefit from allocating resources to support these sources. However, given the clear diversity in preferences, the ON dairy industry must invest in multiple forms of information delivery in order to truly reach the entire dairy producer population.
VARK learning preferences

Nearly 60% of respondents in this study had a singular preference for one of the four VARK modes of learning. More specifically, K and R modes were most common among respondents, with over 45% of all respondents having a preference for K (~25%) or R (~20%). Among bimodal, trimodal, and multimodal respondents, preferences for specific combinations of modes (i.e. AK) were varied, with less than 10% of respondents showing a preference for each possible combination. Fleming and Baume (2006) suggested that information that is accessed using learning strategies that are aligned with one’s mode preferences is more likely to be motivating and result in deeper learning than when learning strategies and preferences are misaligned. Furthermore, in an article reviewing five common learning preference instruments (VARK included), Hawk and Shah (2007) concluded that a match of learning activities to learning preferences should result in: high levels of adult satisfaction with learning, high levels of academic performance, and deep, lasting student learning. Furthermore, Gibson et al. (2006) was able to improve communication between employers and employees among six of eight dairy farms in New Zealand by matching communication approaches with VARK learning preferences. Therefore, researchers, extension specialists, and veterinarians can improve producer communication by identifying target group learning preferences, through the use of learning preference instruments, and subsequently tailoring their communication approaches to align with them.

When compared to the reference population (Fleming, 2011d), the study population contained a significantly higher proportion of respondents with singular preferences. As a result, respondents within the study population had more specialized communication needs than the reference population. Fleming (2011d) noted that 93% of the reference population was comprised of
individuals in education (e.g. teachers, academics, researchers), and as a result, does not represent the profiles of a ‘typical’ population. When compared to other studies investigating VARK preferences among agricultural producers, the data presented here are similar. For example, McLeod (2006) assessed the VARK preferences of New Zealand dairy producers, and reported that 50% of respondents had a singular preference for one of the four modes; with 42% of all respondents having a preference for R (24%) or K (18%). Similarly, Renick (2012) explored VARK preferences of Arizona crop growers, and reported that nearly 45% of respondents had a singular preference for kinesthetic learning.

When the mode preferences of bimodal, trimodal, and multimodal individuals were separated, respondent preferences for K (~60%) and R (~48%) modes were even more apparent. These results have important implications for the dairy industry, as a tailored approach to communication at the population level is generally not possible or feasible. While recognizing that the K and R approaches will not be preferred by all producers, mass media or industry-wide communication efforts will be best served by providing information through these modes. From a kinesthetic perspective, extension efforts should include real-life examples from other farms and provide information that is relatable to the target producers. This information should be communicated through case studies, on-farm demonstrations, farm walks/tours, working models, videos, simulations, and examples that apply information to a specific problem. From a read/write perspective, extension efforts should provide information listed out and described in text, to allow these learners to read and receive information at their pace, in a form to which they can refer back. In the form of lists, descriptions, and stories, this information could be communicated through magazines, factsheets, newsletters, internet, and/or PowerPoint.
**VARK learning preferences and respondent demographics**

Age and education level were significantly associated with the specific modes of delivery. Young respondents (44 and under) preferred kinesthetic learning above other modes, while reading and writing was the most popular preference among older respondents (45 and over). Fleming (2005) reported this to be a common trend and suggested it may be because kinesthetic learning can be time consuming and as an individual ages, they build up a complex network of knowledge and experiences, which aids them in learning through other modes (namely read/write). McLeod (2006) observed a similar trend, with respondents tending to switch from kinesthetic preferences to read/write preferences in their mid-thirties. Furthermore, Renick (2012) found a moderate correlation between the VARK mode preferences and respondent age, suggesting that age may be a predictor of individual learning preferences. As a result, efforts should aim to provide producers with both kinesthetic and reading/writing learning opportunities.

Overall, researchers, extension specialists, and veterinarians should consider the age of their audience, as it may provide important insights into their learning preferences and facilitate the creation of a tailored communication approach.

With respect to level of education, high school educated respondents preferred aural and kinesthetic preferences almost equally, while college/trade school educated respondents had a strong preference for kinesthetic learning. However, university educated respondents exhibited a stronger preference for read/write modes, with aural and kinesthetic modes secondary. These differences might be due to respondents’ previous exposure to different educational teaching styles, or conversely, their decision on educational institution was based on their learning preferences. College/trade schools typically focus on real-life applications, using simulation, demonstration, and hands-on experiential learning methods; benefiting the kinesthetic learner.
University education typically suits aural and/or read/write learners by focusing on deeper thinking, theoretical frameworks, and deconstructing complex problems through lecture, independent study, and assigned readings. Renick (2012) also observed a moderate correlation between VARK mode preferences and respondents’ education level. Thus, consideration of the level of education of the target audience may allow researchers, extension specialists, and veterinarians to communicate more effectively by aligning preferences with communication approaches.

**Limitations**

The response rate obtained for FF producers (54%) and control producers (17%) reported in this study may have resulted in selection bias, in the form of non-response bias, as non-responders may have held different preferences than study respondents. Recent estimates on average herd size in ON show that the study population was representative of the larger provincial population (DHI 2013). However, further assessing the representativeness of the study population is difficult, as current and accurate data on the demographics of ON dairy producers are not readily available. Statistics Canada (2011) indicated that 71.6% of all ON farmers were male, while the average age of ON farm operators was 54.5 years. Assuming these census estimates reflect the ON dairy producer population, the study population tended to have more male producers, who were slightly younger than the population estimates from Statistics Canada. Additionally, as FF producers voluntarily agreed to participate in the active FF extension program, their responses and views with respect to extension and communication may not adequately reflect that of the larger ON dairy producer population. As a result, the extent to which the specific results discussed here can be generalized may be limited.
CONCLUSIONS

From a dairy producer perspective, effective agricultural extension involves the provision of pragmatic information, in a supportive setting, where organizers are accountable for ensuring that the participants’ needs are met, and for motivating change. While veterinarians are in a particularly useful position to provide such criteria, they must be able to communicate effectively in order to influence producer thinking and behaviour. Communication efforts can be improved through the use of learning preference instruments, such as the VARK, to further understand each producer’s preferences for learning. Researchers, extension specialists, and veterinarians should tailor their communication approaches, based on the results of these practices, to better meet the needs of their audience(s) to provide more effective agricultural extension. Most importantly, results from this study show that kinesthetic learning is a common preference among ON dairy producers. Communication and education efforts will be more effective by providing producers with opportunities to learn kinesthetically.

From a larger population perspective, an individual level understanding of producer preferences and perceptions, and a tailored communication approach, is not always possible. It is important to consider the target audiences’ preferences for, and perceptions of, various information sources, as this can impact the uptake of the information being disseminated. Large-scale extension efforts with ON dairy producers will benefit from utilizing veterinarians and published producer magazines for communication. Furthermore, the messages relayed from these sources will be most impactful for producers if they are framed for the kinesthetic and/or read/write learner. However, it is clear that multiple delivery methods need to be used, while maintaining a clear and consistent message, to ensure effective uptake of information among all producers in the ON dairy industry.
REFERENCES


Table 1 | Proportion of Ontario (ON) dairy producer respondents (n = 141) for whom specific factors were reported as important for effective communication with producers (October 2010 – December 2011; ON, Canada).

<table>
<thead>
<tr>
<th>Factors</th>
<th>n</th>
<th>#  (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time management/efficiency</td>
<td>47</td>
<td>(33.3)</td>
</tr>
<tr>
<td>Knowledgeable speaker/organizer</td>
<td>41</td>
<td>(29.1)</td>
</tr>
<tr>
<td>Convenient</td>
<td>29</td>
<td>(20.6)</td>
</tr>
<tr>
<td>Provide incentives (e.g. cash, free tests, guest speakers)</td>
<td>17</td>
<td>(12.1)</td>
</tr>
<tr>
<td>Organizer accountability; follow-up on questions and specific information needs</td>
<td>15</td>
<td>(10.6)</td>
</tr>
<tr>
<td>Motivating</td>
<td>15</td>
<td>(10.6)</td>
</tr>
<tr>
<td>Provide networking opportunities</td>
<td>11</td>
<td>(7.8)</td>
</tr>
<tr>
<td><strong>Information Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realistic/practical recommendations</td>
<td>59</td>
<td>(41.8)</td>
</tr>
<tr>
<td>Simple/plain language</td>
<td>39</td>
<td>(27.7)</td>
</tr>
<tr>
<td>Economics; ways to improve profitability</td>
<td>29</td>
<td>(20.6)</td>
</tr>
<tr>
<td>Sharing and interpreting results from specific tests; results reported in the literature</td>
<td>16</td>
<td>(11.3)</td>
</tr>
<tr>
<td>Accurate/unbiased</td>
<td>14</td>
<td>(9.9)</td>
</tr>
<tr>
<td>Provide evidence/support</td>
<td>7</td>
<td>(5.0)</td>
</tr>
<tr>
<td><strong>Information Sources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veterinarians</td>
<td>39</td>
<td>(27.7)</td>
</tr>
<tr>
<td>Group meetings with dairy producers</td>
<td>30</td>
<td>(21.3)</td>
</tr>
<tr>
<td>On-farm learning</td>
<td>22</td>
<td>(15.6)</td>
</tr>
<tr>
<td>Experts</td>
<td>22</td>
<td>(15.6)</td>
</tr>
<tr>
<td>Fact sheets/newsletters/magazines</td>
<td>21</td>
<td>(14.9)</td>
</tr>
<tr>
<td>Internet accessibility</td>
<td>16</td>
<td>(11.3)</td>
</tr>
<tr>
<td>New/unique ways of presenting it</td>
<td>6</td>
<td>(4.3)</td>
</tr>
</tbody>
</table>

* Up to 5 responses per respondent permitted
Table 2 | Comparison of Visual, Aural, Read/write, and Kinesthetic (VARK) learning preferences between Ontario (ON) dairy producer respondents (n = 149) and a VARK reference population (comprised of a sample of respondents who completed the VARK questionnaire online between September and December of 2012; n = 145,358 (Fleming, 2011d)) (October 2010 – December 2011; ON, Canada).

<table>
<thead>
<tr>
<th>Category</th>
<th>VARK Learning Preference</th>
<th>Study Population (n = 149) # (%)</th>
<th>VARK Population (n = 145,358) # (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singular</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual (V)</td>
<td></td>
<td>0 (0.0)*</td>
<td>4,215 (2.9)</td>
<td></td>
</tr>
<tr>
<td>Aural (A)</td>
<td></td>
<td>18 (12.1)*</td>
<td>10,175 (7.0)</td>
<td></td>
</tr>
<tr>
<td>Read/Write (R)</td>
<td></td>
<td>30 (20.1)*</td>
<td>21,803 (15.0)</td>
<td></td>
</tr>
<tr>
<td>Kinesthetic (K)</td>
<td></td>
<td>38 (25.5)*</td>
<td>16,861 (11.6)</td>
<td>0.008</td>
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<tr>
<td>Bimodal</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual-Aural (VA)</td>
<td></td>
<td>0 (0.0)</td>
<td>726 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Visual-Read/Write (VR)</td>
<td></td>
<td>1 (0.7)</td>
<td>1,598 (1.1)</td>
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<td>Visual-Kinesthetic (VK)</td>
<td></td>
<td>4 (2.7)</td>
<td>3,343 (2.3)</td>
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</tr>
<tr>
<td>Aural-Read/Write (AR)</td>
<td></td>
<td>4 (2.7)</td>
<td>4,360 (3.0)</td>
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<td>Aural-Kinesthetic (AK)</td>
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<td>12 (8.1)*</td>
<td>6,395 (4.4)</td>
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</tr>
<tr>
<td>Read-Write/Kinesthetic (RK)</td>
<td></td>
<td>6 (4.0)</td>
<td>4,942 (3.4)</td>
<td>0.584</td>
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<tr>
<td>Trimodal</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual-Aural-Read/Write (VAR)</td>
<td></td>
<td>5 (3.4)</td>
<td>1,162 (0.8)</td>
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</tr>
<tr>
<td>Visual-Aural-Kinesthetic (VAK)</td>
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<td>4 (2.7)</td>
<td>3,924 (2.7)</td>
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<tr>
<td>Aural-Read/Write-Kinesthetic (ARK)</td>
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<td>11 (7.4)</td>
<td>9,012 (6.2)</td>
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<tr>
<td>Visual-Read/Write-Kinesthetic (VRK)</td>
<td></td>
<td>2 (1.3)</td>
<td>3,488 (2.4)</td>
<td>0.045</td>
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<tr>
<td>Multimodal</td>
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<td></td>
<td></td>
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<tr>
<td>Visual-Aural-Read/Write-Kinesthetic (VARK)</td>
<td></td>
<td>14 (9.4)*</td>
<td>53,346 (36.7)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Proportion in that subcategory is significantly different (p < 0.05) between study and reference population.
Table 3 | Comparison of Ontario (ON) dairy producer respondents with visual (n = 29), aural (n = 69), read/write (n = 72), and kinesthetic (n = 91) preferences by demographic characteristics (age, gender, education level and herd size) (October 2010 – December 2011; ON, Canada).

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>n</th>
<th>Visual # (%)</th>
<th>Aural # (%)</th>
<th>Read/Write # (%)</th>
<th>Kinesthetic # (%)</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Overall</td>
<td>149</td>
<td>29 (19.5)</td>
<td>69 (46.3)</td>
<td>72 (48.3)</td>
<td>91 (61.1)</td>
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</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt; 35</td>
<td>39</td>
<td>7 (17.9)</td>
<td>19 (48.7)</td>
<td>12 (30.8)</td>
<td>32 (82.1)</td>
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</tr>
<tr>
<td>35 to 44</td>
<td>37</td>
<td>9 (24.3)</td>
<td>18 (48.6)</td>
<td>19 (51.4)</td>
<td>26 (70.3)</td>
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</tr>
<tr>
<td>45 to 54</td>
<td>46</td>
<td>8 (17.4)</td>
<td>20 (43.5)</td>
<td>26 (56.5)</td>
<td>19 (41.3)</td>
<td></td>
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<tr>
<td>55 to 64</td>
<td>23</td>
<td>4 (17.4)</td>
<td>10 (43.5)</td>
<td>14 (60.9)</td>
<td>10 (43.5)</td>
<td></td>
</tr>
<tr>
<td>&gt; 65</td>
<td>3</td>
<td>1 (33.3)</td>
<td>1 (33.3)</td>
<td>1 (33.3)</td>
<td>3 (100.0)</td>
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</tr>
<tr>
<td>Unknown</td>
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<td>0 (0.0)</td>
<td>1 (100.0)</td>
<td>0 (0.0)</td>
<td>1 (100.0)</td>
<td>0.013</td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>130</td>
<td>24 (18.5)</td>
<td>63 (48.5)</td>
<td>63 (48.5)</td>
<td>78 (60.0)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>19</td>
<td>5 (26.3)</td>
<td>6 (31.6)</td>
<td>9 (47.4)</td>
<td>13 (68.4)</td>
<td>0.599</td>
</tr>
<tr>
<td>Education level</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Grade school</td>
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<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>2 (100.0)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Some high school</td>
<td>6</td>
<td>0 (0.0)</td>
<td>2 (33.3)</td>
<td>3 (50.0)</td>
<td>5 (83.3)</td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>40</td>
<td>7 (17.5)</td>
<td>24 (60.0)</td>
<td>17 (42.5)</td>
<td>23 (57.5)</td>
<td></td>
</tr>
<tr>
<td>College/trade school</td>
<td>70</td>
<td>15 (21.4)</td>
<td>29 (41.4)</td>
<td>31 (44.3)</td>
<td>46 (65.7)</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>30</td>
<td>6 (20.0)</td>
<td>13 (43.3)</td>
<td>18 (60.0)</td>
<td>16 (53.3)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>1 (100.0)</td>
<td>1 (100.0)</td>
<td>1 (100.0)</td>
<td>1 (100.0)</td>
<td>0.035</td>
</tr>
<tr>
<td>Herd Size</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 51</td>
<td>37</td>
<td>6 (16.2)</td>
<td>15 (40.5)</td>
<td>17 (45.9)</td>
<td>21 (56.8)</td>
<td></td>
</tr>
<tr>
<td>51 to 150</td>
<td>96</td>
<td>20 (20.8)</td>
<td>48 (50.0)</td>
<td>46 (47.9)</td>
<td>64 (66.7)</td>
<td></td>
</tr>
<tr>
<td>&gt; 150</td>
<td>16</td>
<td>3 (18.8)</td>
<td>6 (37.5)</td>
<td>9 (56.3)</td>
<td>6 (37.5)</td>
<td>0.186</td>
</tr>
</tbody>
</table>

* Note: double counting is involved, as the demographic characteristics of respondents with bimodal (n = 27), trimodal (n = 22), and multimodal (n = 14) preferences have been incorporated within the frequency count for each mode found in their score (e.g. a bimodal respondent classified as ‘VA’ is counted once under visual and once under aural).
Figure 1 | Proportion of Ontario (ON) dairy producer respondents (n = 153) that listed the usefulness of each extension method/information source (veterinarians, magazines, other producers, extension personnel, producer organizations, internet, scientific journals) in each rank category (1-7; 1 being the ‘most useful’ and 7 being the ‘least useful’ for gaining farm-related information) (October 2010 – December 2011; ON, Canada).
Figure 2 | Proportion of Ontario (ON) dairy producer respondents (n = 149) with a preference for visual (n = 29), aural (n = 69), read/write (n = 72), or kinesthetic (n = 91) modes as part of a singular, bimodal, trimodal, or multimodal set of learning preferences (October 2010 – December 2011; ON, Canada). Double counting is involved, as respondents with bimodal (n = 27), trimodal (n = 22), and multimodal (n = 14) preferences have been incorporated within the frequency counts for each mode found in their score (e.g. a bimodal respondent classified as ‘VA’ is counted once under visual and once under aural)
CHAPTER SIX

Cost-benefit analysis of the Ontario Focus Farm process for improving on-farm adoption of JD control recommendations

ABSTRACT

The objective was to perform a cost-benefit analysis (CBA) of the implementation of an active agricultural extension process, called Ontario Focus Farms (FF) (previously described in Chapter 3, 4), to facilitate the adoption of recommended on-farm management practices to control Johne’s disease (JD) on Ontario (ON) dairy farms. A partial budget model was created to estimate the annual herd cost of JD in an average 78-cow ON dairy herd. The impact of JD control strategies on Neonatal Calf Diarrhea (NCD) was also considered by creating a second partial budget model to estimate the annual herd cost of NCD. With these estimates, a CBA was performed to assess the net benefits of implementing on-farm management scenarios (i.e. implementing one, two, or three of: calf feeding, maternity pen management, maternity area structure changes), where the benefits represent a reduction in the annual cost of JD and NCD. These models informed the final CBA assessing the net benefits of FF implementation over a 10-year period. The annual herd cost of JD was estimated to be $3,241.95, while the annual herd cost of NCD was estimated to be $1,309.17. When farms were expected to have both JD and NCD, all scenarios implemented over a 10-year period yielded positive net benefits ranging from $439.10 to $2,543.30 per farm. Overall, FF implementation in ON over a 10-year period yielded positive net benefits of $426,350.83 or $749,807.98, depending on whether veterinarians or non-veterinarians served as the facilitators, suggesting that its implementation would be valuable for reducing the burden of JD and NCD on ON dairy farms. Importantly, benefits of FF implementation are also likely to accrue to veterinarians, as a consequence of professional
facilitator training, and the ON dairy industry, as a result of improved milk quality and safety. As a result, the true net benefits of FF implementation are likely to be substantially higher than those explicitly monetized in this study. Overall, the FF process should be considered an economically viable program, worthy of investment by the dairy industry, veterinarians, and producers, as it has tremendous potential to yield positive net benefits to a variety of stakeholders within the ON dairy industry.

INTRODUCTION

Johne’s disease (JD) is an important production-limiting disease affecting dairy cattle and other ruminants in many countries worldwide (Sweeney et al., 2012). In addition to decreased milk production and premature culling of subclinical animals, clinically affected animals typically develop chronic diarrhea and waste away over time (Tiwari et al., 2006). In Canada, recent studies report that 10% to 40% of dairy herds have at least two seropositive cows (Tiwari et al., 2006; 2009). Two partial budgets, monetizing the annual herd costs of JD using Canadian estimates, estimated losses of $2,472 (50-cow dairy herd with 7% apparent within-herd prevalence (Chi et al., 2002) and $2,992 (61-cow dairy herd with 12.7% within-herd prevalence (Tiwari et al., 2008). Extrapolating these estimates to all of Canada has resulted in an estimated annual loss of over $15 million for the Canadian dairy industry (McKenna et al., 2006).

Additionally, there is growing concern over research suggesting that the causal organism, *Mycobacterium avium* subsp. *paratuberculosis* (MAP), plays an important role in causing Crohn’s disease (CD) in genetically susceptible humans (Feller et al., 2007; Waddell et al., 2008; Chiodini et al., 2012; Sweeney et al. 2012). A causal-link between MAP and CD, or even a perception among consumers that MAP exposure (through the consumption of dairy products) is a health risk, could have devastating financial impacts on the Canadian dairy industry.
With no cost-effective treatment available, the most common approach to addressing the disease is through JD control programs based on periodic testing of cows to identify test-positive cows and implementing management changes to improve farm biosecurity (Sweeney et al., 2012). In Canada, JD control is coordinated nationally; however, each province is responsible for creating and administering their control program (Barker et al., 2012). Beginning in 2010, Ontario (ON) implemented a three-year voluntary JD control program, called the Ontario Johne’s Education and Management Assistance Program (OJEMAP) (OJEMAP, 2009). The voluntary program was comprised of an education component, a veterinarian-administered on-farm risk assessment, and an option for a fully compensated whole-herd JD test. The education component of OJEMAP focused on the development of an extension model to improve the adoption of on-farm management practices to control JD. The resulting model, Ontario Focus Farms (FF), is a self-directed, learner-centred process that aims to influence producer behaviour by addressing their knowledge, attitudes, perceptions, and opinions (Chapter 3). Practically, FF is implemented as a series of professionally facilitated small group meetings of dairy farmers, which are self-directed based on group-identified priorities. Results of an evaluation of the FF process showed that it was effective in improving participants’ knowledge about JD, and changing their attitude and behaviour with respect to on-farm management; with 81% of FF respondents implementing at least one on-farm management change for JD control compared to 38% of control respondents (Chapter 4). Having obtained positive results from the FF evaluation, the next step is to continue to implement the process with more producers across the province to help reduce the burden of JD in ON. However, further implementation requires additional investment. To facilitate the acquisition of funds to continue to implement FF, and to demonstrate the cost-effectiveness of FF, an economic evaluation is required.
Cost-benefit analysis (CBA) provides a framework for economically evaluating the efficacy of the FF process for JD control. Commonly used in economics, CBA considers future costs and benefits, which accrue over a given time period, in present day dollars by discounting future cash flows at a predetermined rate, to obtain the Present Value (PV). The PV costs and PV benefits are then subtracted to calculate the Net Present Value (NPV), or the value of the expected future returns of an investment minus the value of the expected future costs (Boardman et al., 2010). From this perspective, costs of FF implementation mainly represent direct transactions for goods and services (e.g. meeting rooms, facilitation costs, etc.). The benefits of FF implementation accrue as a result of FF participants implementing on-farm management changes (i.e. calf feeding changes, changes to maternity pen management, maternity area structure changes), which reduce the cost of JD primarily through the prevention of new MAP infections. The main objective of this study was to perform a CBA to evaluate the NPV of implementing FF in ON over a 10-year period to facilitate the adoption of on-farm management practices to prevent and control JD.

**METHODS**

**General modeling approach**

While the costs of FF implementation are easy to monetize, the benefits are more complicated, given the need to first estimate the cost of JD to an average farm and the impact of implementing various on-farm management practices on the prevalence of JD over time. While Canadian estimates of the herd cost of JD are available (Chi et al., 2002; Tiwari et al., 2008) they are dated and based on the characteristics of dairy herds in the Maritime provinces, and as such are not likely to be representative of the current ON dairy industry. Thus, the first step to meet the
The objective was to create a partial budget to estimate the annual herd cost of JD on an average ON dairy farm. Furthermore, given the fecal-oral transmission of MAP, the implementation of management changes for JD control also have indirect effects on other fecal-orally transmitted diseases, most notably the control of Neonatal Calf Diarrhea (NCD). Therefore, there was also a need to create a partial budget to estimate the annual herd cost of NCD on an average ON dairy farm.

The second step was to perform a CBA of the implementation of one, two, or three on-farm management practices (i.e. calf feeding changes, changes to maternity pen management, maternity area structural changes) to assess the net benefits of implementing various combinations of on-farm changes to prevent the spread of JD. The final step was to use the previously calculated estimates to inform the completion of a CBA to assess the net benefits of FF implementation in the ON dairy industry over a 10-year period.

For all CBA models, PV costs and PV benefits were calculated using equation 1 and 2. For this study, all discounting was done for a 10-year time period. Given that a moderate level of uncertainty in the realization of future cash flows exists, a discount rate of 8% was used, a rate that is commonly used in agricultural economic analyses (Wolf et al., 2002; FAO, 2003; Pillars et al., 2009). Once all PV costs and PV benefits were estimated, the NPV was calculated using equation 3.

All partial budgets and CBA models were built in Microsoft® Excel 2011 for Mac (version 14.3.8). All monetized estimates are reported in Canadian dollars (CAD$). Model parameters and estimates were obtained from published literature, when available, personal communication. 
with an expert, and/or informed author assumptions. The specific parameters, estimates and calculations used for all analyses are discussed in detail below.

**Estimating the cost of Johne’s Disease and Neonatal Calf Diarrhea**

Input parameters used for the partial budget models included industry- and herd-level characteristics, JD impacts on milk production and culling, and NCD impacts on treatment costs and inputs lost to calf mortality.

*Industry- and herd-level characteristics*

The average milk price for all analyses was set at $77/100kg (DFO, 2013), the average ON dairy herd size was set at 78 milking cows (CanWest DHI, 2013), and it was assumed that each cow would calve once each year, with 50% of all calves born (39) being heifer calves.

As the vast majority of the JD testing for the OJEMAP was done using a commercial milk enzyme-linked immunosorbent assay (ELISA) (Parachek; Prionics, Zurich, Switzerland), an effort was made to collect estimates for the cost of JD that were obtained with a milk ELISA. Based on recent Canadian findings from Ontario (Pieper et al. unpublished) and Ontario, Manitoba, Saskatchewan, and British Columbia (Sorge et al. 2010; 2011a), the apparent within-herd test positive prevalence of JD was assumed to be 7%. The reported sensitivity (Sn = 61.1%) and specificity (Sp = 98%) of the Prionics milk ELISA (Hendrick et al., 2005a), and the apparent within-herd prevalence of JD, were used to estimate the true within-herd prevalence of JD using equation 4 (Dohoo et al., 2009). Using this equation, the estimated true within-herd prevalence of JD used in this study was 10%.

The incidence of NCD was assumed to be 23% based on recent findings from Windeyer (2013), while the case fatality rate of NCD was set at 6% (Windeyer et al., 2014). Additionally,
the severity of NCD cases was assumed to be 85% mild and 15% severe based on personal communication with a dairy calf specialist (K. Leslie, University of Guelph, Guelph, Ontario, personal communication).

**Johne’s Disease – reduced milk production**

A recent study, using data from milk recorded Canadian dairy farms found a significant association between milk ELISA test result, parity group, and mean 305-day milk production (Sorge et al., 2011b). Both low test positive score (≥0.1 – <1.0) and high test positive score (≥1.0) cows produced significantly less milk as parity group increased. Data from OJEMAP indicates that 11% (147/1,385) of all JD milk ELISA test positive cows had high test scores (OJEMAP, 2013). For this study, the milk loss estimates reported by Sorge et al. (2011b) for parity groups 1 and 2 were weighted by the proportion of low and high test-positive animals, based on the reported findings of OJEMAP (2013), and then averaged to obtain a single value for the average milk loss of a MAP-infected animal in parity group 1 and 2. The milk loss estimates reported by Sorge et al. (2011b) for parity group ≥3, were averaged and then similarly weighted based on the OJEMAP (2013) data. The resulting estimates were an average of 72 kg/cow/305-day lactation, 211.34 kg/cow/305-day lactation, and 460.78 kg/cow/305-day lactation lost for cows in parity group 1, 2, and ≥3, respectively.

With estimates of the average milk loss among MAP-infected animals in each parity group, estimates of the number of MAP-infected cows in each parity group were needed; however, Canadian estimates were not available. Nielsen et al. (2002) reported the odds of a JD test-positive cow, using a milk ELISA, in parity group 1 (OR = 1.00), parity group 2 (OR = 3.15), and parity group ≥3 (OR = 3.87) for cows in Danish dairy herds. These odds were summed to obtain a constant of 8.02. The total number of MAP-infected cows in this study (7.8) was divided
by the constant and then multiplied by the odds of an infected cow arising in each parity group (Nielsen et al., 2002). The resulting estimates for the number of MAP-infected cows in each parity group were 0.97, 3.06, and 3.76 MAP-infected cows in parity group 1, 2, and ≥3, respectively.

The total cost of reduced milk production, in each parity group, was estimated by multiplying the average milk price by the average milk loss for that parity group, which was then multiplied by the estimated number of MAP-infected cows in that parity group. The cost in each parity group was then summed to obtain the total annual herd costs due to reduced milk production.

**Johne’s Disease – suboptimal culling**

Suboptimal culling refers to the premature culling of MAP-infected cows and subsequent need for replacements. The cow culling decision module ‘Cow Value’, found in the dairy herd management computer program DairyComp305 (DC305; Valley Agricultural Software, Tulare, CA) was used to obtain estimates of the cost of having to prematurely cull and replace a MAP-infected cow. This module considers a number of herd characteristics and calculates the NPV of each cow in the herd relative to the average replacement heifer. Specifically, Cow Value considers the following inputs: heat detection rate, conception rate, voluntary waiting period, average days open, heifer cost, cow cull value, milk price/100kg, marginal feed costs, maintenance feed costs, discount rate, cull rate (by parity), average 305-day milk production, and lactation persistence. Based on this calculation, cows with a positive NPV are more valuable to that farm than an average replacement heifer and should remain in the herd, while cows with a negative NPV are less valuable and should be replaced. If a cow with a positive NPV is culled and replaced, the NPV is considered the cost of making that transaction. Cow Value estimates
were computed using default values for every ON dairy farm registered with CanWest DHI that had a JD milk ELISA high test-positive cow (OJEMAP, 2013). Estimates were separated based on low ($\geq 0.1 < 1.0$) and high ($\geq 1.0$) test-positive results and then averaged. The resulting estimates were a NPV of $874$ for low test-positive cows and $753$ for high test-positive cows. To obtain a single estimate of the average cost of culling and replacing a MAP-infected cow, estimates were weighted based on the proportion of high and low test-positive cows reported by OJEMAP (2013), resulting in an average cost of $860.70$ per cow.

To get an estimate of the herd cost of suboptimal culling due to MAP infection the number of cows being prematurely culled was needed. Previous partial budgets on the cost of JD in Canadian dairy herds used estimates of 10.9% (Tiwari et al., 2008) and 20% (Chi et al., 2002). Additionally, Sorge (2010) reported that JD milk ELISA test-positive cows in Canada were three times more likely to be culled than test-negative herd mates, within one year of the JD test, due to their test-positive status. For the present study, it was assumed that MAP-infected cows had a 20% increased risk of being culled prematurely. Based on this assumption, the number of MAP-infected cows was multiplied by the average cost of suboptimal culling per cow, which was then multiplied by the risk of being suboptimally culled, resulting in a herd estimate of $1,342.95$.

**Neonatal Calf Diarrhea – treatment costs**

The annual number of heifer calves with NCD was estimated by multiplying the estimate of the number of heifer calves born each year (39) by the estimated incidence of NCD (23%) reported by Windeyer (2013). The number of heifer calves treated for mild and severe NCD was estimated by multiplying the number of heifer calves with NCD by the proportion of heifer calves assumed to have mild (85%) and severe (15%) cases of NCD. The cost of treating mild and severe cases of NCD, including veterinary costs and drugs administered, was assumed to be
$35/day and $120/day, respectively (K. Leslie, University of Guelph, Guelph, Ontario, personal communication). Waltner-Toews et al. (1986a) reported that the average number of days calves were treated for NCD was 3 days, which was the estimate used for treatment of all heifer calves with NCD in this study. The total treatment costs for NCD were estimated by multiplying the number of calves treated for both mild and severe cases of NCD by the respective cost of treatment for mild and severe cases, which was then multiplied by the number of treatment days per case.

**Neonatal Calf Diarrhea – inputs lost to heifer calf mortality**

The average age of mortality of calves due to NCD was recently estimated in Canada at 15 days (Windeyer, 2013). The annual number of heifer calves dying due to NCD was estimated by multiplying the number of heifer calves with NCD by the estimated case fatality rate of NCD (6%). The marginal feed costs for pre-weaned heifers was assumed to be $3.00 per day (K. Leslie, University of Guelph, Guelph, Ontario, personal communication). The total feed costs lost due to NCD, per heifer calf, was then estimated by multiplying the marginal feed costs of pre-weaned heifer calves by the average age of mortality due to NCD. The total annual feed costs lost due to NCD mortality was estimated by multiplying the annual number of heifer calves dying due to NCD by the total feed costs lost, per heifer calf, as a result of NCD mortality.

**Cost-Benefit Analysis for implementing on-farm management changes**

A series of assumptions about the management practices currently in place on an average farm in this study were made. It was assumed that newborn heifer calves are typically fed colostrum, by tube or bottle, directly from the dam, and that heifer calves are typically fed bulk-tank milk, or non-saleable waste milk. Maternity pen hygiene was assumed to be average, with visible manure removed and new bedding added to the bedding pack in between calvings. It was also assumed
that heifer calves stayed with the dam for 48 hours prior to being removed, with no physical separation between them during that time. Lastly, it was assumed that herds used a single group maternity area with more than one cow present more than two-thirds of the time. Under these ‘base’ assumptions, the PV costs of JD, using a true within-herd prevalence of 10%, and the PV costs of NCD, using a within-herd incidence of 23%, were calculated over a 10-year term. Levels of within-herd infection for both JD and NCD were assumed to remain fixed over the 10-year period, to provide a conservative estimate of the PV costs of disease over this time frame.

The benefits realized by the implementation of FF accrue to each producer as a reduction in the cost of JD and NCD by preventing new infections, which occurs as a result of the implementation of on-farm changes for JD and NCD control. For this study, it was assumed that producers would focus on making on-farm management changes to one, or more, of the following areas: (1) calf feeding, (2) maternity pen management, (3) maternity area structure. A unique estimate for cost and benefit was assigned to each management change, the specifics of which are described below.

**On-farm management changes**

Farms implementing calf feeding changes were assumed to meet the following criteria: 66% of heifer calves are fed low-risk colostrum from JD milk ELISA test-negative cows; 33% of heifer calves are fed purchased colostrum replacer; 100% of heifer calves are fed milk replacer.

Farms implementing maternity pen management changes were assumed to meet the following criteria: heifer calves are separated from dam (either complete removal from the maternity area or physically separated from dam within maternity area, to prevent suckling but maintain dam-calf contact) within 2 hours of being born; maternity pen is cleaned more frequently and is thoroughly cleaned in between calvings. Farms implementing maternity area structural changes
were assumed to meet the following criteria: structural changes would be made to the existing group maternity area to construct three individual calving pens using farm gates.

**Cost of on-farm management changes**

The cost of calf feeding changes was comprised of the cost of colostrum replacer ($19.70/cow; Wolf et al. unpublished) and milk replacer ($1.63/cow; Quigley 2014). It was assumed that a producer would need 5 extra minutes to properly feed each heifer calf low-risk colostrum. The cost of labour ($17.33/hour; Lang, 2010) was divided by 60 and then multiplied by 5 to monetize this time requirement. An overall estimate for the cost of calf feeding changes per cow was obtained by separately multiplying the estimated cost of each parameter by the proportion of heifer calves receiving each product, then summing the totals, and dividing by the total herd size.

It was assumed that a producer would need an extra 20 minutes per cow to adequately make maternity pen management changes. The cost of labour ($17.33/hour; Lang, 2010) was divided by 60 and then multiplied by 20 to get the cost of maternity pen management changes per cow.

It was assumed that six separate galvanized steel gates would be needed to complete all maternity area structure changes. After sourcing gate prices from a number of Canadian retailers, an estimated total cost for 6 gates was assumed to be $1,000. It was also assumed that another $500 would be incurred to properly install the gates. The life of the gates were estimated to be 10 years. An overall estimate of maternity area structure changes per cow was estimated by dividing the total cost of maternity area structure changes divided by the herd size.
The total annual costs for calf feeding and maternity pen management changes, and the total one-time cost of maternity area structure changes, were estimated by multiplying the cost of implementation per cow by the herd size.

**Benefits of on-farm management changes for Johne’s Disease control**

Estimates of the annual reduction in within-herd JD prevalence, as a result of implementing all three management practices discussed above, range from 5% to 11% (Benedictus et al., 2008; Ferrouillet et al., 2009; Collins et al., 2010; Nielsen et al., 2011). As the two most recent estimates suggest an annual reduction by 10% (Collins et al., 2010; Nielsen et al., 2011), an estimate of 10% was chosen as the annual reduction in JD prevalence as a result of implementing all management practices in this study. This value was then subdivided based on the demonstrated impact of each individual management change.

Several studies have concluded that calves nursing on the dam, feeding pooled colostrum and/or milk, as well as poor hygiene of these products, are risk factors for MAP infection (Goodger et al., 1996; Dorshorst et al., 2006; Nielsen et al., 2008). Additionally, Pithua et al. (2009) reported that calves fed raw colostrum were approximately two times more likely to be JD test-positive, using serum ELISA and fecal culture, than calves fed colostrum replacer. Given the fecal-oral transmission of MAP, it is anticipated that changes to calf feeding, as outlined above, will have a positive effect on preventing new infections.

A number of studies have reported poor maternity pen hygiene as a risk factor for MAP infection (Merkal et al., 1975; Dorshorst et al., 2006; Ferrouillet et al., 2009). A JD simulation suggested that the removal of calves prior to suckling was effective in reducing the within-herd prevalence of JD (Groenendaal et al., 2003), while Merkal et al. (1975) demonstrated that quicker separation of cows from calves to a clean environment significantly decreased the risk of
MAP infection. This lends evidence that the maternity pen management changes outlined above are likely to have a positive effect on preventing new infections. As the environment a calf is born into is the first opportunity for a challenge to disease, even prior to feeding, this management change was deemed to be more effective than calf feeding changes at reducing new infections.

Evidence of the effect of maternity area structure changes on within-herd JD prevalence is currently limited in the literature. One study did experimentally assess the efficacy of individual calving pens, versus group calving pens, to reduce MAP infection among newborn calves in Minnesota (Pithua et al., 2013). They reported that the use of individual calving pens significantly decreased the risk of MAP infection. Therefore, the implementation of this change among producers within this study was considered to be similarly effective to maternity pen management changes.

Based on the estimated annual reduction in within-herd JD prevalence, as a result of all three management practices (10%), the observed impact of each management practice as reported in the literature, and based on biological plausibility, the annual reduction in true within-herd JD prevalence was assumed to be 2% for calf feeding changes and 4% for each of maternity pen management and maternity area structure changes, if the practice was implemented 100% of the time.

**Benefits of on-farm management changes for Neonatal Calf Diarrhea control**

It was assumed that performing all three on-farm management practices would decrease the annual incidence of NCD by 25% (K. Leslie, University of Guelph, Guelph, Ontario, personal communication). This value was then further subdivided among the three specific practices outlined above.
It has been reported that calves suckling colostrum are at increased risk of NCD morbidity and mortality (Wells et al., 1997; Svennson et al., 2003; Gulliksen et al., 2009). Given this risk factor, and anticipating that colostrum and milk quality would be significantly improved as a result of calf feeding changes, it was assumed that implementing calf feeding changes would significantly reduce the incidence of NCD.

The effect of maternity pen management on the incidence of NCD was informed by Wells et al., (1997) who reported that the risk of NCD increases the longer a calf is with the dam in the maternity pen. Trotz-Williams et al. (2007) also showed that the odds of diarrhea among ON calves that were allowed to stay with their dams after birth were higher than those moved within an hour of birth. It was assumed that the effect of this change would have a moderate positive effect on the incidence of NCD. Lastly, Gulliksen et al. (2009) reported that calves born in group maternity pens were are greater risk of morbidity and mortality due to NCD. Given this risk factor, it was expected that maternity area structure changes would be moderately beneficial at reducing the incidence of NCD.

Based on the estimated annual reduction in NCD incidence, as a result of all three management practices (25%), the observed impact of each management practice in the literature, and biological plausibility, the annual reduction in NCD incidence was assumed to be 15% for calf feeding changes and 5% for both maternity pen management and maternity area structure changes, if the practice was implemented 100% of the time.

*Persistence of on-farm management changes*

The realization of costs and benefits of each change are dependent on how persistent producers are at performing the behaviour over time (i.e. feeding calves or removing heifer calves from the maternity area). The persistence of a changed behaviour was assumed to be
influenced by how difficult the behaviour was to perform, and the cost associated with it. With an assumed low implementation difficulty and a relatively small cost, those that committed to making calf feeding changes were expected to perform the behaviour 90% of the time. With a moderate implementation difficulty and a somewhat higher cost, those that committed to maternity pen management changes were expected to perform the behaviour 75% of the time. Lastly, while maternity area structure changes require substantial upfront investment and are assumed to be the most difficult to implement, structural changes are permanent and do not require further producer involvement, resulting in a persistence of 100%.

As persistence was not assumed to be 100% for all practices, the true annual benefits of each on-farm management change for JD were estimated by multiplying the persistence of each changed behaviour by the estimated annual reduction in true within-herd JD prevalence as a result of carrying out the behaviour 100% of the time. While the true annual benefits of each on-farm management change for NCD were estimated by multiplying the persistence of each changed behaviour by the estimated annual reduction in NCD as a result of carrying out the behaviour 100% of the time.

**Net present value of implementing on-farm management changes**

Producers were assumed to implement one, two, or all three of the management practices considered in this study over a 10-year time frame, resulting in seven potential implementation scenarios. Scenarios 1 (calf feeding changes), 2 (maternity pen management changes), and 3 (maternity area structure changes) involve the implementation of one single change and incur annual costs and benefits as outlined above. The remaining scenarios (scenario 4: scenario 1 and 2; scenario 5: scenario 1 and 3; scenario 6: scenario 2 and 3; scenario 7: scenario 1, 2 and 3) incur greater annual costs and benefits due to the implementation of multiple practices; thus, the
costs and benefits of each practice were summed together based on the specific combination of practices implemented.

In addition, as the incubation period of JD is a minimum of two years (Tiwari et al., 2006) and the effect of implementing changes on the within-herd JD prevalence aim to prevent new infections, it was assumed that all benefits did not begin accruing until two years after implementation. Conversely, the effect of changes on the incidence of NCD were expected to be immediate, with annual benefits accruing for two years and then remaining fixed at the second year incidence rate for the remainder of the 10-year term. Lastly, it was assumed that as producers observed positive impacts of the management practices on the incidence of NCD in the first year of implementation, their persistence to perform the change in the second year would improve. For calf feeding changes, persistence was assumed to increase from 90% to 95% in year two, and remain at that level, while the persistence was assumed to increase from 75% to 85% in year two, and remain at that level, for maternity pen management changes.

The PV costs of implementing each scenario were estimated by discounting the total annual costs of implementing each given scenario over a 10-year period, at 8%. The PV benefits of implementing each scenario were estimated by first calculating the PV costs of JD and NCD when no management changes are made. The PV costs of JD and PV costs of NCD after implementation of each management scenario were then calculated and subtracted from the PV costs of JD and NCD with no management changes, to obtain a final estimate of the benefits of reducing the cost of JD and NCD for each scenario.

The NPV of implementing changes was calculated once assuming a farm was only dealing with NCD, and another time assuming a farm was dealing with both JD and NCD. To
estimate the NPV of implementing each management scenario for farms only dealing NCD (within-herd JD prevalence of 0), the PV costs of implementation for each scenario were subtracted from the PV benefits for NCD. The NPV of implementing each management scenario for farms dealing with both JD and NCD was estimated by subtracting the PV cost of implementing each scenario by the sum of the PV benefits of JD and NCD.

**Cost-Benefit Analysis for implementing Ontario Focus Farms**

*Ontario Focus Farm implementation characteristics*

A series of estimates for the implementation of FF were generated based on results of previous work (Chapter 3). In particular, it was estimated that 8 FF groups would be held in ON each year. Each FF group was assumed to have 12 dairy producer participants that formally met 4 times in one year, for 6 hours each meeting. At the end of each year, it was assumed that a new group of dairy producers would begin the FF process.

*Start-up costs*

The start-up costs incurred for FF implementation related to facilitator training and administrative support. Through personal communication with the FF coordinator, an estimate for the cost of professionally training each facilitator was obtained (T. Nelson, Livestock Research and Innovation Corporation, Guelph, Ontario, personal communication). Training occurred over two days, lunch was provided each day, and hotel costs were covered for out of town facilitators (50% of facilitators were assumed to require a hotel). As described in Chapter 3, one facilitator is required per FF group; based on an assumption that 8 FF groups would be run each year, total training costs were estimated for 8 facilitators. Administrative support was also required to recruit facilitators, brief them about project goals and the FF format, assist facilitators in recruiting participants and coordinating project finances. An estimate of 60 hours was
obtained for administrative support (T. Nelson, Livestock Research and Innovation Corporation, Guelph, Ontario, personal communication). An hourly wage of $20 was assumed for administrative support, with an extra $200 assumed to cover consumables (i.e. office space, phone, fax, internet, paper). The total start-up costs were estimated by summing the total costs for facilitator training and administrative support.

**Recurrent costs**

Recurrent costs (i.e. those costs incurred during each FF meeting), included: consumables (i.e. food, refreshments, paper) for each meeting, facilitator costs, a facilitator aid, and costs for guest speakers. Through personal communication with the FF coordinator, estimates were obtained for the cost for consumables at each FF meeting (T. Nelson, Livestock Research and Innovation Corporation, Guelph, Ontario, personal communication). The average cost to rent a meeting room ($200), the average cost of meeting materials ($5), and the cost of lunch per person ($12; facilitator included) were used to estimate the cost of consumables for each FF meeting. Recurrent facilitator costs corresponded to the facilitator’s time to prepare for each FF meeting and to facilitate each FF meeting. Veterinarian facilitators were used for FF implementation (Chapter 3) and were estimated to cost $2,000 per meeting. Considering a veterinarian’s time is costly, an alternative scenario was considered where a member of the dairy industry (termed a ‘non-veterinarian facilitator’) might facilitate each FF meeting, at an estimated cost of $1,000/meeting. Regardless of facilitator type, it was assumed that a facilitator assistant would be needed to help coordinate and implement FF, at an estimated cost of $160/FF meeting (8 hours*$20/hour). The average cost of a guest speaker was estimated to be $1,250 for each FF meeting, and it was assumed that 50% of FF meetings (2 of 4) would use a guest speaker. The total recurrent costs incurred per FF meeting were estimated for implementation with
veterinarian facilitators, and again for implementation with non-veterinarian facilitators, by summing each recurrent cost listed above.

**Opportunity costs for Ontario Focus Farm participants**

As producers forgo their duties on the farm to attend each FF meeting, they incur an opportunity cost (i.e. the value of the next best alternative use of a producer’s time). The average wage of Canadian herd managers ($17.33/hour; Lang, 2010) was used to monetize the marginal opportunity cost. Assuming 1 hour of travel time, and a 6-hour FF meeting, the opportunity cost for each producer was estimated at $121.31, which was then multiplied by the number of FF participants per FF group (12) to obtain the total opportunity cost per FF group per FF meeting.

**Benefits of Ontario Focus Farm implementation**

Given that the benefits of FF implementation accrue to producers as a result of implementing various on-farm management changes, assumptions about the proportion of FF participants that will implement a change, and which changes they will implement, were required to properly monetize annual FF benefits. Chapter 3 reported that ~81% of FF participants implemented at least one on-farm management change for JD control. With an assumed 96 FF participants per year (12 participants/FF group*8 groups), 77.76 producers were estimated to implement one of the seven management scenarios each year.

A series of assumptions about the proportion of producers that would implement each given management scenario (1 – 7) were made based on previous work (Chapter 3 and Chapter 4) and the expectation that implementation difficulty, and the cost of implementation, would influence producer adoption decisions. Results reported in Chapter 3 suggest that the majority of FF participants implemented more than one management practice, many of which focused on changes to calf feeding and maternity pen management. For this study, it was assumed that 25%
of FF participants would make one change, 65% would make two, and 10% would make all three changes. Among the 25% of FF participants estimated to make one change, 50% (12.5% of total) were assumed to implement scenario 1 (calf feeding changes), 40% (10% of total) scenario 2 (maternity pen management changes), and 10% (2.5% of total) scenario 3 (maternity area structure changes). Among the 65% of FF participants estimated to make two changes, 70% (45.5% of total) were expected to implement scenario 4 (calf feeding and maternity pen management changes), 10% (6.5% of total) scenario 5 (calf feeding and maternity area structure changes), and 20% (13% of total) scenario 6 (maternity pen management and maternity area structure changes). The implementation of scenario 6 was estimated to be higher than scenario 5 since both management practices in scenario 6 occur at the level of the maternity pen. Therefore it was assumed that this combination of changes in scenario 6 would be viewed as more beneficial than those in scenario 5.

It was expected that FF participants who had implemented on-farm changes would network with other producers who were not participating in the FF process and recommend the adoption of the same practice they had implemented. It was assumed that each FF participant who had implemented a change would network with 5 other producers, 50% of which were assumed to make the same change as the FF participant. Therefore, the proportion of networked producers implementing each given management scenario was identical to that of the FF participants discussed above. Secondary network effects, a networked producer who further networks with other producers about his/her changes, were not considered in this analysis.

Lastly, for both FF participants and networked producers, it was assumed that 75% of those implementing on-farm changes have both JD and NCD on their farms, while the remaining 25% were assumed to only be dealing with NCD. These proportions were assumed based on the
expectation that that majority of those making changes are likely motivated to do so as a result of the disease being present on their farms. Using these estimates, the number of FF participants and networked producers implementing each change was multiplied by the proportion of those with JD and NCD, and those that just had NCD. The resulting products were then multiplied by the corresponding NPV of implementing each management practice, based on whether or not they had JD as well as NCD, and summed. The sum of the total annual benefits resulting from the implementation of each scenario provided the total annual net benefits for FF implementation.

**Net present value of Ontario Focus Farm implementation**

The total Year 1 FF implementation costs, when implemented with veterinarians or non-veterinarian facilitators, were estimated by summing the recurrent costs per FF meeting with the opportunity costs of a FF group per FF meeting, multiplying by the number of meetings per group (4), and then multiplying by the number of groups per year (8). The product was then added to the total start-up costs to obtain a final estimate of Year 1 FF implementation costs. Year 1 costs, minus the total start-up costs, provided an estimate for the annual cost of FF implementation beyond Year 1. Additionally, in Year 6, it was assumed that another 8 facilitators would be trained, to double the number of FF groups and FF participants involved from Year 6 through 10. Using these estimates, the PV costs of implementing FF over a 10-year period, when using veterinarian or non-veterinarian facilitators, and assuming that another 8 facilitators would be trained at the beginning of Year 6, were separately calculated at a discount rate of 8%.

The PV benefits of FF implementation were estimated by discounting the total annual net benefits of FF implementation, at 8%, over a 10-year period, assuming that the number of participants doubled in Year 6. The NPV of FF implementation over a 10-year period was then
estimated by subtracting the PV benefits of FF implementation by the costs of FF implementation, with either a veterinarian or non-veterinarian facilitator.

Sensitivity analysis

Given a level of uncertainty and inherent variability in some parameter estimates, sensitivity analyses were performed to evaluate the robustness of model estimates. Specifically, it was performed on the annual cost of JD, the annual cost of NCD, the NPV of each management scenario, and the NPV of FF implementation over a 10-year period, to determine the inputs that had the greatest influence on estimates.

Where applicable the discount rate was varied from 5% to 10%, while all other factors were varied by ±10%. For the annual cost of JD, the factors varied included: herd size, true within-herd prevalence, average decrease in milk production, milk price, odds of an infected cow, overall losses for each culled animal, and proportion of MAP-infected cows sub-optimally culled. For the annual cost of NCD, the factors varied included: proportion of severe cases, herd size, incidence, average days treated, cost to treat mild cases, cost to treat severe cases, case fatality rate, marginal feed costs of pre-weaned calves, and average age of mortality. For the NPV of each management scenario, the factors varied included: discount rate, cost, persistence, effect of each on-farm management change, and herd cost of JD and NCD. For the NPV of FF implementation, the factors varied included: discount rate, proportion of producers with JD and NCD, cost, persistence, and effect of each on-farm management changes, number of FF participants, number of networked producers, proportion of networked producers making changes, proportion of FF participants making changes, proportion of those making changes implementing two changes, start-up, opportunity, and recurrent costs, and herd cost of JD and
NCD. Upon completion of all sensitivity analyses, tornado charts (Boardman et al., 2010) were created to provide a visual representation of the sensitivity analysis by ranking them from most sensitive to least sensitive and presenting them graphically.

**RESULTS**

**Partial budgets for Johne’s Disease and Neonatal Calf Diarrhea**

The total economic losses attributed to JD, based on a true within-herd JD prevalence of 10% in a 78-cow dairy herd, were estimated to be $3,241.95 annually ($41.56/cow and $415.63/MAP-infected cow). Approximately 59% ($1,899.26/$3,241.95) of all costs were attributed to reduced milk production, while the remaining 41% ($1,342.69/$3,241.95) were due to suboptimal culling.

The total economic losses attributed to NCD, based on a 23% incidence and 6% case fatality rate in a 78-cow dairy herd, were estimated to be $1,309.17 annually ($16.78/cow and $145.95/sick heifer calf). Treatment of NCD represented the most substantial cost, contributing 98% ($1,284.95/$1,309.17) of the total cost of NCD. The remaining 2% ($24.22/$1,309.17) of financial losses were attributed to feed costs lost to NCD mortality.

Table 1 provides a breakdown of the input parameters and their values, the source of information for the parameter values, and the mathematical formulas used to calculate the annual cost of JD and NCD on an average ON dairy farm.

Of all input parameters, the estimated annual cost of JD was most sensitive to ±10% changes in true within-herd prevalence, and was least sensitive to the proportion of MAP-infected cows sub-optimally culled (Figure 1). Overall, a 10% decrease in true within-herd prevalence (10% to 9%),
changed the annual cost from $3,241.95 to $2,917.76, while a 10% increase in either parameter increased the annual cost to $3,566.15.

The estimated annual cost of NCD was most sensitive to ±10% changes in the proportion of severe cases of NCD and least sensitive to the average age of mortality due to NCD (Figure 2). Overall, a 10% decrease in the proportion of severe cases (15% to 13.5%) decreased the annual cost of JD from $1,309.17 to $1,114.75, while a 10% increase in the proportion of severe cases of NCD (15% to 16.5%) increased the annual cost of JD to $1,503.60.

**Cost-Benefit Analysis for implementing on-farm management changes**

Table 2 presents the costs incurred and the reduction in the annual true within-herd prevalence of JD and annual incidence of NCD, as a result of implementing on-farm management practices (calf feeding, maternity pen management, and maternity area structure) on an average, 78-cow, ON dairy farm. Overall, changes to calf feeding were considered the easiest and least costly to implement ($4.54/cow), followed by maternity pen management changes ($5.78/cow) and maternity area structure ($19.23/cow). The impact of each practice on reducing the true within-herd prevalence of JD, after considering persistence of each change, was highest for changes to maternity area structure (4%/year), followed by maternity pen management (3%/year) and calf feeding changes (1.8%/year). For the annual reduction in the incidence of NCD, changes to calf feeding (13.5%/year), followed by maternity area structure (5%/year) and maternity pen management (3.75%/year) were considered to be the most impactful.

Table 3 provides the PV costs of JD and NCD, discounted at 8% over 10 years, and the NPV of implementing seven unique management scenarios on an average 78-cow ON dairy farm. Assuming a fixed within-herd JD prevalence of 10%, a fixed incidence of NCD of 23%, and no
changes in management, the PV costs for JD and NCD, over a 10-year period, were estimated to be $21,753.77 and $8,784.65, respectively. For farms dealing with both JD and NCD, all seven implementation scenarios resulted in a positive NPV ranging from $439.10 (scenario 2: maternity pen management changes) to $2,543.30 (scenario 5: calf feeding and maternity area structure changes). For farms dealing with just NCD (JD prevalence of 0%), all seven implementation scenarios resulted in a negative NPV ranging from -$19.21 (scenario 1: calf feeding changes) to -$2,569.22 (scenario 7: calf feeding, maternity pen management, and maternity area structure changes).

Figure 3 (a-g) presents tornado plots that express the sensitivity of the NPV of each separate management scenario to ±10% changes in the discount rate, herd cost of JD and NCD, and the cost, effect, and persistence of each management practice, assuming the farm is dealing with both JD and NCD. The NPV of each management scenario was most sensitive to the discount rate and the effect of the specific management practices that were being performed in each scenario. Regardless of parameter changes, all NPV values remained positive.

Figure 4 (a-g) presents tornado plots that express the sensitivity of the NPV of each separate management scenario to ±10% changes in the discount rate, herd cost of NCD, and the cost, effect, and persistence of each management practice, assuming the farm is only dealing with NCD. The NPV of each management scenario was most sensitive to changes in the cost and effect of the specific management practices that were being performed in each scenario and the discount rate. Only +10% changes to parameter estimates for scenario 1 (calf feeding changes) resulted in a positive NPV; changes for all other management scenarios resulted in negative NPVs.
Cost-Benefit Analysis for Ontario Focus Farms implementation

The total implementation costs of FF in ON in Year 1 (8 FF groups, 96 participants, 4 meetings/group) were estimated to be $159,520.80 and $127,520.80 when using veterinarian facilitators and non-veterinarian facilitators, respectively (Table 4). With $12,265.76 of start-up costs incurred in Year 1, the total annual implementation costs of FF beyond Year 1, assuming no additional FF facilitators are trained, were estimated to be $147,255.04 and $115,255.04 when using veterinarian facilitators and non-veterinarian facilitators, respectively.

Based on assumptions about the proportion of FF participants, and networked producers, that would implement each of the seven management scenarios, the total net benefits of FF implementation in Year 1 were estimated to be $190,080.81 (Table 5). Overall, six of the seven management scenarios resulted in positive net benefits as a result of FF implementation, with the majority of producers implementing management scenario 4 (calf feed and maternity pen management changes). However, scenario 2 (maternity pen management changes only) alone resulted in a loss of $2,125.55.

Table 6 presents the PV costs (start-up, recurrent, and opportunity costs), PV benefits (management scenarios 1 to 7), and NPV (PV costs – PV benefits) of implementing FF, with veterinarian or non-veterinarian facilitators, for 10 years. Overall, the implementation of FF with veterinarian facilitators yielded an NPV of $426,350.83, while the implementation of FF with non-veterinarian facilitators yielded a larger NPV of $749,807.98.

The estimated NPV of FF implementation, with veterinarian facilitators, was most sensitive to changes in the discount rate, and was least sensitive to the annual herd cost of NCD (Figure 5). Overall, a decrease in the discount rate (8% to 5%) increased the NPV from $426,350.83 to
$2,139,863.75, while a discount rate of 10% (used to account for a higher degree of uncertainty of parameter estimates) decreased the NPV to -$320,891.49. The estimated NPV of FF implementation with non-veterinarian facilitators was similarly sensitive (data not shown), with a 10% discount rate reducing the NPV to $1,278,825.91, and a 5% discount rate improving the NPV to $2,520,584.37.

Based on the costs and assumptions above, if the total cost of FF implementation were put on the farmer, it would cost $294.11/producer/FF meeting ($1,176.44/producer/year) and $210.78/producer/FF meeting ($843.12/producer/year), when using veterinarian and non-veterinarian facilitators, respectively. Assuming a $50,000 subsidy is obtained for FF implementation, the cost reduces to $163.90/producer/FF meeting ($655.60/producer/year) and $80.57/producer/FF meeting ($322.28/producer/year) for veterinarian and non-veterinarian facilitators, respectively.

**DISCUSSION**

The partial budget for JD estimated the annual herd cost of JD, for a 78-cow dairy farm with a true within-herd prevalence of 10%, to be $3,241.95. The estimate for apparent within-herd JD prevalence was obtained from recent data, reported by Pieper et al. (unpublished) and Sorge et al. (2010; 2011a), which was based on the use of milk ELISA tests. Given the relatively poor sensitivity of this test (61.1%), estimates of the number of MAP-infected cows, and the subsequent losses associated with MAP infection, would be underestimated when this estimate is used. In an attempt to provide a more accurate estimate, the apparent within-herd prevalence was adjusted, using methods reported by Dohoo et al (2009), to estimate the true within-herd prevalence of JD. This adjustment led to an increase in within-herd prevalence of 3% (from 7%
to 10%). Tiwari et al. (2006) notes there is little consensus on the appropriate adjustments needed to accurately estimate true prevalence of MAP infection, and as such, even estimates of true prevalence should be interpreted with caution. While it is reasonable to assume that the number of MAP-infected cows identified by the milk ELISA test is lower than the true number of animals infected in the herd, there exists some uncertainty surrounding the accuracy of the true prevalence estimate. In consideration of this uncertainty, sensitivity analysis was performed. The results of which suggested that ±10% changes in the true within-herd prevalence of JD would result in estimates of the total annual herd cost of JD ranging from $2,917.76 to $3,566.16.

The total annual herd cost of JD was estimated by considering the economic losses attributed to reduced milk production and suboptimal culling (i.e. cost of premature culling and replacing a MAP-infected cow). More specifically, nearly 60% of the estimated annual herd cost resulted from reduced milk production in MAP-infected cows. Numerous studies have reported reduced 305-day milk production among test-positive cows (Benedictus et al., 1987; Wilson et al., 1993; Nordlund et al., 1996; Vanleeuwen et al., 2002; Hendrick et al., 2005b; Sorge et al., 2011b). While it is accepted that MAP infection is associated with a decrease in milk production, estimates tend to vary based on the stage of infection (Benedictus et al., 1987), parity (Wilson et al., 1993), sampling and testing protocols (Tiwari et al., 2006), and the diagnostic accuracy of tests (Hendrick et al., 2005b). Two partial budget models estimating the annual cost of JD, using Canadian specific parameter estimates, are reported in the literature (Chi et al., 2002; Tiwari et al., 2008). Both of these models assumed that milk production among MAP-infected cows did not significantly decrease until lactation 4 or higher, resulting in estimates of the annual herd cost of reduced milk production of $7.10 per cow ($355 for a 50-cow herd with 7% apparent within-herd prevalence; Chi et al., 2002) and $4.16 per cow ($254 for a 61-cow herd with 12.7%
apparent within-herd prevalence; Tiwari et al., 2008), respectively. These estimates are significantly lower than the costs reported in the present study, primarily due to our consideration of reduced milk production in earlier parity groups. The milk loss estimates provided by Sorge et al. (2011b) showed significant milk losses in earlier lactations, and were considered most appropriate for this model, given they used recent, Canadian-specific data obtained using milk ELISA tests. These data, which we weighted based on reports from OJEMAP of the proportion of low and high test-positive cows in ON (OJEMAP, 2013), allowed for a more realistic estimate of the average reduction in milk production among cows in each parity group. With this added complexity a further set of estimates of the odds of a MAP infected cow in each parity group was needed. Nielsen et al. (2002) was used to obtain these estimates, based on milk ELISA results for MAP-infected cows in Denmark, which showed that the probability of an ELISA test-positive cow in parity 1 was two to three times lower than for cows in higher parity groups. With these data, we were able to estimate the expected decreases in milk production, and subsequently, the cost of milk loss, by parity group using more recent estimates than the previously reported economic models. The resulting annual cost of decreased milk production estimated in this study, $24.30 per cow ($1,899.26 for 78-cow herd with 10% true within-herd prevalence), is thus much larger than previous reports, as we considered losses in earlier lactations, suggesting that previous models may have underestimated the true milk losses due to MAP infection.

The remaining 41% of the estimated annual herd costs of JD in this study related to suboptimal culling. McKenna et al. (2006) and Hasanova and Pavlik (2006) both reviewed current literature addressing the economics of JD, concluding that premature culling, as a result of MAP infection, represented one of the major economic burdens of JD. As the production, and thus value, of a
cow generally increases as she gets older, the losses due to prematurely culling a cow are the unrealized future income of that cow and the cost of replacing her with a new heifer. The Dairy Comp 305 module Cow Value provided a useful means of obtaining ON-specific estimates for the cost of suboptimal culling. It compared the future projected income to each farm resulting from retaining a JD test-positive cow, to the future projected income to the farm resulting from replacing the test-positive cow with an average replacement heifer. Given that the module considers the JD test-positive cow to be a healthy cow, it was expected that the majority of Cow Value estimates would be positive, indicating that retaining that cow is more beneficial to the farm than replacing it. Assuming that MAP infection was cause for replacing the cow, the positive Cow Value estimate represented the net farm income lost as a result of replacement. It was assumed that 20% of MAP-infected cows would be prematurely culled each year, resulting in an annual cost due to suboptimal culling of $17.21 per cow ($1,342.69). These results are lower than estimates from Chi et al. (2002) and Tiwari et al. (2008), who estimated an annual cost of $26.60 per cow ($1,330 for a 50-cow herd with a 7% apparent within-herd prevalence) and $22.52 per cow ($1,374 for a 61-cow herd with a 12.7% apparent within-herd prevalence), respectively. Differences in these values are primarily due to the fact that we did not incorporate reduced slaughter value into our estimate, while both previous Canadian economic models did. The decision to not include reduced slaughter value stemmed from the lack of published Canadian data on which to base these estimates. American estimates suggest that MAP infection decreases slaughter value by up to 30% in some cases (Benedictus et al., 1987); however, this reduction is primarily expected in clinically infected animals, and given that the majority of cases in Canada are subclinical (Tiwari et al., 2006), it was decided that inclusion of decreased slaughter value might overestimate the true cost of JD in an ON context. Furthermore, Chi et al.
(2002) made an assumption on the reduced slaughter value based on American data, while
Tiwari et al. (2008) made assumptions based on veterinary consultation. More data on the impact
of JD on slaughter value, in a Canadian context, are needed to adequately monetize the costs of
suboptimal culling.

Overall, the estimated total annual herd cost of JD in this study ($3,241.95) was robust to
changes in parameter estimates by ±10%, decreasing to as low as $2,917.76 and increasing to as
high as $3,566.16. The total annual cost of JD per cow estimated in this study ($41.56) was
lower than the per-cow costs reported in other Canadian economic assessments. Chi et al. (2002)
reported a total cost of $49.24 per cow for a 50-cow dairy herd with an apparent within-herd
prevalence of 7%, while Tiwari et al. (2008) reported a total cost of $49.05 per cow for a 61-cow
dairy herd with an apparent prevalence of 12.7%. The differences observed here are primarily
due to the fact that both former models considered mortality and reproductive losses due to MAP
infection, while we did not. As McKenna et al. (2006) notes, research on the effect of JD on
fertility, mortality, and predisposition to other diseases, such as mastitis, are inconsistent. Similar
to reduced slaughter value, these findings are more likely to be attributed to clinical cases of JD,
and given the low expected proportion of clinical cases in an ON context, a decision was made to
not monetize these losses. As a result, our estimate of the total annual herd costs of JD may thus
be considered conservative.

Given the fecal-oral transmission of MAP, any on-farm management practice implemented to
break this transmission cycle is likely to have positive impacts on other diseases, most notably
NCD (McKenna et al., 2006). Therefore, in order to appropriately monetize the benefits of
implementing various on-farm management practices, a partial budget for the average annual
herd cost of NCD was also required. The primary costs associated with NCD in dairy calves
primarily relate to treatment costs and mortality due to NCD (Gunn, 2003). While recent ON estimates were available for the incidence (23%; Windeyer, 2013) and case fatality rate of NCD (6%; Windeyer et al., 2014), a lack of estimates on the cost of treatment and the severity of NCD cases make accurate assumptions on the treatment costs difficult. Similarly, the cost of mortality, quantified as the feed inputs lost to calf mortality, required assumptions about the marginal feed costs. Personal communication with a dairy calf specialist provided the information needed to make informed assumptions regarding these parameter estimates (K. Leslie, University of Guelph, Guelph, Ontario, personal communication). With the assumptions provided, the annual herd cost of NCD for an average 78-cow dairy herd was estimated to be $1,309.17 ($33.57 per heifer calf). Other estimates of the cost of NCD per calf vary; Sischo et al. (1990) reported a cost of $13.33 per calf among 43 dairy herds in California, while Gunn (2003) reported a mean cost of $73.30 per calf among 46 Australian dairy farms. While differences in geographic location, herd management, herd recruitment, and sampling procedures all likely play a role in the differing estimates, several assumptions made to calculate the cost of NCD in this study may have resulted in an over- or under-estimation of the true costs. Sensitivity analysis provided a better understanding of the robustness of estimates, with final estimates being most sensitive to changes in the proportion of severe NCD cases, which resulted in a minimum cost of $1,140.09 and a maximum of $1,178.26.

For JD control, the single most effective management change was considered to be maternity area structure changes, due to the fact that producers incurred a one-time up-front cost for implementation, which would then result in positive net benefits over and above other management practices, primarily due to the fact that these practices were in place 100% of the time. The second best change for JD control was considered to be maternity pen management,
followed by calf feeding changes. For NCD, calf feeding changes were considered the most effective, followed by maternity area structure changes, again due to 100% persistence of the behaviour, and then maternity pen management. Despite the fact that numerous observational studies have reported associations between poor management and JD (Benedictus et al., 2008; Ferrouillet et al., 2009; Collins et al., 2010; Nielsen et al., 2011; Sorge et al., 2011a) and NCD (Wells et al., 1997; Svennson et al., 2003; Gulliksen et al., 2009; Windeyer, 2013; Windeyer et al., 2014), there is very little evidence in the literature that quantifies the impact of various changes in on-farm management on JD or NCD. Assumptions made here were based on current understanding of disease transmission pathways and the potential for each change to limit calf exposure to contaminated manure. However, these assumptions may have over- or under-estimated the true level of impact. More analytical epidemiological studies are needed to substantiate claims of efficacy by quantifying the impact of various changes in management on the within-herd prevalence of JD and incidence of NCD.

In this study it was assumed that producers considering on-farm changes for JD control would implement one, two, or all three of the management practices considered (i.e. calf feeding changes, maternity pen management changes, maternity area structure changes), resulting in seven possible management scenarios. Given the estimates of cost and efficacy for each management practice, certain scenarios were more beneficial than others, depending on whether both JD and NCD were present. For those dealing with JD and NCD, all seven strategies resulted in a positive NPV, suggesting that any of the changes in on-farm management would be beneficial in reducing the cost of disease. The most useful scenario was scenario 5, where producers implemented changes to maternity area structure combined with calf feeding changes, which resulted in a net benefit of $2,543.30 per producer over a 10-year time frame. The primary
reason for the success of this scenario was due to the low cost for implementation, relative to the other management scenarios. While changes to maternity area structure require a large up-front cost, the permanent nature of the change means no further costs are incurred and persistence of the change is 100%. By combining these changes with calf feeding changes, which have the lowest recurrent costs, a moderate impact on JD, and a high impact on NCD, producers are able to keep their costs low. Recognizing that parameter estimates regarding the cost of JD and NCD and the cost and benefit of implementing changes are likely to vary, sensitivity analysis was performed. Not surprisingly, the estimates for each scenario were most sensitive to changes in the discount rate, followed by the estimated effect, cost, and persistence of each given management change. The discount rate in particular takes into consideration the time value of money (i.e. recognizes that the value of an amount of money today is worth more than the same value of money obtained one year from now, because the money today could be invested and gain interest over that year) and the uncertainty regarding the realization of future cash flows (Boardman et al., 2010). A higher discount rate is used when less certain about the realization of future cash flows, which reduces the future value of money, subsequently reducing the NPV. A lower discount rate is used when certainty is higher, which results in a larger future value of money and subsequently increases the NPV. Importantly, all changes in parameters maintained positive net benefits, supporting the finding that, for those dealing with both JD and NCD, implementing on-farm management practices are an effective method for control.

Given that not all participants in FF will be dealing with JD on their farms, the NPV of each management scenario on farms just dealing with NCD was assessed. Interestingly, all seven of the management strategies resulted in a negative NPV, suggesting that, while these practices do reduce the burden of NCD, the costs of the change outweigh the benefits. Recommendations for
prevention of NCD typically focus on improved hygiene and quantity of colostrum feeding, as well as use of vaccination (Rossini, 2004, NADIS, 2014). Improved calf feeding changes were considered in this study, and were expected to have a high impact on the incidence of NCD, which, when solely implemented, resulted in a NPV of -$19.21. Sensitivity analysis suggested that positive net benefits were attainable if costs of calf feeding were reduced, or their efficacy or persistence were improved. Therefore, ensuring that producers continue to perform these behaviours over time is a key factor in the realization of benefits. Additionally, had this model incorporated other approaches to NCD control, such as the use of vaccination, it might be expected that the NPV would improve. Overall, the estimates on the cost-effectiveness of various implementation scenarios suggest that the adoption of multiple management changes proposed here is only beneficial if the farm is dealing with both JD and NCD.

Overall, the NPV of FF implementation, with veterinarian or non-veterinarian facilitators, was positive, indicating that the implementation of the FF process over a 10-year period to address JD, and indirectly address NCD, on ON dairy farms is a worthwhile investment for the dairy industry. Chapter 3 identified that while veterinarians were useful as FF facilitators, veterinarians may not be the ideal candidates for FF facilitation given their training to instruct, provide recommendations and answer questions; behaviours contrary to the role of a facilitator. For this reason, the NPV of FF implementation with a non-veterinarian facilitator, who was also considerably less expensive, was considered. However, veterinarians do provide useful advantages for FF facilitation, such as their knowledge of each participant’s farm and their understanding of disease and on-farm conditions, so considerations should be given with respect to which type of facilitator is used, based on the specific goals and finances of the project. If all FF costs are passed down to the FF participants then the cost would be nearly $300 per producer
per meeting (using veterinarian facilitators). This cost is likely too high to attract much participation among producers. In addition, given that the reduction of prevalence of JD represents a positive for not only producers, but for veterinarians and the dairy industry in general, we suggest that an annual subsidy should be provided to implement the FF process. The result of a $50,000 annual subsidy for FF implementation would reduce the cost to roughly $160 per producer per meeting if using veterinarian facilitators. Ideally, the cost would be reduced to $100 per producer per meeting (requiring a subsidy of $74,500). Alternatively, non-veterinarian facilitators could be used to reduce this cost, in which case a $50,000 subsidy would result in a cost of roughly $80 per producer per meeting.

The costs of the FF process are relatively easy to monetize, based on the desired number of groups to run and the number of meetings to hold per group. The majority of these estimates were provided by Chapter 3 and 4, which described the implementation and evaluation of the FF process for JD control. Quantifying and monetizing the benefits of FF implementation becomes the particularly challenging piece of the cost-benefit analysis. With estimates on the annual cost of JD and NCD, and the NPV of seven unique management scenarios, the final piece to quantifying the benefits was to estimate the proportion of FF participants that implement each specific scenario. In addition to FF participants, the number of producers who were effectively networked (i.e. influenced to adopt on-farm changes by interacting with FF participants) by FF participants were considered. One of the goals of agricultural extension is to educate producers in the hopes that they will not only use that information to improve their own farm situation, but relay that information to other producers throughout their own social networks (Andreata, 2001; Fisher, 2005). This was an important consideration for the monetization of the benefits of the FF process, as each FF participant was expected to relay information about the change they had
made to five other producers, 50% of whom were assumed to implement that same change. The estimated benefits resulting from networked producers should be considered conservative, as those FF participants implementing management changes over a 10-year period were only estimated to network with 5 producers in total. Furthermore, there is a possibility that networked producers would then further recommend changes they have made on to other producers (i.e. secondary networking), who might then adopt on-farm changes, resulting in the accrual of further benefits as a result of FF implementation. Importantly, with these conservative estimates, the NPV of FF implementation was positive, suggesting that if further networking and secondary networking benefits were to be realized the NPV of FF implementation would continue to rise.

While the proportion of FF participants and networked producers implementing any given change, in any given year, will be highly variable, based on each producer’s own personal farm situation (e.g. disease burden, financial resources, motivation, etc.), a series of assumptions about the proportion of producers implementing each change were made based on the evaluation of the FF process from Chapter 3 and 4. Sensitivity analysis revealed that the NPV of FF implementation was robust when the proportion of FF participants and networked producers making a change each year, or the specific proportion of producers making each change, were increased or decreased by 10%. Therefore, while there is some uncertainty about these parameter estimates, the NPV of FF implementation remained positive when these values were decreased.

One of the most important and highly sensitive assumptions that impacted the NPV of FF implementation was the proportion of producers that were assumed to be dealing with both JD and NCD on their farms. It was assumed that, as the FF process was designed to address JD control specifically, the majority (75%) of producers implementing changes would be dealing with both JD and NCD. Importantly, sensitivity analysis revealed that a 10% decrease in this
proportion (67.5%) would result in a negative NPV of FF implementation of -$313,679.89 when veterinarian facilitators were used; it remains positive ($115,975.03) when non-veterinarian facilitators are used. Therefore, the success of FF implementation ultimately appears to be highly influenced by the proportion of producers that have a JD problem.

It is important to note that there are other benefits of FF implementation, which accrue to producers, veterinarians, and the dairy industry as a whole, that are likely to result in positive net benefits as a result of FF implementation. Participation in an active-learning process, such as FF, is likely to have other benefits, beyond simply providing information and advice for controlling JD. Access to information from numerous sources, improved producer-producer social networks, farm visits and critiques, and one-on-one collaboration with context experts, veterinarians, and other producers, provide participants with an opportunity to customize their learning based on their needs (Chapter 3, 4). As a result, participants are likely to pick up other tips, suggestions, and practical changes that can be made to address pertinent issues on their farms other than JD or NCD. Furthermore, they will develop problem-solving skills and improve their capacity to learn and experiment, which will aid producers in improving their on-farm operation moving forward. The FF process also provides an opportunity for improving the capacity of producers to make changes, by establishing a social network, which groups of producers can continue to rely upon outside of the process. While not quantified, these are benefits that are indirectly realized as a result of participation in the FF process that should be considered.

If veterinarians are used as facilitators for the FF process, there are some tangible benefits that accrue to them as well. Professional facilitator training is likely to improve a veterinarian’s skill-set with respect to client communication. Approaches such as active listening, asking open-ended questions, and focusing on the individual’s perceptions, attitudes and mindset are keys to
facilitation (Pierce et al., 2000), which are taught to all facilitators (Chapter 3). Lam et al. (2011) suggested that veterinarians should ask producers probing, open-ended questions to gain a better understanding of each producer’s mindset, in the hopes that this understanding will allow the veterinarian to provide better service. Therefore, it might be expected that veterinarians, and thus, their clinical practices, will benefit outside of the FF process as a result of the facilitator training. Furthermore, veterinarians are likely to have many clients within their FF groups, which might be expected to strengthen relationships with existing clients, perhaps improving client retention for the practice, and perhaps bring in new business as a result of positive relationships with non-clients. While there may be inherent issues with respect to whose clients participate in a process such as this, it is reasonable to expect that veterinarians, and their clients, will benefit as a result from the FF process due to improved service delivery.

Lastly, provincial dairy organizations (e.g. Dairy Farmers of Ontario) serve to benefit from FF implementation in a number of ways. Most notably, implementation of the FF process across the province represents a tangible effort to address the presence of JD in ON. By decreasing the prevalence of JD and incidence of NCD, the FF process aids in improving milk quality and safety. With links between MAP and Crohn’s disease being made in the scientific literature, implementing FF and proactively addressing this issue benefits the industry. A causal-link between MAP and CD, or even a perception among consumers that MAP exposure (through the consumption of dairy products) is a health risk, could have devastating financial impacts on the Canadian dairy industry. Groenendaal and Zagmutt (2008) investigated these potential impacts in the U.S. dairy industry, and reported that strict regulatory changes and reduced milk demand could result in over USD$1 billion lost per year. In addition, the industry may benefit from improved stakeholder communication between veterinarians and producers. This engagement
may be used to facilitate industry-wide changes or regulations by providing an opportunity for veterinarians and/or other industry members to adequately communicate the details of these changes to producer groups.

Given the benefits that accrue to various stakeholders, it would seem reasonable to suggest that producers, veterinarians, and industry play a role in funding the implementation of FF. Given the benefits that accrue to the industry, a $50,000 annual subsidy might be appropriate, while veterinarians could agree to facilitate the FF meetings at the cost of a non-veterinarian facilitator, leaving producers to cover the remaining $100 per meeting. A multi-funded effort across stakeholders would provide opportunities for all to mutually benefit and help facilitate the improvement of milk quality and safety for the ON dairy industry.

CONCLUSIONS

The total annual herd cost of JD to an average ON dairy farm, with a true within-herd prevalence of 10%, was estimated to be $3,241.95. While the total annual herd cost of NCD to an average ON dairy farm, with an incidence rate of 23%, was estimated to be $1,309.17. Even with conservative estimates about the parameters influencing these costs, it is clear that both of these diseases are costly to a dairy farm operation if left unmanaged. Implementation of various combinations of calf feeding changes, maternity pen management changes, and maternity area structure changes resulted in net benefits, depending on the presence of JD and NCD and the specific management practices implemented. When only NCD was present, all combinations failed to yield positive benefits. Thus, while on-farm management practices do help reduce the incidence of NCD, the implementation of them alone are not enough to yield positive results. However, when JD and NCD was present, every combination yielded positive net benefits, with
the implementation of calf feeding changes in combination with maternity area structure changes being the most beneficial. Thus, in a scenario where both JD and NCD are present, the effects of on-farm changes on NCD provide an added indirect benefit of implementing changes to prevent and control JD.

Overall, the implementation of the FF process over a 10-year period yielded positive net benefits, suggesting that its implementation would be valuable for reducing the burden of JD and NCD on ON dairy farms. Importantly, benefits to veterinarians, as a result of professional facilitator training, and to the ON dairy industry, as a result of improved milk quality and safety, also accrue as a result of FF implementation. Therefore, the true net benefits of FF implementation are likely to be substantially higher than what has been explicitly monetized in this study. As a result, the costs of FF implementation should be distributed across stakeholders benefiting from the FF process in the form of reduced veterinarian costs or subsidies provided by industry. Given the positive net benefits of FF implementation discussed in this study, the FF process should be considered an economically feasible agricultural extension program with tremendous potential to yield positive net benefits to a variety of stakeholders within the ON dairy industry.
REFERENCES


List of Equations:

Equation 1\(^a\):  \( \text{Present Value Costs} = C_1 / (1 + r)^1 + C_2 / (1 + r)^2 + \ldots + C_t / (1 + r)^t \)

Equation 2\(^a\):  \( \text{Present Value Benefits} = B_1 / (1 + r)^1 + B_2 / (1 + r)^2 + \ldots + B_t / (1 + r)^t \)

Equation 3:  \( \text{Net Present Value} = \text{Present Value Benefits} - \text{Present Value Costs} \)

Equation 4:  \( \text{True within-herd prevalence} = \frac{\text{Apparent Prevalence} + \text{Test Specificity} - 1}{\text{Test Specificity} + \text{Test Sensitivity} - 1} \)

\(^a\)Where \( C_t \) and \( B_t \) are the total costs and total benefits for each year (t), respectively, and \( r \) is the discount rate.
Table 1 | Input parameters and estimates, sources of parameter estimates, and the mathematical formulas used to calculate the annual financial cost (CAD$) of Johne’s disease (JD) and Neonatal Calf Diarrhea (NCD) on an average Ontario (ON) dairy farm.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Milk price (/kg)</td>
<td>-</td>
<td>$0.77</td>
<td>DFO, 2013</td>
</tr>
<tr>
<td>2</td>
<td>Herd size (milking cows)</td>
<td>-</td>
<td>78</td>
<td>DHI, 2013</td>
</tr>
<tr>
<td>3</td>
<td>Apparent within-herd prevalence of JD&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-</td>
<td>7%</td>
<td>Pieper et al. unpublished; Sorge et al. 2010; 2011a Dohoo et al., 2009; IDEXX, 2010</td>
</tr>
<tr>
<td>4</td>
<td>True within-herd prevalence of JD&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(3)+0.98-1 / 0.52+0.98-1</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Number of MAP infected cows</td>
<td>(4)*(3)</td>
<td>7.8</td>
<td>-</td>
</tr>
</tbody>
</table>

**Johne's Disease – Reduced Milk Production**

| 6  | Average reduction in milk yield per parity group (kg/cow/305-day lactation)<sup>b</sup> | - | (a) Parity 1 - 72.00 (b) Parity 2 - 211.34 (c) Parity ≥3 - 460.78 | Sorge et al., 2011b |
| 7  | Odds of a MAP infected cow per parity group | - | (a) Parity 1 - 1.00 (b) Parity 2 - 3.15 (c) Parity ≥3 - 3.87 | Nielsen et al., 2002 |
| 8  | Number of MAP infected cows per parity group<sup>c</sup> | Parity 1 - ((5) / 8.02)*(7a) Parity 2 - ((5) / 8.02)*(7b) Parity ≥3 - ((5) / 8.02)*(7c) | (a) Parity 1 - 0.97 (b) Parity 2 - 3.06 (c) Parity 3 - 3.76 | - |
|   | HRMP Total Annual Herd cost of Reduced Milk Production | ((1)*(10a)*(13a)) + ((1)*(10b)*(13b)) + ((1)*(10c)*(13c)) | $1,899.26 | - |

**Johne's Disease – Suboptimal Culling**

| 9  | Average cost of culling and replacing a MAP infected cow<sup>d</sup> | - | $860.70 | OJEMAP, 2013 |
| 10 | Increased risk of prematurely culling MAP infected cows | - | 20% | Chi et al., 2002 |
|   | HSC Total herd cost of Suboptimal Culling | (5)*(9)*(10) | $1,342.69 | - |

**Total Annual Herd Cost of Johne’s Disease**

| HL - JD | Total Annual Herd Losses due to JD | HRMP + HSC | $3,241.95 | - |

<sup>a</sup> Apparent prevalence based on JD testing with IDEXX Milk ELISA (Sensitivity = 61.1%; Specificity = 98%; IDEXX, 2013)

<sup>b</sup> Losses are weighted based on 11% high-positive cows and 89% low test-positive cows (with milk ELISA) in ON (OJEMAP, 2013)

<sup>c</sup> A constant of 8.02 (sum of all odds) is used to proportionately weight the number of cows per parity group by the odds of a MAP infected cow

<sup>d</sup> The DairyComp 305 module Cow Value provided cost of replacing a JD high and low test-positive with an average replacement heifer

<sup>e</sup> Assumption made that all calves are treated for NCD

<sup>f</sup> Assumption made that calves are treated for all three days
Table 1 (continued) | Input parameters and estimates, sources of parameter estimates, and the mathematical formulas used to calculate the annual financial cost (CAD$) of Johne’s disease (JD) and Neonatal Calf Diarrhea (NCD) on an average Ontario (ON) dairy farm.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Number of heifer calves (/year)</td>
<td>(1)*0.5</td>
<td>39</td>
<td>Assumption</td>
</tr>
<tr>
<td>12</td>
<td>Incidence of NCD</td>
<td>-</td>
<td>23%</td>
<td>Windeyer, 2013</td>
</tr>
<tr>
<td>13</td>
<td>Case fatality rate of NCD</td>
<td>-</td>
<td>6%</td>
<td>Windeyer et al., 2014</td>
</tr>
<tr>
<td>14</td>
<td>Number of heifer calves with NCD (/year)</td>
<td>(11)*(12)</td>
<td>8.97</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>Proportion of mild NCD cases</td>
<td>-</td>
<td>85%</td>
<td>Assumption</td>
</tr>
<tr>
<td>16</td>
<td>Proportion of severe NCD cases</td>
<td>-</td>
<td>15%</td>
<td>Assumption</td>
</tr>
</tbody>
</table>

**Neonatal Calf Diarrhea – Treatment Costs**

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Number of heifer calves treated for mild NCD]^t</td>
<td>(14)*(15)</td>
<td>7.63</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Number of heifer calves treated for severe NCD]</td>
<td>(14)*(16)</td>
<td>1.36</td>
<td>K. Leslie, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>19</td>
<td>Cost of treatment for mild NCD (/day)</td>
<td>-</td>
<td>$35.00</td>
<td>Windeyer et al., 2014</td>
</tr>
<tr>
<td>20</td>
<td>Cost of treatment for severe NCD (/day)</td>
<td>-</td>
<td>$120.00</td>
<td>Windeyer, 2013</td>
</tr>
<tr>
<td>21</td>
<td>Average number of days treated for NCD]</td>
<td>-</td>
<td>3</td>
<td>Waltner-Toews et al., 1986a</td>
</tr>
<tr>
<td>TC</td>
<td>Total Annual Treatment Costs for NCD</td>
<td>((17)<em>(19) + (18)</em>(20))*21</td>
<td>$1,284.95</td>
<td>-</td>
</tr>
</tbody>
</table>

**Neonatal Calf Diarrhea – Inputs Lost to Heifer Calf Mortality**

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Annual number of heifer calves dying due to NCD</td>
<td>(11)<em>(12)</em>(13)</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Marginal feed costs of pre-weaned calves (/day)</td>
<td>-</td>
<td>$3.00</td>
<td>K. Leslie, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>24</td>
<td>Average age of mortality due to NCD (days)</td>
<td>-</td>
<td>15</td>
<td>Windeyer, 2013</td>
</tr>
<tr>
<td>25</td>
<td>Total feed costs lost (/heifer calf)</td>
<td>(23)*(24)</td>
<td>$45.00</td>
<td>-</td>
</tr>
<tr>
<td>FCL</td>
<td>Total Annual Feed Costs Lost due to NCD mortality</td>
<td>(22)*(25)</td>
<td>$24.22</td>
<td>-</td>
</tr>
</tbody>
</table>

**Total Annual Herd Cost of Neonatal Calf Diarrhea**

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL</td>
<td>Herd Losses due to NCD (/year)</td>
<td>TC + FCL</td>
<td>$1,309.17</td>
<td>-</td>
</tr>
</tbody>
</table>

^a Apparent prevalence based on JD testing with Prionics Milk ELISA (Sensitivity = 61.1%; Specificity = 98%; Hendrick et al., 2005a)
^b Losses are weighted based on 11% high-positive cows and 89% low test-positive cows (with milk ELISA) in ON (OJEMAP, 2013)
^c A constant of 8.02 (sum of all odds) is used to proportionately weight the number of cows per parity group by the odds of a MAP infected cow
^d The DairyComp 305 module Cow Value provided cost of replacing a JD high and low test-positive with an average replacement heifer.
^e Assumption made that all calves are treated for NCD
^f Assumption made that calves are treated for all three days
Table 2 | Cost (CAD$) of making management changes for calf feeding, maternity pen management, and maternity pen structure and the effect of each change on Johne’s disease (JD) prevalence and Neonatal Calf Diarrhea (NCD) incidence on an average Ontario dairy farm.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Herd size (milking cows)</td>
<td>-</td>
<td>78</td>
<td>Assumption</td>
</tr>
<tr>
<td>2</td>
<td>Number of heifer calves (/year)</td>
<td>(1)*0.5</td>
<td>39</td>
<td>Assumption</td>
</tr>
<tr>
<td>3</td>
<td>Cost of labour (/hour)</td>
<td>-</td>
<td>$17.33</td>
<td>Lang, 2010</td>
</tr>
<tr>
<td>4</td>
<td>Cost milk replacer (/heifer calf)</td>
<td>-</td>
<td>$1.63</td>
<td>Quigley, 2014</td>
</tr>
<tr>
<td>5</td>
<td>Cost of colostrum replacer (/heifer calf)</td>
<td>-</td>
<td>$19.70</td>
<td>Wolf et al., unpublished</td>
</tr>
</tbody>
</table>

Management Change 1 - Calf Feeding

6   | Implementation difficulty              | -                        | Low       | Assumption                 |
7   | Annual JD prevalence reduction        | -                        | 2%        | Dorshorst et al., 2006; Nielsen et al. 2008; Pithua et al., 2009 |
8   | Annual NCD incidence reduction        | -                        | 15%       | Wells et al., 1997; Svennson et al., 2003; Gulliksen et al., 2009; Leslie (per. Comm) |
9   | Persistence                            | -                        | 90%       | Assumption                 |
10  | True annual JD prevalence reduction   | (7)*(9)                  | 1.8%      | -                          |
11  | True annual NCD incidence reduction   | (8)*(9)                  | 13.5%     | -                          |
12  | Cost of implementation (/cow)         | $[(2*0.66)*(3/60)*5 + (2*0.33)*(5 + 2*4)] / (1) | $4.54     | -                          |

Total annual herd costs of Calf Feeding changes

$((9)*(12))*(1) = $318.71

\[a\] Assume 66% of heifer calves receive JD test-negative colostrum from dam (assume 5 minutes for feeding); 33% of heifer calves receive colostrum replacer; 100% of heifer calves receive milk replacer

\[b\] Assume 20 minutes required to perform action

\[c\] Assume that 3 individual maternity pens are made from 1 group maternity area. Gate costs are $1000 and smaller structural costs for installment are $500. The pens are assumed to have a life of 10 years
Table 2 (continued) | Cost (CAD$) of making management changes for calf feeding, maternity pen management, and maternity pen structure and the effect of each change on Johne’s disease (JD) prevalence and Neonatal Calf Diarrhea (NCD) incidence on an average Ontario dairy farm.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Implementation difficulty</td>
<td>-</td>
<td>Moderate</td>
<td>Assumption</td>
</tr>
<tr>
<td>14</td>
<td>Annual JD prevalence reduction</td>
<td>-</td>
<td>4%</td>
<td>Merkal et al., 1975; Groenendaal et al., 2003; Dorshorst et al., 2006; Ferrouillet et al., 2009</td>
</tr>
<tr>
<td>15</td>
<td>Annual NCD incidence reduction</td>
<td>-</td>
<td>5%</td>
<td>Wells et al., 1997; Trotz-Williams et al., 2007; K. Leslie, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>16</td>
<td>Persistence</td>
<td>-</td>
<td>75%</td>
<td>Assumption</td>
</tr>
<tr>
<td>17</td>
<td>True annual JD prevalence reduction</td>
<td>(14)*(16)</td>
<td>3%</td>
<td>-</td>
</tr>
<tr>
<td>18</td>
<td>True annual NCD incidence reduction</td>
<td>(15)*(16)</td>
<td>3.75%</td>
<td>-</td>
</tr>
<tr>
<td>19</td>
<td>Cost of implementation (/cow)</td>
<td>((2) / 60)*20</td>
<td>$5.78</td>
<td>Assumption</td>
</tr>
<tr>
<td>20</td>
<td>Management Change 2 - Maternity Pen Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Annual JD prevalence reduction</td>
<td>-</td>
<td>4%</td>
<td>Gulliksen et al., 2009; K. Leslie, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>22</td>
<td>Annual NCD incidence reduction</td>
<td>-</td>
<td>5%</td>
<td>Assumption</td>
</tr>
<tr>
<td>23</td>
<td>Persistence</td>
<td>-</td>
<td>100%</td>
<td>Assumption</td>
</tr>
<tr>
<td>24</td>
<td>True annual JD prevalence reduction</td>
<td>(21)*(23)</td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>True annual NCD incidence reduction</td>
<td>(22)*(23)</td>
<td>5%</td>
<td>-</td>
</tr>
<tr>
<td>26</td>
<td>Cost of implementation (/cow)</td>
<td>($1,500 / (1))</td>
<td>$19.23</td>
<td>Assumption</td>
</tr>
<tr>
<td>27</td>
<td>Total one-time herd costs of Maternity Pen Management</td>
<td>((16)<em>(19))</em> (1)</td>
<td>$338.13</td>
<td>-</td>
</tr>
<tr>
<td>28</td>
<td>Management Change 3 – Maternity Area Structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Annual JD prevalence reduction</td>
<td>-</td>
<td>4%</td>
<td>Pithua et al., 2013</td>
</tr>
<tr>
<td>30</td>
<td>Annual NCD incidence reduction</td>
<td>-</td>
<td>5%</td>
<td>Gulliksen et al., 2009; K. Leslie, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>31</td>
<td>Persistence</td>
<td>-</td>
<td>100%</td>
<td>Assumption</td>
</tr>
<tr>
<td>32</td>
<td>True annual JD prevalence reduction</td>
<td>(21)*(23)</td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td>33</td>
<td>True annual NCD incidence reduction</td>
<td>(22)*(23)</td>
<td>5%</td>
<td>-</td>
</tr>
<tr>
<td>34</td>
<td>Cost of implementation (/cow)</td>
<td>($1,500 / (1))</td>
<td>$19.23</td>
<td>Assumption</td>
</tr>
<tr>
<td>35</td>
<td>Total one-time herd costs of Maternity Area Structure</td>
<td>((23)<em>(26))</em> (1)</td>
<td>$1,500</td>
<td>-</td>
</tr>
</tbody>
</table>

*a Assume 66% of heifer calves receive JD test-negative colostrum from dam (assume 5 minutes for feeding); 33% of heifer calves receive colostrum replacer; 100% of heifer calves receive milk replacer
b Assume 20 minutes required to perform action
c Assume that 3 individual maternity pens are made from 1 group maternity area. Gate costs are $1000 and smaller structural costs for installment are $500. The pens are assumed to have a life of 10 years
Table 3 | Present Value (PV) costs (CAD$) of JD and NCD, discounted at 8% over 10 years, and the Net Present Value (NPV) of implementing seven unique management scenarios (i.e. implementing changes to one, two, or three of: calf feeding, maternity pen management, maternity area structure), on an average 78-cow Ontario dairy farm.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate (%)</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>Term (years)</td>
<td>10</td>
<td>-</td>
</tr>
</tbody>
</table>

No Management Changes

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual JD within-herd prevalence (%)</td>
<td>10</td>
<td>Assume annual prevalence fixed over 10-yr period</td>
</tr>
<tr>
<td>Annual NCD within-herd incidence (%)</td>
<td>23</td>
<td>Assume annual incidence fixed over 10-yr period</td>
</tr>
<tr>
<td>PV costs of JD</td>
<td>$21,753.77</td>
<td>$3241.94 annually (Table 1), discounted over 10 yrs</td>
</tr>
<tr>
<td>PV costs of NCD</td>
<td>$8,784.65</td>
<td>$1309.17 annually (Table 1), discounted over 10 yrs</td>
</tr>
</tbody>
</table>

Scenario 1 - Calf Feeding Changes

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV cost of implementation</td>
<td>$2,138.56</td>
<td>$318.71 annually (Table 2), discounted over 10 yrs</td>
</tr>
<tr>
<td>PV costs of JD after implementation</td>
<td>$20,560.05</td>
<td>-</td>
</tr>
<tr>
<td>PV costs of NCD after implementation</td>
<td>$6,665.30</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for JD</td>
<td>$1,193.72</td>
<td></td>
</tr>
<tr>
<td>PV benefits for NCD</td>
<td>$2,119.35</td>
<td>-</td>
</tr>
<tr>
<td>NPV of implementing scenario 1</td>
<td>-$19.21</td>
<td>Applicable to farms with NCD only (no JD)</td>
</tr>
<tr>
<td>NPV of implementing scenario 1</td>
<td>$1,174.51</td>
<td>Applicable to farms with NCD and JD</td>
</tr>
</tbody>
</table>

Scenario 2 - Maternity Pen Management Changes

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV cost of implementation</td>
<td>$2,268.88</td>
<td>$338.13 annually (Table 2), discounted over 10 yrs</td>
</tr>
<tr>
<td>PV costs of JD after implementation</td>
<td>$19,685.00</td>
<td>-</td>
</tr>
<tr>
<td>PV costs of NCD after implementation</td>
<td>$8,145.44</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for JD</td>
<td>$2,068.77</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for NCD</td>
<td>$639.21</td>
<td>-</td>
</tr>
<tr>
<td>NPV of implementing scenario 2</td>
<td>-$1,629.67</td>
<td>Applicable to farms with NCD only (no JD)</td>
</tr>
<tr>
<td>NPV of implementing scenario 2</td>
<td>$439.10</td>
<td>Applicable to farms with NCD and JD</td>
</tr>
</tbody>
</table>

Scenario 3 – Maternity Area Structure Changes

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV cost of implementation</td>
<td>$1,500</td>
<td>One-time cost of $1,500 in Year 1 (Table 2)</td>
</tr>
<tr>
<td>PV costs of JD after implementation</td>
<td>$19,350.66</td>
<td>-</td>
</tr>
<tr>
<td>PV costs of NCD after implementation</td>
<td>$7,985.74</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for JD</td>
<td>$2,403.11</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for NCD</td>
<td>$798.91</td>
<td>-</td>
</tr>
<tr>
<td>NPV of implementing scenario 3</td>
<td>-$701.03</td>
<td>Applicable to farms with NCD only (no JD)</td>
</tr>
<tr>
<td>NPV of implementing scenario 3</td>
<td>$1,702.08</td>
<td>Applicable to farms with NCD and JD</td>
</tr>
</tbody>
</table>

a Scenarios 1-7 assumed to reduce NCD incidence in Year 1 and 2, with Year 3-10 fixed at Year 2 value, and to reduce within-herd prevalence of JD starting in Year 3. Persistence of calf feeding changes is assumed to increase from 90% to 95% in Year 2, while persistence of maternity pen management changes are assumed to increase from 75% to 85% in Year 2. Persistence changes assumed to remain fixed at Year 2 values.

b Benefits for JD realized as a reduction in the 10-year costs of JD, calculated as: PV costs of JD (scenario 0) - PV costs of JD (after implementing a scenario)

c Benefits for NCD realized as a reduction in the 10-year costs of NCD, calculated as: PV costs of NCD (scenario 0) - PV costs of JD (after implementing a scenario)

d NPV of implementing a scenario, calculated as: PV benefits for NCD (or NCD and JD) - PV cost of implementation.
Table 3 (continued) | Present Value (PV) costs (CAD$) of JD and NCD, discounted at 8% over 10 years, and the Net Present Value (NPV) of implementing seven unique management scenarios (i.e. implementing changes to one, two, or three of: calf feeding, maternity pen management, maternity area structure), on an average 78-cow Ontario dairy farm.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 4 - Calf Feeding and Maternity Pen Management Changes&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV cost of implementation</td>
<td>$4,407.44</td>
<td>$656.84 annually (scenario 1 + 2), discounted over 10 yrs</td>
</tr>
<tr>
<td>PV costs of JD after implementation</td>
<td>$18,655.59</td>
<td>-</td>
</tr>
<tr>
<td>PV costs of NCD after implementation</td>
<td>$6,110.04</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for JD&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$3,098.18</td>
<td>-</td>
</tr>
<tr>
<td>PV benefits for NCD&lt;sup&gt;c&lt;/sup&gt;</td>
<td>$2,674.61</td>
<td>-</td>
</tr>
<tr>
<td>NPV of implementing scenario 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-$1,732.83</td>
<td>Applicable to farms with NCD only (no JD)</td>
</tr>
<tr>
<td>NPV of implementing scenario 4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>$1,365.35</td>
<td>Applicable to farms with NCD and JD</td>
</tr>
</tbody>
</table>

| Scenario 5 - Calf Feeding and Maternity Area Structure Changes<sup>a</sup> | | |
| PV cost of implementation | $3,638.50 | $868.61 in Year 1, $318.7 annually beyond Year 1 (scenario 1 + 3), discounted over 10 yrs |
| PV costs of JD after implementation | $18,385.17 | - |
| PV costs of NCD after implementation | $5,971.45 | - |
| PV benefits for JD<sup>b</sup> | $3,368.60 | - |
| PV benefits for NCD<sup>c</sup> | $2,813.20 | - |
| NPV of implementing scenario 5<sup>d</sup> | -$825.30 | Applicable to farms with NCD only (no JD) |
| NPV of implementing scenario 5<sup>d</sup> | $2,543.30 | Applicable to farms with NCD and JD |

| Scenario 6 - Maternity Pen Management and Maternity Area Structure Changes<sup>a</sup> | | |
| PV cost of implementation | $3,768.82 | $888.03 in Year 1, $338.13 annually beyond Year 1, (scenario 2 + 3) discounted over 10 yrs |
| PV costs of JD after implementation | $17,752.31 | - |
| PV costs of NCD after implementation | $7,376.85 | - |
| PV benefits for JD<sup>b</sup> | $4,001.45 | - |
| PV benefits for NCD<sup>c</sup> | $1,407.80 | - |
| NPV of implementing scenario 6<sup>d</sup> | -$2,361.02 | Applicable to farms with NCD only (no JD) |
| NPV of implementing scenario 6<sup>d</sup> | $1,640.43 | Applicable to farms with NCD and JD |

| Scenario 7 - Calf Feeding, Maternity Pen Management, and Maternity Area Structure Changes<sup>a</sup> | | |
| PV cost of implementation | $5,907.38 | $1,206.74 in Year 1, $656.894 annually beyond Year 1 (scenario 1+2+3) discounted over 10 yrs |
| PV costs of JD after implementation | $16,907.04 | - |
| PV costs of NCD after implementation | $5,446.49 | - |
| PV benefits for JD<sup>b</sup> | $4,846.73 | - |
| PV benefits for NCD<sup>c</sup> | $3,338.16 | - |
| NPV of implementing scenario 7<sup>d</sup> | -$2,569.22 | Applicable to farms with NCD only (no JD) |
| NPV of implementing scenario 7<sup>d</sup> | $2,277.51 | Applicable to farms with NCD and JD |

<sup>a</sup> Scenarios 1-7 assumed to reduce NCD incidence in Year 1 and 2, with Year 3-10 fixed at Year 2 value, and to reduce within-herd prevalence of JD starting in Year 3. Persistence of calf feeding changes is assumed to increase from 90% to 95% in Year 2, while persistence of maternity pen management changes are assumed to increase from 75% to 85% in Year 2. Persistence changes assumed to remain fixed at Year 2 values.

<sup>b</sup> Benefits for JD realized as a reduction in the 10-year costs of JD, calculated as: PV costs of JD (scenario 0) - PV costs of JD (after implementing a scenario).

<sup>c</sup> Benefits for NCD realized as a reduction in the 10-year costs of NCD, calculated as: PV costs of NCD (scenario 0) - PV costs of JD (after implementing a scenario).

<sup>d</sup> NPV of implementing a scenario, calculated as: PV benefits for NCD (or NCD and JD) - PV cost of implementation.
Table 4 | Input parameters and estimates, assumptions and sources of parameter estimates, and the mathematical formulas used to calculate the costs (CAD$) (start-up costs, opportunity costs, and recurrent costs) incurred as a result of implementing Focus Farms (FF) in Year 1, and beyond Year 1, for Ontario (ON) dairy producers.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
<th>Formula</th>
<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of FF meetings (/FF group/year)</td>
<td>-</td>
<td>4</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>2</td>
<td>Number of FF groups (/year)</td>
<td>-</td>
<td>8</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>3</td>
<td>Number of participants (/FF group)</td>
<td>-</td>
<td>12</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>4</td>
<td>Average FF meeting duration (hours)</td>
<td>-</td>
<td>6</td>
<td>Chapter 3</td>
</tr>
<tr>
<td></td>
<td><strong>Start-Up Costs - Training</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Average cost of training FF facilitators</td>
<td>-</td>
<td>$1,271.72</td>
<td>T. Nelson, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>6</td>
<td>Duration of training for FF facilitators (days)</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Lunch cost (/person/day)</td>
<td>-</td>
<td>$12.00</td>
<td>Assumption</td>
</tr>
<tr>
<td>8</td>
<td>Hotel cost (/person/day)</td>
<td>-</td>
<td>$125.00</td>
<td>Assumption</td>
</tr>
<tr>
<td>9</td>
<td>Training costs per facilitator</td>
<td>(5) + (6)*(7) + (8)*0.5</td>
<td>$1,358.22</td>
<td>Assume 50% require hotel</td>
</tr>
<tr>
<td>10</td>
<td>Number of FF facilitators</td>
<td>-</td>
<td>8</td>
<td>1 FF facilitator per FF group</td>
</tr>
<tr>
<td>TC</td>
<td>Total Training Costs</td>
<td>(9)*(10)</td>
<td>$10,865.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Start-Up Costs - Administrative Support</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Hours worked (/FF meeting)</td>
<td>-</td>
<td>60</td>
<td>T. Nelson, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>12</td>
<td>Wage (/hour)</td>
<td>-</td>
<td>$20.00</td>
<td>Assumption</td>
</tr>
<tr>
<td>13</td>
<td>Consumables</td>
<td>-</td>
<td>$200.00</td>
<td>Office space, phone, fax, internet, paper</td>
</tr>
<tr>
<td>AC</td>
<td>Total Administrative Costs</td>
<td>(11)*(12) + (13)</td>
<td>$1,400.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Start-Up Costs (TSC)</strong></td>
<td>TC + AC</td>
<td>$12,265.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Opportunity Cost of FF Participants</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Marginal opportunity cost (/hour)</td>
<td>-</td>
<td>$17.33</td>
<td>Lang, 2010</td>
</tr>
<tr>
<td>15</td>
<td>Opportunity costs (/FF participant/FF meeting)</td>
<td>(14)*((4) + 1)</td>
<td>$121.31</td>
<td>Assume 1 hour of travel time</td>
</tr>
<tr>
<td>OC</td>
<td>Total Opportunity Costs (/FF group/FF meeting)</td>
<td>(15)*3</td>
<td>$1,455.72</td>
<td></td>
</tr>
</tbody>
</table>
Table 4 (continued) | Input parameters and estimates, assumptions and sources of parameter estimates, and the mathematical formulas used to calculate the costs (CAD$) (start-up costs, opportunity costs, and recurrent costs) incurred as a result of implementing Focus Farms (FF) in Year 1, and beyond Year 1, for Ontario (ON) dairy producers.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable Name</th>
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<th>Estimate</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Recurrent Costs - Meetings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Average meeting room cost (/FF meeting)</td>
<td>-</td>
<td>$200.00</td>
<td>T. Nelson, University of Guelph, Guelph, ON, personal communication</td>
</tr>
<tr>
<td>17</td>
<td>Average cost of meeting materials (/FF meeting)</td>
<td>-</td>
<td>$5.00</td>
<td>Assumption</td>
</tr>
<tr>
<td>MC</td>
<td>Total Meeting Cost (/FF meeting)</td>
<td>$(3) + (1)*(7) + (16) + (17)$</td>
<td>$361.00</td>
<td>Lunch provided for facilitator each meeting</td>
</tr>
<tr>
<td></td>
<td><strong>Recurrent Costs – Facilitator</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFC</td>
<td>Veterinarian Facilitator (VF) Costs (/facilitator/FF meeting)</td>
<td>-</td>
<td>$2,000.00</td>
<td>T. Nelson, University of Guelph, Guelph, ON, personal communication; Costs include meeting preparation and full-day facilitation fee</td>
</tr>
<tr>
<td>NFC</td>
<td>Non-veterinarian Facilitator (NF) Costs (/facilitator/meeting)</td>
<td>-</td>
<td>$1,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Recurrent Costs - Facilitator Assistant</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Hours worked (/FF meeting)</td>
<td>$(4) + 2</td>
<td>8</td>
<td>2 hours set-up/wrap-up</td>
</tr>
<tr>
<td>19</td>
<td>Wage (/hour)</td>
<td>-</td>
<td>$20.00</td>
<td>Assumption</td>
</tr>
<tr>
<td>FA</td>
<td>Facilitator Aid costs (/FF meeting)</td>
<td>$(18)*(19)</td>
<td>$160.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Recurrent Costs - Guest Speaker</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS</td>
<td>Average Guest Speaker costs (/FF meeting)</td>
<td>-</td>
<td>$1,250.00</td>
<td>Assumption</td>
</tr>
<tr>
<td></td>
<td>**Total Recurrent Costs - Veterinarian Facilitator (TRCV) (/FF meeting)</td>
<td>MC + VFC + FA + GS*(0.5)</td>
<td>$3,146.00</td>
<td>Assume guest speaker at 50% of FF meetings</td>
</tr>
<tr>
<td></td>
<td>**Total Recurrent Costs - Non-veterinarian Facilitator (TRCN) (/FF meeting)</td>
<td>MC + NFC + FA + GS*(0.5)</td>
<td>$2,146.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Year 1 FF Implementation Costs (Veterinarian Facilitator)</strong></td>
<td>TSC + (OC + TRCV)<em>1</em>(2)</td>
<td>$159,520.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Year 1 FF Implementation Costs (Non-veterinarian Facilitator)</strong></td>
<td>TSC + (OC + TRCN)<em>1</em>(2)</td>
<td>$127,520.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Annual FF Implementation Costs Beyond Year 1 (VF)</strong></td>
<td>(OC + TRCV)<em>1</em>(2)</td>
<td>$147,255.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Annual FF Implementation Costs Beyond Year 1 (RF)</strong></td>
<td>(OC + TRCR)<em>1</em>(2)</td>
<td>$115,255.04</td>
<td></td>
</tr>
</tbody>
</table>
Table 5 | Proportion of Focus Farm (FF) participants, and networked producers, that are assumed to implement each of the seven management scenarios, and the resulting benefits (CAD$) that accrue to producers as a result of FF implementation each year.

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable</th>
<th>Formula</th>
<th>Estimate</th>
<th>Assumption/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of producers participating in FF each year</td>
<td>-</td>
<td>96</td>
<td>Table 2</td>
</tr>
<tr>
<td>2</td>
<td>Proportion of participants making an on-farm management change</td>
<td>-</td>
<td>81%</td>
<td>Chapter 3, 4</td>
</tr>
<tr>
<td>3</td>
<td>Number of FF participants making an on-farm management change per year</td>
<td>(1)*(2)</td>
<td>77.76</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Number of producers networked per FF participant per year</td>
<td>-</td>
<td>5</td>
<td>Assumption</td>
</tr>
<tr>
<td>5</td>
<td>Total number of producers networked per year</td>
<td>(3)*(4)</td>
<td>388.8</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Proportion of networked producers making an on-farm management change</td>
<td>-</td>
<td>50%</td>
<td>Assumption</td>
</tr>
<tr>
<td>7</td>
<td>Total number of networked producers making an on-farm management change per year</td>
<td>(5)*(6)</td>
<td>194.4</td>
<td>-</td>
</tr>
</tbody>
</table>

**Scenario 1 - Calf Feeding Changes**

8 Proportion of producers making an on-farm change that implement scenario 1 - 12.5% Assumption

9 Number of FF producers implementing scenario 1 (3)*(8) 9.72 -

10 Number of networked producers implementing scenario 1 (7)*(8) 24.3 -

11 NPV of scenario 1 (NCD) - -$19.21 Table 4

12 NPV of scenario 1 (JD and NCD) - $1,174.51 Table 4

13 Total annual net benefits from scenario 1 implementation\(^b\) \[\frac{((9)+(10))*0.25}{((9)+(10))*0.75}\] * (11) + $29,804.35 -

**Scenario 2 - Maternity Pen Management Changes**

14 Proportion of producers making an on-farm change that implement scenario 2 - 10% Assumption

15 FF producers implementing scenario 2 (3)*(14) 7.78 -

16 Networked producers implementing scenario 2 (7)*(14) 19.44 -

17 NPV of scenario 2 (NCD) - -$1,629.67 Table 4

18 NPV of scenario 2 (JD and NCD) - $439.10 Table 4

19 Total annual net benefits from scenario 2 implementation\(^b\) \[\frac{((15)+(16))*0.25}{((15)+(16))*0.75}\] * (17) + $2,125.55 -

**Scenario 3 - Maternity Area Structure Changes**

20 Proportion of producers making an on-farm change that implement scenario 3 - 2.5% Assumption

21 FF producers implementing scenario 3 (3)*(20) 1.94 -

22 Networked producers implementing scenario 3 (7)*(20) 4.86 -

23 NPV of scenario 3 (NCD) - -$701.03 Table 4

24 NPV of scenario 3 (JD and NCD) - $1,702.08 Table 4

25 Total annual net benefits from scenario 3 implementation\(^b\) \[\frac{((21)+(22))*0.25}{((21)+(22))*0.75}\] * (23) + $7,493.25 -

\(^a\) Assumptions based on Chapter 3 and 4 results.

\(^b\) Assume that 75% of those implementing a management scenario have JD and NCD issues. Assume that the remaining 25% only have NCD issues.
Table 5 (continued) | Proportion of Focus Farm (FF) participants, and networked producers, that are assumed to implement each of the seven management scenarios, and the resulting benefits (CAD$) that accrue to producers as a result of FF implementation each year.

<table>
<thead>
<tr>
<th>ID</th>
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<th>Formula</th>
<th>Estimate</th>
<th>Assumption/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Proportion of producers making an on-farm change that implement scenario 4</td>
<td>-</td>
<td>45.5%</td>
<td>Assumption&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>27</td>
<td>FF producers implementing scenario 4</td>
<td>(3)*(26)</td>
<td>35.38</td>
<td>-</td>
</tr>
<tr>
<td>28</td>
<td>Networked producers implementing scenario 4</td>
<td>(7)*(26)</td>
<td>88.45</td>
<td>-</td>
</tr>
<tr>
<td>29</td>
<td>NPV of scenario 4 (NCD)</td>
<td>-</td>
<td>-1,732.83</td>
<td>Table 4</td>
</tr>
<tr>
<td>30</td>
<td>NPV of scenario 4 (JD and NCD)</td>
<td>-</td>
<td>$1,365.35</td>
<td>Table 4</td>
</tr>
<tr>
<td>31</td>
<td>Total annual net benefits from scenario 4 implementation&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$[(27)+(28)]*0.25]*29 +</td>
<td>$73,160.94</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$[(27)+(28)]*0.75]*30</td>
<td></td>
<td></td>
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</table>

Scenario 5 - Calf Feeding and Maternity Area Structure Changes

<table>
<thead>
<tr>
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<th>Variable</th>
<th>Formula</th>
<th>Estimate</th>
<th>Assumption/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Proportion of producers making an on-farm change that implement scenario 5</td>
<td>-</td>
<td>6.5%</td>
<td>Assumption&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>33</td>
<td>FF producers implementing scenario 5</td>
<td>(3)*(32)</td>
<td>5.05</td>
<td>-</td>
</tr>
<tr>
<td>34</td>
<td>Networked producers implementing scenario 5</td>
<td>(7)*(32)</td>
<td>12.64</td>
<td>-</td>
</tr>
<tr>
<td>35</td>
<td>NPV of scenario 5 (NCD)</td>
<td>-</td>
<td>-$825.30</td>
<td>Table 4</td>
</tr>
<tr>
<td>36</td>
<td>NPV of scenario 5 (JD and NCD)</td>
<td>-</td>
<td>$2,543.30</td>
<td>Table 4</td>
</tr>
<tr>
<td>37</td>
<td>Total annual net benefits from scenario 5 implementation&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$[(33)+(34)]*0.25]*35 +</td>
<td>$30,094.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$[(33)+(34)]*0.75]*36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scenario 6 - Maternity Pen Management and Maternity Area Structure Changes

<table>
<thead>
<tr>
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<th>Variable</th>
<th>Formula</th>
<th>Estimate</th>
<th>Assumption/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>Proportion of producers making an on-farm change that implement scenario 6</td>
<td>-</td>
<td>13%</td>
<td>Assumption&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>39</td>
<td>FF producers implementing scenario 6</td>
<td>(3)*(38)</td>
<td>10.11</td>
<td>-</td>
</tr>
<tr>
<td>40</td>
<td>Networked producers implementing scenario 6</td>
<td>(7)*(38)</td>
<td>25.27</td>
<td>-</td>
</tr>
<tr>
<td>41</td>
<td>NPV of scenario 6 (NCD)</td>
<td>-</td>
<td>-$2,361.02</td>
<td>Table 4</td>
</tr>
<tr>
<td>42</td>
<td>NPV of scenario 6 (JD and NCD)</td>
<td>-</td>
<td>$1,640.43</td>
<td>Table 4</td>
</tr>
<tr>
<td>43</td>
<td>Total annual net benefits from scenario 6 implementation&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$[(39)+(40)]*0.25]*41 +</td>
<td>$22,646.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$[(39)+(40)]*0.75]*42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scenario 7 - Calf Feeding, Maternity Pen Management, and Maternity Area Structure Changes

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable</th>
<th>Formula</th>
<th>Estimate</th>
<th>Assumption/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>Proportion of producers making an on-farm change that implement scenario 7</td>
<td>-</td>
<td>10%</td>
<td>Assumption&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>45</td>
<td>FF producers implementing scenario 7</td>
<td>(3)*(44)</td>
<td>7.78</td>
<td>-</td>
</tr>
<tr>
<td>46</td>
<td>Networked producers implementing scenario 7</td>
<td>(7)*(44)</td>
<td>19.44</td>
<td>-</td>
</tr>
<tr>
<td>47</td>
<td>NPV of scenario 7 (NCD)</td>
<td>-</td>
<td>-$2,569.22</td>
<td>Table 4</td>
</tr>
<tr>
<td>48</td>
<td>NPV of scenario 7 (JD and NCD)</td>
<td>-</td>
<td>$2,277.51</td>
<td>Table 4</td>
</tr>
<tr>
<td>49</td>
<td>Total annual net benefits from scenario 7 implementation&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$[(45)+(46)]*0.25]*47 +</td>
<td>$29,007.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$[(45)+(46)]*0.75]*48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Annual Net Benefits of Focus Farm Implementation

<table>
<thead>
<tr>
<th>ID</th>
<th>Variable</th>
<th>Formula</th>
<th>Estimate</th>
<th>Assumption/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Total annual net benefits from scenario 7 implementation&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$[(13)+(19)+(25)+(31)]*[(37)+(43)+(49)] +</td>
<td>$190,080.8</td>
<td></td>
</tr>
</tbody>
</table>
<pre><code>                                                                                       | $[(45)+(46)]*0.25]*47 +                                                 |                   |                  |
                                                                                       | $[(45)+(46)]*0.75]*48                                                  |                   |                  |
</code></pre>

<sup>a</sup> Assumptions based on Chapter 3 and 4 results.

<sup>b</sup> Assume that 75% of those implementing a management scenario have JD and NCD issues. Assume that the remaining 25% only have NCD issues.
Table 6 | Present Value (PV) costs (start-up, recurrent, and opportunity costs), PV benefits (management scenarios 1 to 7), and Net Present Value (NPV) (PV costs – PV benefits) of implementing Focus Farms (FF), with veterinarian or non-veterinarian facilitators, for 10 years (discounted at 8% over a 10-year period).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discount rate</strong></td>
<td>8%</td>
<td>-</td>
</tr>
<tr>
<td><strong>Focus Farm Implementation Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total FF start-up costs</td>
<td>$12,265.76</td>
<td></td>
</tr>
<tr>
<td>Annual recurrent costs for FF implementation with veterinarian facilitator</td>
<td>$100,672.00</td>
<td></td>
</tr>
<tr>
<td>Annual recurrent costs for FF implementation with non-veterinarian facilitator</td>
<td>$68,672.00</td>
<td>Table 4</td>
</tr>
<tr>
<td>Annual opportunity costs of FF participants</td>
<td>$46,583.04</td>
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</tr>
<tr>
<td><strong>Present Value Costs for Implementing Focus Farms for 10 years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV start-up costs</td>
<td>$20,613.63</td>
<td></td>
</tr>
<tr>
<td>PV recurrent costs (vet facilitator)</td>
<td>$1,017,596.20</td>
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</tr>
<tr>
<td>PV recurrent costs (non-veterinarian facilitator)</td>
<td>$694,139.05</td>
<td></td>
</tr>
<tr>
<td>PV participants' opportunity cost</td>
<td>$470,863.04</td>
<td></td>
</tr>
<tr>
<td>PV costs of FF implementation for 10 years (vet facilitator)</td>
<td>$1,509,072.87</td>
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</tr>
<tr>
<td>PV costs of FF implementation for 10 years (non-veterinarian facilitator)</td>
<td>$1,185,615.72</td>
<td></td>
</tr>
<tr>
<td><strong>Total Annual Net Benefits of Focus Farm Implementation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario 1 - Calf feeding</td>
<td>$29,804.35</td>
<td></td>
</tr>
<tr>
<td>Scenario 2 - Maternity pen management</td>
<td>-$2,125.55</td>
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</tr>
<tr>
<td>Scenario 3 - Structural barn changes</td>
<td>$7,493.25</td>
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</tr>
<tr>
<td>Scenario 4 - Calf feeding and maternity pen management</td>
<td>$73,160.94</td>
<td>Table 5</td>
</tr>
<tr>
<td>Scenario 5 - Calf feeding and structural barn changes</td>
<td>$30,094.05</td>
<td></td>
</tr>
<tr>
<td>Scenario 6 - Maternity pen management and structural barn changes</td>
<td>$22,646.16</td>
<td></td>
</tr>
<tr>
<td>Scenario 7 - Calf feeding, maternity pen management, structural barn changes</td>
<td>$29,007.61</td>
<td></td>
</tr>
<tr>
<td><strong>Present Value Benefits for Implementing Focus Farms for 10 years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV benefits of Scenario 1</td>
<td>$303,471.15</td>
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<tr>
<td>PV benefits of Scenario 2</td>
<td>-$21,642.57</td>
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<tr>
<td>PV benefits of Scenario 3</td>
<td>$76,297.11</td>
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<tr>
<td>PV benefits of Scenario 4</td>
<td>$744,140.11</td>
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<tr>
<td>PV benefits of Scenario 5</td>
<td>$306,420.92</td>
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<tr>
<td>PV benefits of Scenario 6</td>
<td>$230,585.65</td>
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<tr>
<td>PV benefits of Scenario 7</td>
<td>$295,358.67</td>
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</tr>
<tr>
<td>Total PV benefits</td>
<td>$1,953,423.83</td>
<td>-</td>
</tr>
<tr>
<td><strong>Net Present Value of Focus Farm Implementation for 10 Years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV for FF implementation with veterinarian facilitators</td>
<td>$426,350.83</td>
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<tr>
<td>NPV for FF implementation with non-veterinarian facilitists</td>
<td>$749,807.98</td>
<td>-</td>
</tr>
</tbody>
</table>

* Values calculated assuming 8 new FF groups per year, 12 FF participants per group, 4 FF meetings per group (see Table 2)
* Values calculated assuming 8 new FF groups per year, 12 FF participants per group, 4 FF meetings per group (see Table 2)
* Assumptions: 8 new FF groups per year, 12 new FF participants per group, 4 FF meetings per group from Year 1 to 5. In Year 6, 8 new FF facilitators are trained; 16 new FF groups per year, 12 new FF participants per group, 4 FF meetings per group from Year 6 to 10. All PV calculations discounted at 8% over 10 years.
* Benefits are the Net Present Value of implementing each management scenario over a 10-year period, discounted at 8%. Calculated as: PV benefits of management change – PV costs of implementing the management scenario. Values presented assume 81% of FF participants (77.76/year) and 50% of networked producers (240/year) implement 1 of the 7 management scenarios each year, and 75% of those that make on-farm changes have both JD and NCD (proportion of those implementing each scenario provided in Table 5).
* NPV of implementing FF over a 10-year period. Calculated as: total PV benefits - PV costs of FF implementation
Figure 1 | Tornado plot of the sensitivity of the estimated the annual cost of Johne’s Disease (JD) on an average Ontario dairy herd ($3,241.95) to ±10% changes in herd size, true within-herd prevalence, average decrease in milk production by parity group, milk price, odds of a MAP-infected cow by parity group, overall losses for each culled animal, and the annual proportion of MAP-infected cows sub-optimally culled.
Figure 2 | Tornado plot of the sensitivity of the estimated annual cost of Neonatal Calf Diarrhea (NCD) on an average Ontario dairy herd ($1,309.17) to ±10% changes in herd size, incidence, proportion of severe cases, average days treated, cost to treat mild cases, cost to treat severe cases, case fatality rate, marginal feed costs of pre-weaned calves, and the average age of mortality.
Figure 3a | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 1 (calf feeding changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.
Figure 3b | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 2 (maternity pen management changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.
Figure 3c | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 3 (maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NPV at 10% Discount Rate</th>
<th>NPV at 5% Discount Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in JD (4%) and NCD (5%) due to maternity area structure changes (/year)</td>
<td>$1,178.26</td>
<td>$1,140.09</td>
</tr>
<tr>
<td>Cost of maternity area structure changes ($19.23/cow)</td>
<td>$21.50</td>
<td>$17.30</td>
</tr>
<tr>
<td>Herd cost of NCD ($1,1309.17/year)</td>
<td>$1,178.26</td>
<td>$1,140.09</td>
</tr>
<tr>
<td>Cost of calf feeding changes ($4.54/cow)</td>
<td>$4.99</td>
<td>$4.09</td>
</tr>
<tr>
<td>Cost of maternity pen management changes ($5.78)</td>
<td>$6.36</td>
<td>$5.20</td>
</tr>
<tr>
<td>Persistence of calf feeding changes (90%/year)</td>
<td>81%</td>
<td>99%</td>
</tr>
<tr>
<td>Persistence of maternity pen management changes (75%/year)</td>
<td>67.5%</td>
<td>82.5%</td>
</tr>
<tr>
<td>Herd cost of JD ($3,241.95/year)</td>
<td>$3,566.16</td>
<td>$2,917.76</td>
</tr>
<tr>
<td>Reduction in JD (2%) and NCD (15%) due to calf feeding changes (/year)</td>
<td>1.8%, 13.5%</td>
<td>2.2%, 16.5%</td>
</tr>
<tr>
<td>Reduction in JD (4%) and NCD (5%) due to maternity pen changes (/year)</td>
<td>3.6%, 4.5%</td>
<td>4.4%, 5.5%</td>
</tr>
</tbody>
</table>

- 10% decrease in parameter estimate
- 10% increase in parameter estimate
### Figure 3d | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 4 (calf feeding and maternity pen management changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.

<table>
<thead>
<tr>
<th>Element</th>
<th>$800</th>
<th>$1,000</th>
<th>$1,200</th>
<th>$1,400</th>
<th>$1,600</th>
<th>$1,800</th>
<th>$2,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate (8%)</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Reduction in JD (2%) and NCD (15%) due to calf feeding changes (/year)</td>
<td>1.8%, 13.5%</td>
<td></td>
<td></td>
<td>2.2%, 16.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in JD (4%) and NCD (5%) due to maternity pen changes (/year)</td>
<td>3.6%, 4.5%</td>
<td>4.5%, 5.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of maternity pen management changes ($5.78)</td>
<td>$6.36</td>
<td>$5.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of calf feeding changes ($4.54/cow)</td>
<td>$4.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistence of maternity pen management changes (75%/year)</td>
<td>67.5%</td>
<td>82.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistence of calf feeding changes (90%/year)</td>
<td>81%</td>
<td>99%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herd cost of NCD ($1,130.17/year)</td>
<td></td>
<td></td>
<td>$1,178.26</td>
<td>$1,140.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of maternity area structure changes ($19.23/cow)</td>
<td>$21.50</td>
<td>$17.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herd cost of JD ($3,241.95/year)</td>
<td>$3,566.16</td>
<td></td>
<td>$2,917.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in JD (4%) and NCD (5%) due to maternity area structure changes (/year)</td>
<td>3.6%, 4.5%</td>
<td>4.4%, 5.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- 10% decrease in parameter estimate
- 10% increase in parameter estimate
Figure 3e | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 5 (calf feeding and maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.
### Figure 3f: Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 6 (maternity pen management and maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.

<table>
<thead>
<tr>
<th>Scenario 6: Maternity pen management &amp; maternity area structure changes</th>
<th>Discount rate (8%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in JD (4%) and NCD (5%) due to maternity area structure changes (year)</td>
<td>10%: 3.6%, 4.5% 4.4%, 5.5%</td>
</tr>
<tr>
<td>Cost of maternity pen management changes ($5.78)</td>
<td>10%: $6.36, $5.20</td>
</tr>
<tr>
<td>Reduction in JD (4%) and NCD (5%) due to maternity pen changes (year)</td>
<td>10%: 3.6%, 4.5% 4.4%, 5.5%</td>
</tr>
<tr>
<td>Cost of maternity area structure changes ($19.23/cow)</td>
<td>10%: $21.50, $17.30</td>
</tr>
<tr>
<td>Persistence of maternity pen management changes (75%/year)</td>
<td>10%: 82.5%, 67.5%</td>
</tr>
<tr>
<td>Herd cost of NCD ($1,130.17/year)</td>
<td>10%: $1,178.26, $1,140.09</td>
</tr>
<tr>
<td>Cost of calf feeding changes ($4.54/cow)</td>
<td>10%: $4.99, $4.09</td>
</tr>
<tr>
<td>Persistence of calf feeding changes (90%/year)</td>
<td>10%: 99%, 81%</td>
</tr>
<tr>
<td>Herd cost of JD ($3,241.95/year)</td>
<td>10%: $3,566.16, $2,917.76</td>
</tr>
<tr>
<td>Reduction in JD (2%) and NCD (15%) due to calf feeding changes (year)</td>
<td>10%: 1.8%, 13.5% 2.2%, 16.5%</td>
</tr>
</tbody>
</table>

*Note: The diagram illustrates the impact of various parameters on the Net Present Value (NPV) of scenario 6, showing the sensitivity of the NPV to changes in the discount rate and herd costs of JD and NCD, as well as the cost, effect, and persistence of each management practice.*
Figure 3g | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 7 (calf feeding, maternity pen management and maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne's Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with a true within-herd JD prevalence of 10% and an incidence of NCD of 23%.
Figure 4a | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 1 (calf feeding changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 4b | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 2 (maternity pen management changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 4c | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 3 (maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 4d | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 4 (calf feeding and maternity pen management changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 4e | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 5 (calf feeding and maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 4f | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 6 (maternity pen management and maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 4g | Tornado plot of the sensitivity of the Net Present Value (NPV) of scenario 7 (calf feeding, maternity pen management, maternity area structure changes) to ±10% changes in the discount rate, herd cost of Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), and the cost, effect, and persistence of each management practice, assuming the farm is dealing with an incidence of NCD of 23% (i.e. no JD).
Figure 5 | Tornado plot of the sensitivity of the Net Present Value (NPV) of Ontario Focus Farm (FF) implementation over a 10-year period to ±10% changes in the discount rate, proportion of producers with Johne’s Disease (JD) and Neonatal Calf Diarrhea (NCD), cost, persistence, and effect of each on-farm management changes, number of FF participants, number of networked producers, proportion of networked producers making changes, proportion of FF participants making changes, proportion of those making changes implementing two changes, start-up, opportunity, and recurrent costs, and herd cost of JD and NCD.
CHAPTER SEVEN

Concluding remarks, study limitations and future research

Johne’s disease (JD) is a production limiting disease, which is responsible for chronic wasting in dairy cattle and other ruminants (Sweeney et al., 2012). While important from an animal health and economic standpoint, the causal organism of JD, *Mycobacterium avium* subsp. *paratuberculosis* (MAP), raises public health concern. Although evidence of a causal link between MAP and Crohn’s disease (CD) remains inconclusive, numerous studies have identified associations between MAP infection and prevalence of Crohn’s disease in humans, suggesting a zoonotic potential (Hermon-Taylor and El-Zaatari 2004; Feller et al., 2007; Waddell et al., 2008; Chiodini et al., 2012). JD negatively impacts cow health, dairy farm economics, and consumer health. In response to this, dairy industries worldwide have attempted to control this disease to maintain healthy dairy herds that produce dairy products with all possible safety guarantees for human consumption.

Because JD has a prolonged incubation period (2 to 6 years), eradication of this chronic, insidious disease is an unlikely scenario (Collins et al., 2010). Furthermore, lack of an effective vaccine and the inability to cost-effectively treat cattle for MAP infection presents little opportunity for controlling JD through medical intervention (McKenna et al., 2006). Moreover, imperfect diagnostic tests, with particularly low sensitivities, result in the misclassification of MAP-infected animals, further complicating opportunities for cow-specific treatment if it were available. Given these current limitations, it is generally agreed that the only way to address JD
is through the implementation of on-farm management practices to holistically control the spread of MAP within the herd and prevent new infections from occurring.

Currently JD control programs utilize veterinarian administered risk assessments (RA) to identify high-risk on-farm management practices and influence producer behaviour to adopt JD control measures (Kennedy and Allworth, 2000; Groenendaal et al., 2003; Nielsen, 2007; Collins et al., 2010; Barker et al., 2012). However, while we know RAs are effective at highlighting the important on-farm risk areas for JD control (Sorge et al., 2011), the recommendations made by veterinarians need to be adopted and sustained by the producer, in order to be effective. JD control is hindered by a low level of implementation among producers (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010). Thus, one of the most significant challenges facing effective prevention and control of JD is how to improve producer compliance of on-farm management practices among producers.

The research objectives of this thesis were to: (1) understand the social factors that influence producer behaviour, by exploring ON dairy producer attitudes towards JD, their perceptions of recommendations for control and the barriers to implementing them, and motivators for change, (2) investigate the role of agricultural extension, and the utility of different communication methods, for influencing producer behaviour, and (3) provide evidence for the efficacy, and economic feasibility of producer learning groups for influencing producer behaviour.

Findings from Chapter 2 suggest that producers perceive lack of physical resources (i.e. time, money, infrastructure) as critical barriers to on-farm change. In addition, they perceived intrinsic barriers such as priority of JD, their motivation, and their perception of the practicality of JD control recommendations as significant barriers. Similarly, Chapter 4 showed that although
producers perceived JD control as important and perceived pressure from veterinarians and industry organizations to make on-farm changes, they questioned their ability to effectively control JD. These are important findings, as they suggest that keys to influencing producer behaviour lie with changing producer perceptions and attitudes toward JD prevention and control. It is important that extension and outreach efforts continue to routinely, and consistently, communicate the importance of JD control at both producer and industry levels. It is also important to consider that the content of communication regarding JD control should be framed in regards to the costs, time, and infrastructure requirements for implementation in order to address important physical resource barriers identified in this thesis. Future communication must also focus on the efficacy of recommended changes with respect to the immediate impacts on many fecal- orally transmitted diseases and the long-term persistence needed to effectively control JD. By targeting these perceptions, attitudes, and opinions, communication efforts are more likely to influence producer behaviour.

Chapter 2 showed that producers perceived a lack of motivation as an important barrier to adoption of JD control strategies. In focus groups, both producers and veterinarians described the importance of extrinsic (i.e. incentives, premiums, penalties, regulation, and agricultural extension and communication) and intrinsic (i.e. pride, responsibility) forms of motivation. These opportunities to motivate change can generally be categorized as methods that result in coerced and mandated change (i.e. incentives, premiums, penalties, regulations), or methods/factors that result in voluntary change (i.e. agricultural extension and communication, pride, responsibility). The key difference being that coerced change does not aim to influence the social factors previously discussed (i.e. attitude, perception, knowledge, beliefs, skills), and as a result, often only influences change while those coercive pressures exist. Whereas voluntary
change generally stems from a change in internal social factors, which results in the individual seeing value in performing the behaviour and an increased likelihood that the behaviour will be sustained over time. Interestingly, while RAs aim to influence voluntary behaviour change, the poor producer adherence to recommendations for JD prevention and control observed among various groups of dairy producers (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010) suggests that they are ineffective. Therefore, while the RA is an effective tool for targeting areas for change, it appears that a larger emphasis should be placed on addressing the social factors of change for RA-based programs to be successful.

Viewing RA-based control programs from an agricultural extension perspective provides insight into why they might not be expected to be particularly effective at influencing change among producers. RA-based programs traditionally approach producer extension from a linear, top-down perspective (e.g. knowledge holder (i.e. veterinarian) instructing knowledge user (i.e. producer)), where the aim is to persuade producers to voluntarily change their behaviour. Importantly, these approaches tend to be ineffective at influencing producer behaviour as they devalue the knowledge, skills and adaptive abilities of producers, as these approaches hold researchers as exclusive creators of knowledge, while producers are simply the recipients (Chambers, 1983; Russell et al., 1989; Coutts and Roberts, 2011). More effective forms of agricultural extension to induce behaviour change involve participatory, bottom-up approaches, which embrace ‘systems thinking’, theories of adult education, and action learning principles, to address the social factors influencing change (Andreata, 2001; Fulton et al., 2003; Friend et al., 2009). Therefore, the implementation of bottom-up agricultural extension approaches thus presents an opportunity to improve RA-based programs to effectively influence the voluntary adoption of JD prevention and control measures.
Chapter 5 investigated ON dairy producer perceptions of the key characteristics of, and preferences for, information sources. From a dairy producer perspective, effective agricultural extension involves the provision of pragmatic information, in a supportive setting, where organizers are accountable for ensuring participants' needs are met and for motivating change. The learning preference instrument, Visual, Aural, Read/write, and Kinesthetic Learning Preferences Questionnaire, also showed that messages will be most impactful for producers if they are framed for the kinesthetic and/or read/write learner. However, given the differing learning style preferences among study respondents, it is clear that there is not a 'one size fits all' approach. This was also true of producer preferences for specific sources of information. Not surprisingly, the majority of respondents ranked veterinarians as the most useful source of information. Peer-to-peer learning was also a popular source of information for many producers. Extension through these avenues provides an opportunity for tailored communication, based on producer specific preferences for information and learning, and allows for the specific social factors influencing change to be addressed for each producer. From a larger population perspective, an individual level understanding of producer preferences and perceptions, and a tailored communication approach, is not always possible. Large-scale extension efforts with ON dairy producers will benefit from utilizing published producer magazines for communication. Overall, it is clear that veterinarians are still key to multiple delivery methods and maintaining a clear and consistent message is crucial, to ensure effective uptake of information among all producers in the ON dairy industry.

Given the demonstrated efficacy of bottom-up approaches for influencing change, and the relative importance of veterinarian-producer and peer-to-peer communication approaches, producer learning groups present a useful opportunity to effectively communicate with producers.
and to provide a group tailored communication approach to adequately address the social factors influencing producer behaviour (Chapter 3). However, an implementation framework is needed to properly implement these producer-learning groups and to realize the benefits of these approaches. Chapter 3 focused on establishing a framework for the implementation of a producer-centred learning process, called Focus Farms, to facilitate the voluntary adoption of on-farm management practices, among ON dairy producers, for the prevention and control of JD. The ON Focus Farm approach (FF) was implemented as a series of 4 meetings per year, with 8 separate FF groups of roughly 12 dairy producers each, which were facilitated by professionally trained veterinarians. The approach is built upon the principles of adult education and experience-based learning, with a specific focus on: being participatory, self-directed, and collaborative; emphasizing honest communication and a trusting environment; promotes planning, action, and implementation; and engages participants in reflective practice for learning. Qualitative evaluation of the FF process (Chapter 3), revealed that both producers and facilitators agree that a facilitator-moderated, producer-centred environment, which utilized a variety of active-learning techniques, were the key characteristics in making FF a useful extension process to influence producer behaviour.

The success of the approach is ultimately determined by whether the FF process is able to influence producer behaviour. The results of a pre-post evaluation of FF for it’s impacts on participants perceptions, knowledge, attitudes, and behaviour with regard to JD control (Chapter 4) showed that FF was an effective method for improving the adoption of on-farm management practices for JD control. Producers reported improvements in their attitude and perception towards JD control and exhibited improved ‘subjective’ and ‘objective’ knowledge levels. These changes in perception, knowledge, attitude and behaviour were more significant among FF
producers compared to a control group of non-participating ON dairy producers, suggesting that the conceptual framework and practical approach of FF is effective in influencing change. Importantly, the majority of FF producers (81%) reported implementing at least one on-farm management change, and this proportion was significantly higher than that of the control group. As a result, this study showed that an RA-based control program for JD could be improved with the implementation of a bottom-up agricultural extension process, which addressed the social factors influencing producer behaviour.

A final key consideration of this study is in regards to the economic feasibility and potential sustainability of the FF process. Chapter 6 showed that the implementation of FF over a 10-year period resulted in net benefits, which accrue to dairy producers as a result of implementing on-farm management and reducing the cost of JD and Neonatal Calf Diarrhea (NCD), of $426,350.83 or $749,807.98 as a result of using veterinarian or regular facilitators, respectively. These estimates were calculated based on a number of assumptions about the annual herd cost of JD and NCD, the cost-benefit of implementing various on-farm management practices, and the proportion of FF participants that would actually implement each practice. Given a degree of uncertainty surrounding some of these estimates, the reported net benefits may have over- or under-estimated the true net benefits as a result of FF. However, it is also important to note that the benefits of FF implementation do not simply accrue to its participants. It is expected that FF participants will network with other producers and pass along what they have learned, and FF participants are also expected to benefit from establishing social networks, which will likely help them address other pertinent issues on their farm. Veterinarians benefit from engaging in a process that professionally trains them in facilitation, which can improve the provision of a tailored communication approach, resulting in improved client service beyond the life of the FF
process. Lastly, FF implementation also benefits the dairy industry by focusing on the constant improvement of milk quality and safety on participants’ farms. Therefore, the true net benefits of FF implementation are likely to be substantially larger than those estimated here.

As with any research project, there are inherent limitations and potential sources of bias. The degree of behavioural change observed among FF respondents in this study may be influenced by volunteer bias. Given FF was advertised as a process aimed at on-farm improvement for participants it might be expected that those volunteering to participate were already planning on-farm changes in some form, which may have resulted in the higher levels of adoption observed in the FF group. From the control group perspective, a low response rate (17%) may have contributed to selection bias in the form of non-response bias. Chapter 4 showed that while herd production and reproduction comparisons between FF and control respondents were not significantly different, FF participants tended to have slightly better herd characteristics. Furthermore, demographic comparisons between FF and control respondents showed that FF respondents were more likely to be younger, have larger herds, and have higher herd rankings for productivity (Chapter 4). Herd production and reproduction comparisons made between all study participants and the ON dairy producer population showed that study participants generally had better herd productivity, suggesting that the FF group was not representative of the ON dairy producer population. Therefore, the participants in this study may be more progressive and informed than the overall ON dairy population, and as a result, some caution may need to be applied in the generalizing of these findings to the broader population. However, the main aim of this study was to explore producer perspectives, and as focus group studies are not aimed at generalizing findings this may be less of a concern. Future studies may want to assess the extent
to which these results exist among a larger producer population by administering a survey to a
group of randomly sampled producers.

Another potential source of bias in this study is the use of self-reports to obtain information on
the implementation of on-farm changes for JD prevention and control. Given the participants’
knowledge of the goals of the FF process, it is conceivable that respondents deliberately biased
their answers by providing socially desirable responses. As a result, respondents may have been
more inclined to indicate they had made on-farm management changes to prevent and control JD,
which would overestimate the true impact of the FF process. Future studies can assess this by
having veterinarians confirm self-reported changes, or by having veterinarians provide their own
report of the on-farm changes. Results of veterinarian feedback could then be compared to
producer feedback, allowing for inter-rater assessments of reliability.

The cost-benefit analysis reported in Chapter 6 employed the use of a number of assumptions to
obtain final estimates on the cost of JD and NCD, the net benefits of implementing various on-
farm management practices, and the net benefits of FF implementation. These assumptions were
made due to limited evidence in the literature. While sensitivity analysis provided information on
the robustness of estimates to ±10% changes in parameter estimates, uncertainty and reliability
of some published estimates remains an issue. Other economic models have employed the use of
stochastic dynamic modeling (Chi et al., 2002; Tiwari et al., 2008), which use Monte-Carlo
simulations to run thousands of iterations of a model, using probability distributions around each
estimate, to assess the likelihood of various scenarios and outcomes. While these distributions
are often based on assumptions similar to the ones used in this study, probabilistic modeling adds
an element of complexity, which may allow for the creation of more appropriate estimates and
provide a more robust model.
Despite the limitations and potential biases of this study, the conclusions presented within this thesis provide unique contributions to our understanding of dairy producer behaviour and approaches for influencing that behaviour to effectively prevent and control on-farm disease. In her 2010 PhD dissertation, Dr. Ulrike Sorge concluded that remarkably little has changed with respect to our understanding of MAP and the transmission of JD since in the 1950s, and that our focus moving forward should be to develop more effective ways to control JD on the farm (Sorge, 2010). While more research is certainly still needed to improve our understanding of the efficacy of current control methods, the success of any JD control program is ultimately dependent on the producer compliance and adoption of on-farm management practices. While improving our understanding of the efficacy of specific management practices is beneficial, it still does not address the issue of producer behaviour. Simply put, without implementation, the time, effort, and resources devoted to developing rigorous and impactful research to prevent and control JD will be fruitless. As a result, future research efforts should focus on the improvement of control program delivery and implementation by strengthening communication training and developing novel outreach tools/approaches.

**DIRECTIONS FOR FUTURE RESEARCH**

While this study has contributed to our understanding of JD prevention and control, and agricultural extension, this study also generated many questions, which are briefly discussed below:

1. Are on-farm management changes made for JD prevention and control sustained over time? How frequently are the behaviours performed, and how does this affect the overall impact of on-farm management changes on the spread of JD?
In order for producers to realize the benefits of on-farm change, the behaviours must be sustained over time, which will steadily decrease the number of new infections and consequently, the prevalence of JD. However, the social factors influencing producer behaviour are not static, they are routinely influenced by new information and experiences, and as a result, there is potential for producer behaviour to change as well. An interesting study would be to conduct a longitudinal study, which would follow up with FF participants one year after study completion to see if the changes they reported were sustained. Other longer-term effects of FF, such the establishment of social networks, could also be assessed to help identify the true impact of FF implementation.

2. What is the perceived efficacy of various forms of online extension and communication for ON dairy producers?

Given the popularity, cost-effectiveness, and relative ease with which information can be presented on the internet, it is likely that online and virtual forms of extension and communication will be heavily relied upon for future producer outreach. However, internet accessibility in rural areas, computer illiteracy, and learning preferences among producers may represent challenges to the uptake of information from these sources. A study assessing producer use, accessibility, and preferences for forms of online learning would provide useful insights into the efficacy of online forms of communication, a form that will likely continue to dominate communication efforts moving forward. Furthermore, given the improvement in technologies and software, there are multiple forms of online learning that can take place. Examples of this can be found for JD control specifically. Nearly all JD control programs worldwide have established a website, which houses pertinent information about the program and links for additional information. More creative forms of online learning have been established as well.
Interactive software programs, such as the simulation game, JD Consult, in the U.S. (McDonald et al., 2012), or the online RA and herd-tracking database in the U.K., www.myhealthyherd.com (Orpin et al., 2012) are becoming popular tools to engage producers in online learning.

Furthermore, the results of this study were used to create a unique form of educational video called ‘whiteboard scribing’, which conveys a concise message about a complex topic through recorded time-lapse whiteboard drawings that are sped up to match the speed of a narrator. This video, called ‘Johne’s Disease in Canadian dairy herds: What it means for farmers’, can be found on YouTube (http://youtu.be/u0Y0ew5yMo8) and has been popular among producers, researchers, and extension specialists since its release on November 11th, 2013. With the advent of new, active learning technologies, a study to evaluate the types of methods that would be preferred by producers, the efficacy of those methods, and the costs associated with implementation would be valuable for improving extension efforts in a technological age.

3. What are the communication approaches currently employed by veterinarians for recommending JD control? Can communication approaches be improved through training in facilitation?

With a lack of provincial funding for extension specialists, veterinarians are being relied on more than ever to provide producers with the necessary information to maintain healthy, productive herds and steadily improve their operations. As this study has demonstrated, the communication approaches used to influence producer behaviour is of paramount importance. A useful study would be to evaluate the current communication approaches ON veterinarians employ with their clients. Chapter 3 and 4 showed that veterinarians who were professionally trained in the art of facilitation felt their communication skills and ability to meet clients’ needs had improved as a result. Therefore, a pre-post intervention assessment of veterinarian communication techniques
before and after professional facilitator training could provide useful insights into how we train future veterinarians and how existing veterinarians might improve their skill set to more adequately address client needs.

In conclusion, the findings of this thesis suggest that producers’ attitude towards JD matters, and that any JD control management strategies should be producer-centred. Efforts to prevent and control disease on producers’ farms require a better understanding of the factors that influence producer behaviour, and the techniques that can be employed to influence those factors. This study contributes to this understanding in an ON, context and sets the stage for further research to improve our ability to combat disease at the farm-level for the entire industry. A producer-centred approach to managing chronic diseases requires a paradigm shift for the veterinary profession, and this thesis provides strong evidence that, if done correctly, this approach will be effective for influencing behaviour and ensuring the realization of benefits to all stakeholders.
REFERENCES


APPENDIX I

Introductory script and line of questioning for Ontario Focus Farm focus groups

INTRODUCTION

“Hi everyone. I would like to thank you all for taking the time today to join our discussion about Johne’s Disease extension and the Focus Farm process. My name is [Insert Name] and I will be moderating the discussions today. [Insert Name] will also be present to take notes on the discussion.

The goal today is to openly discuss your opinions and attitudes towards a variety of issues relating to Johne’s Disease, calf health management, extension in Ontario and the Focus Farm process. It is important to note that there are no right or wrong answers during these discussions; we are interested in your honest opinions, so please feel comfortable in expressing them.

I will be audio-recording the discussions today for data analysis. Our research team and a single professional transcriptionist will be the only ones with access to these recordings. All personal information will be kept confidential and at no point in time will we release any identifying information.

Just before we get started, I would like to mention a few ‘house-keeping’ things. For your participation today you will receive $50 cash at the end of the session. Please be sure to sign the attendance form indicating that you have received compensation. We also have some refreshments at the back of the room; please feel free to help yourself through the session. Once our discussion is over today I would appreciate it if you could refrain from discussing others people’s opinions outside of the room in order to ensure confidentiality and privacy of everyone’s comments. At any point during this session, you may refuse to answer questions or choose to withdraw from the study without consequences. I would also like to emphasize that we want to be sure to hear everyone’s opinions today, so at certain points I may interrupt you or call on you to ensure everyone has a chance to speak. We will be wrapping things up today after about 2 hours.
Please keep in mind that participation is key to the success of a focus group, so I encourage you all to share your thoughts on each topic. My role here is to keep the discussion moving, keep us on time and make sure everyone has a chance to speak.

If there are no questions, I would like to ask you to read and sign the consent form to participate in this study.”
FIRST LINE OF QUESTIONING (~ 1 hour)

“Okay, so just to get things going I would like to go around the room and have everyone introduce themselves where do you farm, how many cows do you milk and what do you enjoy most about being a dairy farmer?”

“I would like to start our discussions today by talking about your attitudes and opinions towards managing Johne’s Disease.”

1. What comes to mind when you think about Johne’s Disease?
   - Do you feel Johne’s Disease is a problem for the Ontario dairy industry?
   - How does Johne’s Disease rank in your priorities compared to other diseases?

   **Action:** Distribute and read “JD Recommendation sheet” to the group (attached below)

   “Here are the management practices that are most commonly recommended to prevent and control Johne’s Disease in Ontario”

2. When you think about implementing these recommended management practices on your farm, what do you see as the main barriers to adopting these recommendations?
   - What kinds of barriers do you see for someone who hasn’t done these?
   - Can you think of potential solutions to address these barriers?
   - Do you feel Johne’s Disease is, or could be, a problem on your farm?

   “I would like to transition now to talk a little more generally about what motivates you to make changes on your farm and how you prefer to receive new information”

3. How do you think we can motivate producers to make changes to address Johne’s Disease?
   - How does the actions of your peers affect what you do?
   - What motivates you to make any sort of change on your farm?

4. Think about the people you consult to get new information on management decisions (i.e. vet), how would you like them to provide you with new information?
   - I prefer to get new info. in writing, what is the most useful method for you?

   **Action:** Announce a 5-7 break, hand out ‘Elements of Focus Farms’ sheet (attached below)
SECOND LINE OF QUESTIONING (~ 1 hour)

“I would now like to talk a little about the Focus Farm process that you were involved in.”

5. What were the aspects of the Focus Farm process you liked?
   - How was it different than other clubs you have participated in?

6. What were the aspects of the Focus Farm process you didn’t like?
   - How was it different than other clubs you have participated in?

7. How could the Focus Farm process be improved?

“Okay, now let’s take a look at the Elements of Focus Farms sheet I passed out at the break. Your responses to these questions will help us figure out whether your group had the qualities that make a successful Focus Farm group”

8. Based on these questions, how do you feel your group did?

9. Was the Focus Farm process useful to you as an educational process?
   - Can you tell me something you learned from this process?
   - Can you tell me about some of the changes you made or planned on your farm?
Primary Recommendations for Johne’s Disease Management in Ontario

From 662 RAMP’s (OJEMAP, 2010)

These are the top 10 recommendations made to producers on the RAMP forms for Johne’s Disease…

What barriers do you see in making these changes on your farm?

1. Don’t buy cows, or buy from low risk herds
2. Remove calves quickly from maternity area
3. Feed more colostrum to newborn calves and feed it on time
4. Don’t walk through feed bunk or calf pens with dirty boots
5. Collect and feed low risk colostrum to calves from high risk cows
6. Separate newborn calf from cow
7. Don’t feed non-saleable milk to calves
8. Don’t use calving pen as the hospital (sick) pen
9. Re-test herd annually
10. Feed low risk milk to calves
Elements of Focus Farms

Your answers to the following questions will help us find out whether your group had all of the elements of a successful Focus Farm group.

Take a look… what do you think?

1. Did you participate in all parts of the process?
   Example. Discussions, identifying topics, deciding on activities, etc.

2. Did you feel the meetings were customizable and addressed your needs?

3. Did you honestly discuss your issues, opinions and priorities?

4. Did you take action and make or plan changes?
   Example. Changes to management, in the way you approach a problem, etc.

5. Did you reflect on those changes?

6. Is this something you would continue as a group?
APPENDIX II

Post-Ontario Focus Farm intervention questionnaire

Monday, December 5th, 2012

As the Focus Farm process wraps up in Ontario we are asking participants to take another 15 minutes to complete this final evaluation survey. Your responses here will be linked to your responses on the first survey, which you completed early on in the process.

Our primary goal is to show that the Focus Farm approach to producer learning is more effective than other, more traditional, methods of education. Also, we plan to not only listen to your feedback, but use it to improve the process to better meet your needs.

Your participation here is essential for us to show that this is a useful process and one that should be continued here in Ontario. With your help we can make this approach more routine for you and your fellow producers with the goal of improving your herds health and the quality of the product it produces.

_A few minutes of your time can help us improve the Focus Farm process to better serve you!_

This survey is also available online at: [www.surveymonkey.com/s/focusfarm](http://www.surveymonkey.com/s/focusfarm)

**Note:** Once you have completed the survey please fold the survey, place in the provided envelope and drop in your local mailbox. All postage has been prepaid and there will be no cost to you for sending the survey back.

**Incentive**
For completing this survey you will be entered into a draw to receive one of five $10 Tim Horton’s gift cards or one of two cash prizes of $250.

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_Thank you for your time, we appreciate your input and feedback!_
TEST YOUR KNOWLEDGE

The following questions focus on various facts and management practices about Johne’s disease. Please read each question carefully and check the correct response(s). Please circle your answer for True and False questions. Please note that certain questions may have more than 1 correct answer.

1. Johne’s disease is caused by a bacterium called *Mycobacterium avium paratuberculosis* (MAP). In most infections, where do you think the bacteria came from?
   - Adult cow to calf
   - Calf to calf
   - Adult cow to adult cow
   - Calf to adult cow
   - Bull to cows

2. Which do you think contains the greatest number of MAP bacteria?
   - Manure (feces)
   - Milk
   - Saliva
   - Uterine fluids
   - Urine

3. Cattle with Johne’s disease generally spread MAP through:
   - Saliva
   - Manure (feces)
   - Urine
   - Breathing
   - Direct contact

4. Roughly how long do you think MAP survives in soil or on pastures?
   - 1 hour
   - 1 day
   - 1 week
   - 1 month
   - 1 year
5. Where do you think MAP bacteria multiply?

- Soil
- Water
- Manure (feces)
- Infected cattle
- Pasture

6. True or False: Most animals infected with MAP show no signs of infection:

TRUE  FALSE

7. MAP bacteria can be transmitted when manure (feces) from infected animals contaminates:
(Please choose all that apply).

- Water hay/silage swept up from cows and given to heifers
- Water runoff from milking barn to calf hutch
- Teats
- Colostrum
- Water troughs
- Pastures
- All of the above

8. Some methods that can be used to prevent the spread of MAP bacteria include:
(Please choose all that apply).

- Calving in clean, dry dedicated calving pens or stalls
- Use of milk replacer to feed calves
- Keeping calves away from sources of water contaminated with manure from infected cows
- Use of pasteurized milk for feeding calves
- All of the above.

9. The length of time between infection and when there are visible signs of Johne’s disease is generally:

- Several hours
- Several days
- Several weeks
- Several months
- Several years

10. Do you think cattle infected with MAP, but who are healthy looking, are able to spread Johne’s?

YES  NO
11. Clinical signs of Johne’s disease are mostly seen in which age group of cattle?
   - Young calves
   - Calves several months old
   - Bulling heifers
   - Adult cattle 2 to 5 years old
   - Adult cattle 6 to 9 years old

12. True or False: Once Johne’s disease is diagnosed in a herd, it can never be controlled:
   - TRUE
   - FALSE

13. When do you think a newborn dairy calf should be removed from the dam to minimize Johne’s?
   - After the calf has suckled approximately 4 litres of colostrum from the dam
   - Before the next cow in the pen freshens
   - Before it stands to nurse, within 30 minutes of birth (as soon as possible)
   - Within 48 hours

14. True or False: Herds on the Johne’s program can be certified as having completed the full program requirements but NOT as “Johne’s free”.
   - TRUE
   - FALSE

15. The clinical signs of Johne’s disease include:
   - Chronic diarrhea
   - Frequent coughing
   - Weight loss
   - Abortion
   - Inadequate performance
   - Mastitis
   - All of the above

16. Calves are considered to be more susceptible to MAP infection than adults. What do you think “more susceptible” really means?
   - Calves develop signs of Johne’s disease more quickly than adult cattle
   - Calves are exposed to MAP bacteria more often than adult cattle
   - Calves can become infected by a smaller dose of MAP bacteria than for adult cattle
   - MAP bacteria are attracted to calves but not to adult cattle
   - None of the above. Calves are not more susceptible to MAP

17. True or False: Pooling of colostrum from multiple cows is recommended to make sure enough milk is on hand at all times and it presents low risk for MAP infection.
   - TRUE
   - FALSE
18. Colostrum management is an important component of a Johne’s disease control program. Managers of an infected herd should: (Please choose all that apply).
- Use a commercial colostrum product (artificial colostrum)
- Pool colostrum to maintain a steady supply
- Allow calf to nurse colostrum, then switch to milk replacer
- All of the above

19. Which of the following management practices on dairy farms do you think will spread Johne’s? (Please choose all that apply).
- Feeding waste milk to calves
- Pooling colostrum that is fed to newborn calves
- Using the same equipment to move cow manure and feed for heifers
- Allowing young cattle access to ponds that are contaminated with manure from the herd
- All of the above

20. What do you think the best approach to get the best estimate of the level of Johne’s in your herd is?
- Wait until a perfect test is developed
- Don’t bother to test and rely on clinical signs instead
- Test your herd on an annual basis

21. Which of the following characteristics of dairy herds do you think increases the likelihood of being MAP infected? (Please choose all that apply).
- Frequently buying replacement cattle
- Larger herds (over 300 cows)
- Use contract heifer raiser to rear heifers as replacements
- All of the above

22. Which of the following steps do you think is the most important for an effective Johne’s disease control program?
- Limiting exposure of calves to contaminated colostrum, milk and manure
- Using artificial insemination
- Resting pastures contaminated with manure from infected animals
- Disinfecting all farm tools

23. What do you think is the most effective strategy for keeping Johne’s disease out of an uninfected herd?
- Pool waste milk for calves
- Base purchase decisions on current test results
- Use different equipment for moving manure and feed
- Lime all pastures before spreading manure
24. True or False: Most of the cows infected with MAP in a herd will be detected the first time the adults in the herd are tested.

TRUE    FALSE

25. Which of the following methods do you think is best for disinfecting farm tools?

- Rinsing after use
- Washing with soap and water
- Scrubbing with soap and water, then disinfecting
- Disinfecting immediately after use

26. True or False: Animals with confirmed cases of clinical Johne’s disease can be treated and cured in a cost-effective manner.

TRUE    FALSE

27. Once a cow is identified as having Johne’s disease, what do you think should happen?

- Keep the cow to “naturally vaccinate” all other adult cattle
- Introduce the infected cow to heifers before bulling to “naturally vaccinate” before pregnancy
- Have the cow euthanized and rendered
- Cull the cow and all progeny of the cow
- Cull the cow and keep the progeny of the cow

28. True or False: Herds who have all cows test negative on their Johne’s herd program test can consider themselves “Johne’s free”.

TRUE    FALSE

29. What do you think is the minimum number of adult cattle (over 2 years old) that should be tested in order to get a reasonably accurate estimate of the MAP infection status of a 100 head dairy herd? (100 total).

- 5
- 15
- 30
- 75
- 100
For each of the following statements please circle the number that most adequately reflects your opinion. 
1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly Agree

<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>It is expected of me to make changes in management to prevent and control Johne’s disease on my farm</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>I intend to make changes in management to prevent and control Johne’s disease on my farm</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>I am concerned about the health effects of Johne’s disease on my herd</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>I am concerned about the financial costs of Johne’s disease</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>I am concerned about the possible human health risks (e.g. Crohn’s) of Johne’s disease</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>6</td>
<td>I currently use many of the recommended prevention and control strategies for Johne’s disease on my farm</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Prevention and control strategies for Johne’s disease are very effective</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Preventing and controlling Johne’s disease makes me a good manager</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Preventing and controlling Johne’s disease improves herd health</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Being concerned about Johne’s disease is:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>11</td>
<td>Minimizing the financial costs of Johne’s disease is:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>12</td>
<td>Being concerned about the possible human health risks of Johne’s disease is:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>13</td>
<td>Preventing and controlling Johne’s disease on my farm is:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>14</td>
<td>Having effective prevention and control strategies are:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>15</td>
<td>Being a good manager of herd health is:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>16</td>
<td>Improving herd health on my farm is:</td>
<td>Very</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td>17</td>
<td>It is expected of me to make changes in management to improve calf health on my farm</td>
<td>Strongly disagree</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>I intend to make changes in management to improve calf health on my farm</td>
<td>Strongly disagree</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>My fellow producers think it’s important to prevent and control Johne’s disease</td>
<td>Strongly disagree</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Rating</td>
<td>Likelihood</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
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<td>---</td>
</tr>
<tr>
<td>20</td>
<td>My fellow producers have made management changes to prevent and control Johne’s disease</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>My herd veterinarian thinks it’s important to prevent and control Johne’s disease</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Ontario dairy organizations (e.g. DFO, DHI) think it’s important to prevent and control Johne’s disease</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Dairy consumers think it’s important for me to prevent and control Johne’s disease</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>What my fellow producers think is important matters to me</td>
<td>Not at all</td>
<td>1 2 3 4 5</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>What my fellow producers do on their farm matters to me</td>
<td>Not at all</td>
<td>1 2 3 4 5</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>What my herd veterinarian thinks I should do matters to me</td>
<td>Not at all</td>
<td>1 2 3 4 5</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>What DFO and DHI thinks is important matters to me</td>
<td>Not at all</td>
<td>1 2 3 4 5</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Consumer approval of my herd management matters to me</td>
<td>Not at all</td>
<td>1 2 3 4 5</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Making changes to prevent and control Johne’s disease is too time consuming</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Making changes to prevent and control Johne’s disease is too expensive</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>The recommended changes to prevent and control Johne’s disease aren’t realistic</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Preventing and controlling Johne’s disease is difficult because I can’t see any signs or symptoms of it being present</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>The tests for Johne’s disease don’t provide me with accurate enough results to make changes</td>
<td>Strongly disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>When making changes is time consuming I am (more-less likely) to make them</td>
<td>Very -2 -1 0 +1 +2</td>
<td>Likely</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>When making changes is expensive I am (more-less likely) to make them</td>
<td>Very -2 -1 0 +1 +2</td>
<td>Likely</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>When recommended changes don’t seem realistic I am (more-less likely) to make them</td>
<td>Very -2 -1 0 +1 +2</td>
<td>Likely</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>When signs and symptoms of disease aren’t visible I am (more-less likely) to make changes</td>
<td>Very -2 -1 0 +1 +2</td>
<td>Likely</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>When tests aren’t accurate I am (more-less likely) to make changes</td>
<td>Very -2 -1 0 +1 +2</td>
<td>Likely</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What were the three things you liked most about the Focus Farm meetings?

______________________________________________________________________________

______________________________________________________________________________

Was the Focus Farm process useful in increasing your awareness of (1) Johne’s disease? (2) Calf health?

(1) O Yes  O No  | (2) O Yes  O No

Do you think that your knowledge of (1) Johne’s disease has increased? What about your knowledge of (2) calf health management?

(1) O Yes  O No  | (2) O Yes  O No

Do you think that your attitude towards Johne’s disease has changed? How about calf health?

(1) O Yes  O No  | (2) O Yes  O No

If yes, briefly explain how:

______________________________________________________________________________

______________________________________________________________________________

Have you made any management changes for Johne’s on your farm since the Focus Farm process?

O Yes  O No

If yes, briefly explain what changes you’ve made:

______________________________________________________________________________

______________________________________________________________________________

Have you made any management changes for calf health on your farm since the Focus Farm process?

O Yes  O No

If yes, briefly explain what changes you’ve made:

______________________________________________________________________________

______________________________________________________________________________
Have you observed any changes in calf health on your farm since the Focus Farm process started?

☐ Yes  ☐ No

If so, briefly explain what changes you’ve seen:
__________________________________________________________

______________________________________________________________________________

Would you say this change in calf health is a result of the changes you’ve made?

☐ Yes  ☐ No

Has the Focus Farm process helped you plan and/or make management changes on your farm?

☐ Yes  ☐ No

Do you feel that the Focus Farm process has improved your confidence in dealing with Johne’s disease?

☐ Yes  ☐ No

Do you feel that the Focus Farm process has improved your ability to manage calf health?

☐ Yes  ☐ No

Please rank the following sources of information in terms of their usefulness to you as sources of new information. (Please rank 1-8, 1 being the most useful).

Extension personnel ____ Other producers ____
Internet ____ Producer organizations ____
Focus Farm meetings ____ Scientific journals ____
Magazines ____ Veterinarians ____

How would you describe your current level of understanding of Johne’s disease? (circle one)

Complete      Very high      Moderate      Little      None

How would you rate your farm’s current level of risk for getting Johne’s disease? (circle one)

Very high     High        Moderate      Low        Very Low
Overall, how concerned are you about Johne’s disease on your farm? (circle one)

- Very concerned
- Concerned
- Neither concerned nor unconcerned
- Unconcerned
- Very unconcerned

How could the Focus Farm process be improved in your opinion?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Would you be interested in continuing on with the Focus Farm process?

- O Yes
- O No

THANK YOU FOR PARTICIPATING!
Pre-Ontario Focus Farm intervention questionnaire

October 15th, 2010

In an effort to increase the effectiveness of educational programs, such as the Focus Farms project, we hope to better understand what the most effective methods of presenting dairy producers with new, useful information are. Through the Ontario Focus Farm and Johne's Disease Survey we will also be able to better understand how we can help affect change on your farm in a way that will help you to prevent and control Johne’s disease and other calf diseases.

Overall, we expect to show that the Focus Farm Project is effective at helping Ontario dairy producers to discover and adopt innovative and practical management practices to improve calf, heifer and cow health and prevent Johne’s disease.

A few minutes of your time can help us improve the Focus Farm process to better serve you!

This survey is also available online at: www.surveymonkey.com/s/johnesdisease

Note: Once you have completed the survey please fold the survey, place in the provided envelope and drop in your local mailbox. All postage has been prepaid and there will be no cost to you for sending the survey back.

Incentive
For completing this survey you will be entered into a draw to receive one of five $10 Tim Hortons gift cards or one of two cash prizes of $250.

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Steven Roche
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Phone: (519) 830-2809

Faculty Advisor
David Kelton
E-mail: dkelton@uoguelph.ca
Phone: (519) 824-4120 ext. 54808

Thank you for your time, we appreciate your input and feedback!
1. What is your name? (Please print both your first and last name)

_____________________________

2. What is your age in years as of January 1st 2012?

_____________________________

3. What is your sex?

- Male  
- Female  

4. What country were you born in?

_____________________________

5. What percentage of your total household income comes from dairy farming?

_____________________________

6. What is the highest educational level you have completed?

_____________________________

7. Please fill in your Dairy Farmers of Ontario (DFO) license number in the space provided:

_____________________________

8. If applicable, please fill in your CanWest DHI herd number in the space provided:

_____________________________

9. Do you feel Johne's Disease is a problem for the Ontario dairy industry?

- Yes  
- No  
- Don’t Know  

10. Do you feel Johne's Disease is a problem OR a potential problem for you and your farm?

- Yes  
- No  
- Don’t Know
11. How confident are you in your ability to prevent Johne's Disease from infecting your herd?

- Very confident
- Confident
- Somewhat confident
- Very little confidence
- No confidence

12. How confident are you in your ability to control the spread of Johne's Disease in your herd if it were to be infected?

- Very confident
- Confident
- Somewhat confident
- Very little confidence
- No confidence

13. Overall, how concerned are you about Johne's Disease on your farm?

- Very concerned
- Concerned
- Neither concerned nor unconcerned
- Unconcerned
- Very unconcerned

14. Please briefly explain your answer to question 13:

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

15. Please rank the following sources of information in terms of their usefulness to you in understanding Johne's disease. (Please rank from 1-7 using each number once, with 1 being the most useful)

Veterinarians _____  Magazines _____
Other producers _____  Scientific journals _____
Extension personnel _____  Internet _____
Producers organizations _____
16. How would you describe your current level of understanding of the 'general facts' on Johne's Disease?

- Complete
- Very high
- Moderate
- Little
- None

17. How would you describe your current level of understanding of the methods to prevent and control Johne's Disease?

- Complete
- Very high
- Moderate
- Little
- None

18. How would you rate your farm's current level of risk for getting Johne's Disease?

- Very high
- High
- Moderate
- Low
- Very low

19. Hypothetically, if Johne's Disease was present in your herd, given your current management practices, how would you rate your farm's current ability to control the disease?

- Very high
- High
- Moderate
- Low
- Very low

20. How did you hear about the Focus Farm meetings?

- Internet/Website
- Veterinarian
- Newsletter
- Magazine
- Other producers
- Extension personnel
- Conference/meeting
- Other
21. If you chose 'Other' in the previous question, please briefly explain the other source:
_____________________________________________________________

22. What is your main reason for participating in the Focus Farm meetings?
_____________________________________________________________
_____________________________________________________________
_____________________________________________________________

23. Please briefly explain what you hope to get out of the Focus Farm approach.
_____________________________________________________________
_____________________________________________________________
_____________________________________________________________
TEST YOUR KNOWLEDGE

The following questions focus on various facts and management practices about Johne’s disease. Please read each question carefully and check the correct response(s). Please circle your answer for True and False questions. Please note that certain questions may have more than 1 correct answer.

1. Johne’s disease is caused by a bacterium called Mycobacterium avium paratuberculosis (MAP). In most infections, where do you think the bacteria came from?
   - Adult cow to calf
   - Calf to calf
   - Adult cow to adult cow
   - Calf to adult cow
   - Bull to cows

2. Which do you think contains the greatest number of MAP bacteria?
   - Manure (feces)
   - Milk
   - Saliva
   - Uterine fluids
   - Urine

3. Cattle with Johne’s disease generally spread MAP through:
   - Saliva
   - Manure (feces)
   - Urine
   - Breathing
   - Direct contact

4. Roughly how long do you think MAP survives in soil or on pastures?
   - 1 hour
   - 1 day
   - 1 week
   - 1 month
   - 1 year

5. Where do you think MAP bacteria multiply?
   - Soil
   - Water
   - Manure (feces)
   - Infected cattle
   - Pasture
6. True or False: Most animals infected with MAP show no signs of infection:

TRUE
FALSE

7. MAP bacteria can be transmitted when manure (feces) from infected animals contaminates:
(Please choose all that apply).

- Water hay/silage swept up from cows and given to heifers
- Water runoff from milking barn to calf hutches
- Teats
- Colostrum
- Water troughs
- Pastures
- All of the above

8. Some methods that can be used to prevent the spread of MAP bacteria include:
(Please choose all that apply).

- Calving in clean, dry dedicated calving pens or stalls
- Use of milk replacer to feed calves
- Keeping calves away from sources of water contaminated with manure from infected cows
- Use of pasteurized milk for feeding calves
- All of the above.

9. The length of time between infection and when there are visible signs of Johne’s disease is generally:

- Several hours
- Several days
- Several weeks
- Several months
- Several years

10. Do you think cattle infected with MAP, but who are healthy looking, are able to spread Johne’s?

YES
NO

11. Clinical signs of Johne’s disease are mostly seen in which age group of cattle?

- Young calves
- Calves several months old
- Bulling heifers
- Adult cattle 2 to 5 years old
- Adult cattle 6 to 9 years old
12. True or False: Once Johne’s disease is diagnosed in a herd, it can never be controlled:

   TRUE   FALSE

13. When do you think a newborn dairy calf should be removed from the dam to minimize Johne’s?

   O After the calf has suckled approximately 4 litres of colostrum from the dam
   O Before the next cow in the pen freshens
   O Before it stands to nurse, within 30 minutes of birth (as soon as possible)
   O Within 48 hours

14. True or False: Herds on the Johne’s program can be certified as having completed the full program requirements but NOT as “Johne’s free”.

   TRUE   FALSE

15. The clinical signs of Johne’s disease include:

   (Please choose all that apply).
   O Chronic diarrhea
   O Frequent coughing
   O Weight loss
   O Abortion
   O Inadequate performance
   O Mastitis
   O All of the above

16. Calves are considered to be more susceptible to MAP infection than adults. What do you think “more susceptible” really means?

   O Calves develop signs of Johne’s disease more quickly than adult cattle
   O Calves are exposed to MAP bacteria more often than adult cattle
   O Calves can become infected by a smaller dose of MAP bacteria than for adult cattle
   O MAP bacteria are attracted to calves but not to adult cattle
   O None of the above. Calves are not more susceptible to MAP

17. True or False: Pooling of colostrum from multiple cows is recommended to make sure enough milk is on hand at all times and it presents low risk for MAP infection.

   TRUE   FALSE

18. Colostrum management is an important component of a Johne’s disease control program. Managers of an infected herd should: (Please choose all that apply).

   O Use a commercial colostrum product (artificial colostrum)
   O Pool colostrum to maintain a steady supply
   O Allow calf to nurse colostrum, then switch to milk replacer
   O All of the above
19. Which of the following management practices on dairy farms do you think will spread Johne’s? (Please choose all that apply).
- Feeding waste milk to calves
- Pooling colostrum that is fed to newborn calves
- Using the same equipment to move cow manure and feed for heifers
- Allowing young cattle access to ponds that are contaminated with manure from the herd
- All of the above

20. What do you think the best approach to get the best estimate of the level of Johne’s in your herd is?
- Wait until a perfect test is developed
- Don’t bother to test and rely on clinical signs instead
- Test your herd on an annual basis

21. Which of the following characteristics of dairy herds do you think increases the likelihood of being MAP infected? (Please choose all that apply).
- Frequently buying replacement cattle
- Larger herds (over 300 cows)
- Use contract heifer raiser to rear heifers as replacements
- All of the above

22. Which of the following steps do you think is the most important for an effective Johne’s disease control program?
- Limiting exposure of calves to contaminated colostrum, milk and manure
- Using artificial insemination
- Resting pastures contaminated with manure from infected animals
- Disinfecting all farm tools

23. What do you think is the most effective strategy for keeping Johne’s disease out of an uninfected herd?
- Pool waste milk for calves
- Base purchase decisions on current test results
- Use different equipment for moving manure and feed
- Lime all pastures before spreading manure

24. True or False: Most of the cows infected with MAP in a herd will be detected the first time the adults in the herd are tested.

   TRUE
   FALSE
25. Which of the following methods do you think is best for disinfecting farm tools?

- Rinsing after use
- Washing with soap and water
- Scrubbing with soap and water, then disinfecting
- Disinfecting immediately after use

26. True or False: Animals with confirmed cases of clinical Johne’s disease can be treated and cured in a cost-effective manner.

   TRUE
   FALSE

27. Once a cow is identified as having Johne’s disease, what do you think should happen?

- Keep the cow to “naturally vaccinate” all other adult cattle
- Introduce the infected cow to heifers before bulling to “naturally vaccinate” before pregnancy
- Have the cow euthanized and rendered
- Cull the cow and all progeny of the cow
- Cull the cow and keep the progeny of the cow

28. True or False: Herds who have all cows test negative on their Johne’s herd program test can consider themselves “Johne’s free”.

   TRUE
   FALSE

29. What do you think is the minimum number of adult cattle (over 2 years old) that should be tested in order to get a reasonably accurate estimate of the MAP infection status of a 100 head dairy herd? (100 total).

- 5
- 15
- 30
- 75
- 100
VARK A GUIDE TO LEARNING STYLES

The following questions are part of the VARK test. VARK stands for the Visual, Aural, Read/Write and Kinesthetic learning styles. These questions are designed to help identify how you prefer to receive new information.

For the following questions please choose the answer which best explains your preference. Please choose more than one response if a single answer does not match your perception. Leave blank any question that does not apply.

1. You are helping someone who wants to go to your airport, town centre or railway station. You would:
   - Go with him/her
   - Tell him/her the directions
   - Write down the directions
   - Draw, or give him/her a map

2. You are not sure whether a word should be spelled 'dependent' or 'dependant'. You would:
   - See the words in your mind and choose by the way they look
   - Think about how each word sounds and choose one
   - Find it in a dictionary
   - Write both words on paper and choose one

3. You are planning a holiday for a group. You want some feedback from them about the plan. You would:
   - Describe some of the highlights
   - Use a map or website to show them the places
   - Give them a copy of the printed itinerary
   - Phone, text or email them

4. You are going to cook something as a special treat for your family. You would:
   - Cook something you know without the need for instructions
   - Ask friends for suggestions
   - Look through the cookbook for ideas from pictures
   - Use a cookbook where you know there is a good recipe
5. A group of tourists want to learn about the parks or wildlife reserves in your area. You would:

- Talk about, or arrange a talk for them about parks or wildlife reserves
- Show them internet pictures, photographs or picture books
- Take them to a park or wildlife reserve and walk with them
- Give them a book or pamphlets about the parks or wildlife reserves

6. You are about to purchase a digital camera or mobile phone. Other than price, what would most influence your decision?

- Trying or testing it
- Reading the details about its features
- It is a modern design and looks good
- The salesperson telling me about its features

7. Remember a time when you learned how to do something new. Try to avoid choosing a physical skill, e.g. riding a bike. You learned best by:

- Watching a demonstration
- Listening to somebody explaining it and asking questions
- Diagrams and charts – visual clues
- Written instructions – e.g. a manual or textbook

8. You have a problem with your heart. You prefer that the doctor:

- Gave you something to read to explain what was wrong
- Used a plastic model to show what was wrong
- Described what was wrong
- Showed you a diagram of what was wrong

9. You want to learn a new program, skill or game on a computer. You would:

- Read the written instructions that came with the program
- Talk with people who know about the program
- Use the controls or keyboard
- Follow the diagrams in the book that came with it
10. I like websites that have:

- Things I can click on, shift or try
- Interesting design and visual features
- Interesting written descriptions, lists and explanations
- Audio channels where I can hear music, radio programs or interviews

11. Other than price, what would most influence your decision to buy a new non-fiction book?

- The way it looks is appealing
- Quickly reading parts of it
- A friend talks about it and recommends it
- It has real-life stories, experiences and examples

12. You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have:

- A chance to ask questions and talk about the camera and its features
- Clear written instructions with lists and bullet points about what to do
- Diagrams showing the camera and what each part does
- Many examples of good and poor photos and how to improve them

13. Do you prefer a teacher or a presenter who uses:

- Demonstrations, models and practical sessions
- Question and answer, talk, group discussion, or guest speakers
- Handouts, books, or readings
- Diagrams, charts or graphs

14. You have finished a competition or test and would like some feedback. You would like to have feedback:

- Using examples from what you have done
- Using a written description of your results
- From somebody who talks it through to you
- Using graphs showing what you had achieved
15. You are going to choose food at a restaurant or cafe. You would:

- Choose something that you have had before
- Listen to the waiter or ask friends to recommend choices
- Choose from the descriptions menu
- Look at what others are eating or look at pictures of each

16. You have to make an important speech at a conference or special occasion. You would:

- Make diagrams or get graphs to help explain things
- Write a few key words and practice saying your speech over and over
- Write out your speech and learn from reading it over several times
- Gather many examples and stories to make the talk real and practical

On behalf of the Department of Population Medicine at the University of Guelph, OMAFRA and the Focus Farm Project we would like to thank you for participating in our research study.

1. If you have any comments regarding this survey we would love to hear from you. Please fill in any questions, comments or concerns you have in the space below.
APPENDIX IV

Pre-and post-intervention Risk assessment and management assistance plan (RAMP)

Date: DD/MM/YYYY
Cattle Health Risk Assessment and Management Plan (RAMP)

Producer/Farm Name: ____________________________
Producer DFO Licence #: _______________  DHI Herd #:__________________

Johne’s Disease (JD) History
Date of full herd Johne’s test prior to this program test (ddmmyy)
(Check if no Johne’s herd test prior to program test)

Have you ever had any JD clinical (sick) OR test positive cows in your herd?
No         Yes   Don’t know

Section 1: Cattle addition risks:
1. Have you purchased cattle in the last 5 years?
   No       ( 0 pt)
   Yes from 1 herd    (10 pt.)
   Yes from multiple herds  (20 pt)

If YES then:
1.1. Did you buy any of the following in the last 5 years? (Check all that apply)
   Cows   (20 pt)
   Heifers   ( 5 pt)
   Bulls  ( 5 pt)

1.2 Did you ask about any diseases (such as Johne’s) prior to purchase?
   No   (10 pt)
   Yes   ( 2 pt)

Section 2: Calving Area Risks
1. Single or multiple cows in calving area?
2. Manure build up, risk for calf exposure?
3. Manure soiled udders and legs of cows?
4. Calving area used for sick or lame cows?
5. Calving area used by JD clinical or test positive cows?
6. Birth of calves in areas other than designated calving area?
7. Likelihood of calves nursing cow(s)?

Section 3: Heifers – Preweaned Risks

Section 4: Heifers - Weaned to First Calving Risks

Section 5: Cows - Risks

Veterinarian’s Name: ____________________________
Veterinarian’s Signature: _______________________ Date: _____________

Maximum score is 70. Your section score is

Maximum score is 40. Your section score is

Maximum score is 50. Your section score is

Total Risk Score / 300

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Date: ____________  Cattle Health Risk Assessment and Management Plan (RAMP)

Recommendations for changes on this farm:
(Maximum of 3 per RAMP suggested)

1. 

2. 

3. 

Cattle Health and Veterinary Medicine Use Declaration
As prescribed by Regulation 761 made under the MW Act, R.S.O. 1990, c. M. 12, section 34.2

Producer Name (Name on DFO Licence): ___________________ DFO Licence #: ___________________

Veterinarian Name: ____________________________

Veterinarian declaration:
As of this date, I have visibly observed the general health status of the cattle in this herd and found them to be healthy, or receiving satisfactory care and treatment for routine health conditions. I have verified that this producer has in place a system for identifying treated and sick cows and for preventing milk from these cows from entering the producer’s bulk tank(s).

I have reviewed and discussed the use of veterinary medicines with ____________________________, the person responsible for the use of veterinary medicines for this herd. I have advised this person that veterinary medicines must always be used according to label directions, unless a licensed veterinarian who has a valid veterinarian-client-patient relationship (VCPR) with the producer and the producer’s herd has provided written directions to do otherwise.

Veterinarian’s Signature: ____________________________ Date: ____________

Producer declaration:
As a DFO license holder, I acknowledge that I am responsible for and that I do maintain an ongoing relationship with a licensed veterinarian for animal health and advisory services and I agree that veterinary medicines will always be used according to label directions, unless a licensed veterinarian who has a valid veterinarian-client-patient relationship (VCPR) with me has provided written directions to do otherwise.

Print Name: ____________________________

Signature: ____________________________ Date: ____________

Where the licensed producer is a corporation, I have authority to bind the corporation.

Created on 14/01/2013