Evaluating the effect of Focus Farms on Ontario dairy producers' knowledge, attitudes, and behavior toward control of Johne's disease

S. M. Roche,* A. Jones-Bitton,* M. Meehan,* M. Von Massow,† and D. F. Kelton*¹

*Department of Population Medicine, and

†School of Hospitality, Food and Tourism Management, University of Guelph, 50 Stone Road East, Guelph, Ontario, Canada N1G 2W1

ABSTRACT

This study evaluated a participatory-based, experiential learning program, Ontario Focus Farms (FF), which aimed to change dairy producer behavior to control Johne's disease (JD) in Ontario, Canada. The goals were to (1) assess the effect of FF on participating dairy producers' knowledge, attitudes, and behavior with regard to JD control; (2) compare changes in these factors among FF participants to changes among a group of nonparticipating dairy producers; and (3) describe the characteristics of producers who made at least one on-farm management change. Pre- and post-FF intervention questionnaires collected data on respondents' knowledge, attitudes, behavior, herd production, and demographic information; before and after JD-risk assessments were used to assess respondents' on-farm risk of JD transmission. Overall, 176 dairy producers participated in the FF process; 39.8% (70/176) of FF and 14.6% (52/357) of control participants responded to both the pre- and postintervention questionnaires. Upon comparison, FF respondents were more likely to be younger, have larger herds, and have higher management scores. 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 before and after risk assessments. Control respondents' risk assessment scores did not significantly change during the study period. In a JD knowledge assessment, FF and control respondents exhibited a moderate knowledge score before the intervention period, with median scores of 75.9% (22/29) in each group. The FF respondents significantly increased their score at the postintervention assessment, with a median of 82.8% (24/29); control-respondent scores did not significantly change. Both FF and control respon-

dents held strong positive attitudes toward 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. Last, participating in FF, having a moderate herd management score, having 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 appears to be effective at influencing producer behavior toward implementing on-farm management practices for JD control. Future JD control programs should consider implementing peer-learning extension processes, such as FF, in combination with other extension approaches, to influence producer behavior.

Key words: Johne's disease, behavior change, attitude, agricultural extension

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* ssp. *paratuberculosis* (**MAP**), is an important production-limiting disease, affecting cattle in many countries worldwide (Sweeney et al., 2012). In Canada, 32% of dairy herds have at least 2 seropositive cows (Tiwari et al., 2009). Of increasing concern is the evidence suggesting that MAP plays a role in Crohn's disease (Chiodini et al., 2012; Sweeney et al., 2012). A causal link between MAP and Crohn's disease, 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 use veterinarian-administered risk assessments (**RA**) to identify high-risk on-farm management practices and influence producer behavior to adopt JD control practices (Ken-

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¹Corresponding author: dkelton@uoguelph.ca

nedy and Allworth, 2000; Groenendaal et al., 2003; Nielsen, 2007; Collins et al., 2010; Barker et al., 2012). Although RA-based JD control programs have been widely implemented, their efficacy is largely dependent on the veterinarian's ability to communicate with his or her clients and the producer's willingness to adopt the recommended on-farm management practices for JD control (Sorge et al., 2010b). Several studies examining the uptake of on-farm management practices to control JD have reported poor producer uptake (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010b). This is likely due to the inability of the RA, and the veterinarian administering the RA, to address the factors associated with behavioral change (Sorge et al., 2010b). Social psychological theories suggest that behavior is influenced by a complex set of internal (i.e., attitude, perception, knowledge, beliefs, learning preferences, skills) and external (i.e., economics, penalties, mandates, incentives) factors (Boxelaar and Paine, 2005). One such theory is the theory of planned behavior (TPB), which identifies a set of psychological constructs (i.e., latent concepts or factors) that influence behavioral intentions and actual behavior (Ajzen, 2006). Several studies have applied this theory to understand and measure the factors influencing farmer behavior (Kuiper et al., 2005; Jansen et al., 2010a; Garforth et al., 2013), providing evidence of the fact that changes in TPB factors influence different behaviors. The TPB suggests that behavior is influenced by 3 key constructs, each of which is composed of 2 interacting components: (construct 1) attitudes toward the behavior, consists of "behavioral beliefs" (i.e., beliefs about the consequences of the behavior) and an "outcome evaluation" (i.e., the positive or negative judgments about each behavioral belief); (construct 2) subjective norms (i.e., perceived social pressure to perform the behavior), consists of "normative beliefs" (i.e., the positive and negative judgments of the social pressure an individual receives from other individuals they perceive as important) and "motivation to comply" (i.e., the strength of motivation to change their behavior resulting from each source of social pressure); (construct 3) perceived behavioral control (i.e., perceived ability to perform the behavior), consists of "control beliefs" (i.e., beliefs about factors that inhibit or facilitate performing the behavior) and "power to control behavior" (i.e., the individual's perception of the power each factor has on performing the behavior) (Francis et al., 2004). As outlined by the TPB, these 3 constructs combine to influence an individual's intention to perform a given behavior and ultimately his or her behavior (Francis et al., 2004; Ajzen, 2006). Therefore, to effectively influence dairy producer behavior, these factors, or anteced-

ents of behavioral change (i.e., knowledge, attitudes, perceptions), 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 implemented a 3-year, voluntary JD control program, called the Ontario John's Education and Management Assistance Program (OJEMAP) (OJEMAP, 2009). The program was composed 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 an agricultural extension approach that aims to influence producer behavior by addressing their knowledge and attitudes (Roche, 2014). Conceptually, FF uses the principles of adult education and experiential and participatory learning theory and follows 4 key principles: (1) participatory, self-directed, and collaborative, based on group-identified priorities; (2) honest communication and trust; (3) planning, action, and implementation; and (4) reflection. Practically, FF is implemented as a series of meetings, with group sizes between 7 and 12, which are facilitated by professionally trained veterinary practitioners.

The first objective of this study was to evaluate the effect of FF on participating dairy producers with respect to their knowledge and attitudes (i.e., thoughts, opinions, feelings) about, and behavior toward, JD control. The second objective was to compare changes in these factors among FF participants to changes among a group of nonparticipating Ontario dairy producers. The final objective was to investigate and describe the characteristics (i.e., demographic factors, knowledge, and attitudes) of producers who made at least one on-farm management change to control JD.

MATERIALS AND METHODS

Ontario FF

Roche (2014) provides a detailed overview of the implementation of the FF process. Briefly, 8 regions of Ontario were used for FF establishment (Kirkton, Seaforth, Listowel, Tavistock, New Liskeard, Napanee, Winchester, Navan) to address issues surrounding JD control. Two separate cohorts of the FF approach were implemented, which took place between November 2010 and November 2011 (cohort 1) and December 2011 and December 2012 (cohort 2). Cohort 1 consisted of 8 groups and 105 dairy producers, and cohort 2 included

6 groups and 71 producers. Each group consisted of 7 to 12 dairy producers and held a minimum of 5 meetings.

A regional veterinarian, trained in facilitation, was used in each meeting to create a comfortable, supportive, and trusting learning environment. Facilitators ensured meetings were self-directed by participants, meaning that each group controlled the content discussed and learning activities used, through goal setting, prioritization, and discussion. Each meeting was a combination of a half day of on-farm tours and activities and a half day of roundtable discussions and indoor activities. Although 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 or herd, calf feeding and housing, transition-cow management, and lameness. Common activities included exemplar farm tours (as chosen by groups), meeting with technical or content experts (as requested by groups), roundtable group discussions, participant presentations on their farm-specific issues, group work or 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, and so on), and planning or brainstorming sessions focusing on problems common to the group and on producer-specific issues (Roche, 2014).

Participant Recruitment

E-mail and mail-out letters to all Ontario veterinary clinics, and articles in provincial dairy magazines, were sent out to recruit bovine veterinarians to act as FF facilitators. Selection criteria for veterinarians included having practiced in the Ontario dairy industry for more than 2 yr, being willing to be professionally trained in facilitation, and committing to implementing the FF process within their practice region. Veterinarians from 8 regions of Ontario (Seaforth, Kirkton, Listowel, Tavistock, New Liskeard, Napanee, Winchester, Navan) voluntarily agreed to participate in FF as facilitators. In September 2010, all recruited veterinarians successfully completed a professional facilitator-training program (Leadership Strategies: The Facilitation Company). This training included lecture from a professional facilitator, active role-playing and group simulations, and numerous educational materials in the form of a facilitator-training handbook. Each FF facilitator was responsible for establishing one FF group per cohort in their respective regions. Facilitators were not given specific inclusion criteria for recruiting producers and

were asked to simply approach their clients regarding participation. Dairy producers were recruited in person and through clinic newsletters, e-mail, and phone. During recruitment, potential participants were briefed on the concept of FF and the expectation of active participation in group discussions and activities. No fee or incentive was offered for participation in the FF process.

For comparison purposes, another sample of Ontario dairy producers was recruited in April 2011, via e-mail and postal mail, to form a control group. A random number generator was used to select 400 dairy producers from the Ontario milk marketing board (Dairy Farmers of Ontario) database, which holds current contact information for all Ontario producers. The inclusion criteria for participation were being an owner or co-owner of a dairy herd in Ontario for at least 12 mo 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 mo.

Data Collection

Data about producer knowledge, attitudes, and behavior were collected using pre- and postintervention questionnaires; data pertaining to on-farm risk of JD transmission were collected using pre- and postintervention JD RA. In this study, behavior change is defined as the uptake or adoption of at least one on-farm management practice specifically for JD prevention or control.

Preintervention Questionnaire. A preintervention questionnaire (Q1) was administered (paper copy or online) to cohort 1 participants between October and November 2010, and cohort 2 participants and control producers received it between November and December 2011. Data on producers' attitudes and behaviors, with respect to JD control, as well as subjective knowledge of JD (i.e., a producer's assessment of how much he or she knows about 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 a JD assessment, which was adapted from a previously existing JD knowledge assessment (Johne's Information Centre, 2010). The assessment tool was composed of 29 multiple-choice questions and assessed producer knowledge 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 preferences 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, sex, ethnicity, income, education level). Last, respondents were asked to provide access to their CanWest DHI farm-level data including management score (i.e., an annual score, calculated using a point system assessing milk value, udder health, calving interval, age at first calving, herd efficiency, and longevity, used to compare herd performance across herds), herd size, herd turnover rate, and the averages for 305-d milk production per cow (kg), fat production (kg), protein production (kg), SCC, calving interval (days), dry period (days), number of days at first breeding, days open, and number of breedings per cow per year (CanWest DHI, 2009).

Postintervention Questionnaire. A postintervention questionnaire (**Q2**) was administered to cohort 1 participants between November and December 2011, and cohort 2 participants and control producers received the questionnaire between December 2012 and January 2013. The Q2 duplicated the Q1 questions on respondents' attitudes and behaviors 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. The 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, developed according to the TPB manual provided in Francis et al. (2004), was also included in Q2. More specifically, the TPB instrument was created by breaking each construct [i.e., attitudes, social norms, and perceived behavioral control (**PBC**)] into relevant subcomponents (item pairs) and then measuring each item pair individually. The sum of all item pairs relating to one specific construct then represents the overall score for that construct. The 34-item instrument used in this study measured respondents' attitudes, subjective norms, and PBC toward making an on-farm change to control JD. Attitudes were measured using 7 item-pair statements; each pair consisted of a behavioral belief statement

(e.g., I am concerned about the health effects of JD on my herd), rated from 1 to 5 (strongly disagree to strongly agree), and an outcome evaluation statement (e.g., Being concerned about the health effects of JD on my herd is:), rated from -2 to +2 (very unimportant to very important). The 7 item-pair statements for attitudes corresponded to attitudes toward the financial, cow health, and human health effects of JD; prevention and control of disease; efficacy of management practices; and effects on herd health. Subjective norms were measured using 5 item-pair statements, where each pair consisted of a normative belief statement (e.g., My fellow producers made changes to prevent and control JD), rated from -2 to +2 (strongly disagree to strongly agree), and a motivation to comply statement (e.g., What my fellow producers do on their farm matters to me), rated 1 to 5 (not at all to very much so). The 5 item-pair statements corresponded to the amount of social pressure respondents felt from fellow producers, veterinarians, industry organizations, and consumers. Finally, PBC was measured using 5 item-pair statements, where each pair consisted of a control belief statement (e.g., Changing practices to control JD is too time consuming), rated from 1 to 5 (strongly disagree to strongly agree), and a power statement [e.g., When changing practices is time consuming, I am (more or less likely) to change], rated -2 to +2 (much less likely to much more likely). The 5 item-pair statements corresponded to the influence of time commitments, financial cost, and practicality of changes; presence of clinical signs of disease; and test accuracy on perceived control. An overall measurement for each of the TPB constructs was obtained using an expectancy-value equation (TPB construct $\propto \sum b_i e_i$), as outlined by Ajzen (2006). A score for each item pair [composed of a belief statement (b_i) and an outcome statement (e_i)] was calculated by multiplying the value of each belief statement by the value of its corresponding outcome statement. The total score for each construct (a collection of all the item pairs that make up each construct) was then obtained by summing the products from all corresponding item pairs (Francis et al., 2004).

Preintervention JD RA and Management Assistance Plan. The formal JD RA, an on-farm questionnaire developed and implemented by the Canadian dairy industry [called a Risk Assessment and Management Assistance Plan (**RAMP**); OJEMAP, 2012] was used in this study to collect information about specific on-farm risk factors for JD transmission. Cohort 1 participants had received preintervention RAMP (**RAMP1**) completed between September and November 2010, cohort 2 participants and control producers between October and December 2011. The specific herd veterinarian for each producer (regardless

of involvement in FF) was responsible for conducting the RAMP used in this study. In total, the veterinarian-administered RAMP contained 23 items focused on specific management practices. Items were scored as a 1, 4, 7, or 10, with higher scores given for higher risk (OJEMAP, 2010). There were 5 sections in total: (1) cattle-addition risks (maximum score: 60), (2) calving-area risks (maximum score: 80), (3) heifers—preweaned risks (maximum score: 70), (4) heifers—weaned to first calving risks (maximum score: 40), and (5) cows—risks (maximum score: 50). Item scores were summed within each section to provide section scores, which were then summed to provide an overall risk score (maximum score: 300), where a high score represents a high level of risk of JD transmission.

Postintervention JD RAMP. Postintervention RAMP (RAMP2) 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), and all statistical analyses were conducted in STATA/IC 12.1 for Mac (StataCorp, College Station, TX). Unless otherwise indicated, the significance level for all statistical tests was set at $P < 0.05$.

Pre- and Postintervention Questionnaire. Demographic and farm-level characteristics were compared between FF and control respondents using a Fisher's exact test. Demographic characteristics of all respondents (i.e., FF and control respondents), as well as FF and control groups separately, who reported making a behavioral change were compared using a Fisher's exact test. Individual TPB-construct scores were stratified by demographic characteristics (e.g., attitude scores stratified by age groups) of all respondents, as well as FF and control respondents separately, and compared. Differences between individual subcategories of variables (e.g., age group <35 vs. 35 to 44) were assessed using a binomial test for proportions. Within-group comparisons (i.e., FF and control groups) between Q1 and Q2 JD knowledge assessment scores, and respondent answers regarding their attitudes (i.e., awareness, knowledge, and behavior, with respect to JD), were made using Wilcoxon signed-rank tests for paired data. Between-group comparisons, with respect to Q1 and Q2 JD knowledge assessment scores, and TPB responses, among FF and control producers, were made

using Wilcoxon-Mann-Whitney rank sum tests. Last, gain scores (comparisons between 2 repeated measures to assess changes as a loss or gain) were calculated by subtracting preintervention scores from postintervention scores, to assess the difference between Q1 and Q2 knowledge assessments; comparisons were made using t -tests as the data were normally distributed.

Pre- and Postintervention JD RAMP Comparisons. Within-group comparisons (i.e., FF and control groups) between RAMP1 and RAMP2 scores were made using a paired t -test. Between-group comparisons, with respect to RAMP1 and RAMP2 scores among FF and control producers, were made using t -tests. Last, gain scores were calculated by subtracting preintervention scores from postintervention scores, to assess the difference between RAMP1 and RAMP2 scores; comparisons were made using t -tests.

Changes in On-Farm Behavior. 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.

Univariable Regression Analyses. Logistic regression likelihood ratio tests were used to assess the univariable associations between the dichotomous outcome [whether a respondent made at least one on-farm management change (yes or no)] and demographics [cohort, group (FF or control), age, sex, ethnicity, education, income, herd size, and DHI management score], pre- and postintervention knowledge scores, gain scores, pre- and postintervention RAMP scores, VARK learning preferences, and both individual and aggregated (overall) TPB-construct scores. Spearman rank correlation coefficient analyses were performed between predictors, with a correlation coefficient of 0.80 or higher used to indicate high correlation. In the event of 2 variables being highly correlated, the variable with fewer missing values was used.

Multivariable Regression Analyses. A multivariable logistic regression model was used to investigate the characteristics associated with a respondent making at least one on-farm management change to control JD. All explanatory variables unconditionally associated with the outcome at a significance level of 20.0% (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. Confounding was assessed by observing a change of 30.0% or more in model coefficients when a variable was removed; identified confounders were forced into the model. All biologically plausible, 2-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 Postintervention Questionnaires

In total, 51.7% (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). In total, 89.3% (357/400) of dairy producers contacted 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 before administering Q2, 85.2% (52/61) of control-group respondents completed Q2. Statistical comparisons between the herd size, DHI management score, learning-style preferences, 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 significantly more likely to be younger, have larger herds, and have higher DHI management scores than control respondents.

Overall, 97.1% (68/70) FF and 90.4% (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 Ontario DHI herds ($n = 3,090$), in Table 2. Herds of FF and control respondents did not significantly differ.

In Q2, 88.6% (62/70) of FF respondents indicated that the FF process facilitated the implementation of on-farm changes. In addition, 87.1% (61/70) reported that FF increased their ability to implement on-farm changes. Eighty-one percent (57/70) of respondents reported implementing at least one on-farm management change to address JD as a result of FF. Of these respondents, 17.5% (10/57) made 1, 29.8% (17/57) made 2, 28.1% (16/57) made 3, and 24.6% (14/57) made 4 changes. Upon comparison, significantly fewer ($P < 0.01$) control respondents made on-farms changes; 38.5% (20/52) reported implementing at least one on-farm management change. Of these respondents, 50.0% (10/20) made 1, 35.0% (7/20) made 2, and 15.0% (3/20) made 3 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 3 h after birth. Table 3 provides a categorized list of on-farm changes reported by FF and control respondents.

Comparisons of Q1 and Q2 among FF and control respondents, with respect to their subjective knowledge (i.e., how much they think they know) of the general facts of JD control, their perceived level of on-farm risk of JD (i.e., how at risk they believe their farm to be), 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, 82.9% (29/35) of FF and 50.0% (2/4) of control respondents reported making at least one on-farm management change. In addition, 87.0% (20/23) of FF and 14.3% (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. Last, among those who reported an increase in their overall concern about JD on their farm between Q1 and Q2, 80.0% (16/20) of FF and 33.3% (5/15) of control respondents reported making at least one change.

Among FF respondents, Q1 JD knowledge assessment scores (maximum score of 29) ranged from 10 to 27, with a median score of 22. The Q1 scores among control respondents ranged from 14 to 26, with a median score of 22. The distributions of the Q1 JD knowledge assessment scores among FF and control respondents were not significantly different ($P = 0.15$).

The Q2 JD knowledge assessment scores (maximum score of 29), among FF respondents, ranged from 16 to 27, with a median score of 24. Among control respondents, the Q2 scores ranged from 17 to 25, with a median score of 22. The distributions of the Q2 JD-knowledge assessment scores between FF and control respondents were significantly different ($P < 0.01$).

Changes in FF respondent scores between the Q1 and Q2 assessments were statistically significant ($P < 0.01$), whereas changes in control-respondent scores were not ($P = 0.216$). 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 ($P < 0.01$). Among those with positive gain scores, 72.5% (29/40) of FF and 50.0% (9/18) 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 ($P > 0.05$). No significant differences in TPB

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

Characteristic	FF respondents, no. (%)	Control respondents, no. (%)	<i>P</i> -value
Age, yr			
<35	21 (30.0)	9 (17.3)	0.051
35 to 44	22 (31.4)	10 (19.2)	
45 to 54	19 (27.1)	20 (38.5)	
55 to 64	7 (10.1)	12 (23.1)	
>65	0 (0.0)	1 (1.9)	
Unknown	1 (1.4)	0 (0.0)	
Sex			
Male	60 (85.7)	44 (84.6)	0.866
Female	10 (14.3)	8 (15.4)	
Education level			
Grade school	0 (0.0)	1 (1.9)	0.601
Some high school	3 (4.3)	2 (3.8)	
High school	20 (28.6)	14 (26.9)	
College or trade school	35 (50.0)	22 (42.4)	
University	12 (17.1)	12 (23.1)	
Unknown	0 (0.0)	1 (1.9)	
Ethnicity			
Canada	58 (82.9)	45 (86.5)	0.816
Netherlands	9 (12.9)	6 (11.6)	
Switzerland	2 (2.8)	1 (1.9)	
Belgium	1 (1.4)	0 (0.0)	
Unknown	0 (0.0)	0 (0.0)	
Net farm income			
<\$50,000	0 (0.0)	2 (3.8)	0.109
\$50,000 to \$99,999	15 (21.4)	17 (32.7)	
\$100,000 to \$149,999	10 (14.3)	8 (15.4)	
\$150,000 to \$199,999	17 (24.3)	14 (26.9)	
>\$200,000	28 (40.0) ^a	11 (21.2)	
Unknown	0 (0.0)	0 (0.0)	
Focus Farm cohort			
Cohort 1—Dec. 2011 to Dec. 2012	41 (58.6)	NA	NA
Cohort 2—Dec. 2012 to Dec. 2013	29 (41.4)	NA	
Herd Size			
<51	11 (15.7) ^a	21 (40.4)	0.007
51 to 150	50 (71.4) ^a	28 (53.8)	
>150	9 (12.9)	3 (5.8)	
Unknown	0 (0.0)	0 (0.0)	
DHI management score ¹			
<500	7 (10.0)	12 (23.1)	0.049
500–750	42 (60.0) ^a	21 (40.4)	
>750	19 (27.1)	14 (26.9)	
Unknown	2 (2.9)	5 (9.6)	
Learning mode preference			
Visual	0 (0.0)	0 (0.0)	0.130
Aural	7 (10.0)	7 (13.5)	
Read–write	9 (12.9)	13 (25.0)	
Kinesthetic	20 (28.6)	10 (19.2)	
Bimodal	17 (24.3)	7 (13.5)	
Trimodal	10 (14.2)	9 (17.2)	
Multimodal	7 (10.0)	3 (5.8)	
Unknown	0 (0.0)	3 (5.8)	

^aProportion in that subcategory is significantly different ($P < 0.05$) between FF and control respondents.

¹An annual score provided by DHI, calculated using a point system assessing milk value, udder health, calving interval, age at first calving, herd efficiency, and longevity, used to compare herd performance across herds (CanWest DHI, 2009).

constructs ($P > 0.05$) were observed between those that reported making an on-farm change and those that did not. Additionally, no significant differences ($P > 0.05$) were found when the individual values of each TPB

construct were stratified by the demographic characteristics of all respondents (i.e., FF and control respondents), and FF and control respondents separately, and compared. Last, comparisons between the demographic

Table 2. Comparisons between Ontario Focus Farm (FF) herds ($n = 68$), control herds ($n = 47$), and all Ontario CanWest DHI herds ($n = 3,090$) for production and reproduction data obtained between April 2012 and April 2013

Production characteristic	Mean	SD	Minimum	Maximum	FF-control <i>P</i> -value
Average 305-d milk production per cow, kg					
FF herds	9,813.26 ^a	1,285.21	6,269.00	12,718.00	0.116
Control herds	9,424.33 ^b	1,503.14	5,903.00	12,770.00	
All Ontario DHI herds	8,894.48	1,625.99	4,571.00	13,675.00	
Average fat production, kg					
FF herds	377.75 ^a	41.45	307.00	500.00	0.204
Control herds	367.57 ^b	49.19	219.00	485.00	
All Ontario DHI herds	343.88	59.51	178.00	529.00	
Average protein production, kg					
FF herds	316.36 ^a	35.54	235.00	399.00	0.060
Control herds	303.39 ^b	42.25	190.00	396.00	
All Ontario DHI herds	286.10	49.48	148.00	434.00	
Average SCC, $\times 1,000$)					
FF herds	214.05 ^a	79.60	87.00	457.00	0.322
Control herds	226.96 ^b	66.15	93.00	407.00	
All Ontario DHI herds	243.69	97.83	76.00	1,043.00	
Average of the actual calving interval, d					
FF herds	415.55 ^a	23.58	379.00	483.00	0.444
Control herds	419.00 ^b	27.32	372.00	485.00	
All Ontario DHI herds	426.85	44.05	372.00	542.00	
Average dry period, d					
FF herds	68.92	13.93	47.00	119.00	0.621
Control herds	67.59	16.53	45.00	138.00	
All Ontario DHI herds	72.96	22.78	40.00	154.00	
Number of days at first breeding					
FF herds	80.53 ^a	14.43	63.00	134.00	0.369
Control herds	82.83	13.59	63.00	123.00	
All Ontario DHI herds	86.67	18.94	57.00	150.00	
Average days open					
FF herds	133.55 ^a	23.58	97.00	201.00	0.444
Control herds	137.00	27.32	90.00	203.00	
All Ontario DHI herds	146.03	35.50	90.00	260.00	
Number of breedings per cow per year					
FF herds	2.15	0.34	1.00	2.99	0.075
Control herds	2.03	0.37	1.06	3.00	
All Ontario DHI herds	2.07	0.49	1.00	3.44	
Herd turnover rate, %					
FF herds	42.48	10.70	9.82	64.36	0.365
Control herds	40.62	13.30	11.99	73.50	
All Ontario DHI herds	42.86	16.13	12.55	98.78	

^aFF herd mean is significantly different ($P < 0.1$) from all Ontario DHI herds.

^bControl herd mean is significantly different ($P < 0.1$) from all Ontario DHI herds.

characteristics of all respondents that reported making a behavioral change yielded no statistically significant results ($P > 0.05$); further stratification of respondents by intervention group (i.e., FF and control) similarly yielded no significant differences ($P > 0.05$).

Pre- and Postintervention JD RAMP

Overall, 90.1% (82/91) of FF respondents had RAMP1 completed by their herd veterinarian, and 90.7% (78/86; 5 dropouts during intervention period) of remaining respondents had RAMP2 completed. Among control respondents, 75.8% (47/62) had RAMP1 completed, whereas 52.5% (32/61; 1 dropout during inter-

vention 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 (maximum score: 300), and 4 of 5 section scores, significantly decreased ($P < 0.05$), indicating lower risk. The 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 because of missing RAMP1 or RAMP2 score), RAMP gain scores ranged from -75 to $+24$, with an average of -16.6 and a standard deviation of 23.2. Among control respondents that reported making an on-farm change ($n = 17$; 3 were excluded

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)

Management change	Frequency among Focus Farm respondents, ¹ no. (%)	Frequency among control respondents, ¹ no. (%)
Improved on-farm hygiene		
Maternity pen cleaned after each calving	11 (19.3) ^a	1 (5.0)
Separation of equipment for feeding and manure handling	8 (14.0) ^a	0 (0.0)
Purchased new equipment (e.g., skid steer, buckets, and so on)	6 (10.5) ^a	0 (0.0)
Cleaning calf housing area routinely	6 (10.5)	2 (10.0)
General on-farm cleanliness improved	6 (10.5)	1 (5.0)
Building of a new barn or maternity pen	6 (10.5)	3 (15.0)
Boots washed more frequently	4 (7.0)	2 (10.0)
Adding more bedding in calving area	2 (3.5)	2 (10.0)
Improved record keeping	2 (3.5)	1 (5.0)
Total changes	51	12
Calf management		
Calves are removed from maternity pen within 3 h	23 (40.4)	11 (55.0)
Feeding 4 L of colostrum as soon as possible	19 (33.3) ^a	3 (15.0)
Change in colostrum management (i.e., switch to artificial colostrum)	10 (21.1)	4 (20.0)
Focusing on cleaner feedings (milk or colostrum)	7 (12.3)	3 (15.0)
Change in feeding of calves (i.e., switch to milk replacer)	6 (10.5)	4 (20.0)
Overall calf care is better	5 (8.8)	4 (20.0)
Freezing colostrum from low-risk animals	4 (7.0) ^a	0 (0.0)
Started the use of hutches	3 (5.3)	3 (15.0)
Total changes	77	32
Johne's disease (JD)		
Testing for JD routinely	8 (14.0)	2 (10.0)
More aware of JD and managing JD-positive cows	5 (8.8) ^a	0 (0.0)
JD-positive cows are culled more quickly	2 (3.5)	2 (10.0)
Rendering JD-positive animals instead of selling for beef	2 (3.5) ^b	0 (0.0)
Asking about JD status when buying animals	1 (1.8)	0 (0.0)
Stopped buying animals, closed the herd	1 (1.8)	1 (5.0)
Stopped spreading manure on hayfields	1 (1.8)	0 (0.0)
Total changes	20	5

^aProportion in that subcategory is significantly different ($P < 0.05$) between Focus Farm and control respondents.

^bProportion in that subcategory is significantly different ($P < 0.10$) between Focus Farm and control respondents.

¹Multiple responses per respondent permitted.

because of missing RAMP1 or RAMP2 score), RAMP gain scores ranged from -48 to $+42$, with an average of -4.1 and a standard deviation of 33.6 . Gain scores, among FF and control respondents who reported making at least one on-farm management change to address JD, were significantly different ($P = 0.05$).

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 (likelihood ratio $\chi^2(11) = 56.98$, $P < 0.01$) and included 4 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 preferences (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), whereas 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. Last, compared with respondents with multimodal learning preferences (i.e., preference for all 4 modes of learning), 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),

Table 4. Presurvey–postsurvey comparisons of respondents' current level of understanding, their farm's current level of risk, and their overall concern about John's disease on their farm, among 70 Ontario Focus Farm and 52 Control respondents (October 2010 – January 2013; Ontario, Canada)¹

Presurvey response	Postsurvey response					
	Focus Farm respondents			Control respondents		
	Complete	Very high	Moderate	Little	None	Total
How would you rate your current level of understanding of the general facts on control of John's disease?						
Complete	—	2	1	—	—	5
Very high	—	14	3	—	—	29
Moderate	1	19	10	—	—	17
Little	—	7	6	—	—	1
None	—	2	—	—	—	—
Total	1	44	20	—	—	52
	Very high	High	Moderate	Low	Very low	0.017
How would you rate the current level of risk for getting John's disease at your farm?						
Very high	—	—	—	—	—	—
High	—	—	3	2	—	2
Moderate	—	2	6	10	—	13
Low	1	1	9	12	—	27
Very low	—	—	3	3	—	10
Total	1	3	21	27	2	52
	Very concerned	Concerned	Neither concerned nor	Unconcerned	Very unconcerned	0.136
Overall, how concerned are you about John's disease on your farm?						
Very concerned	—	1	—	—	—	7
Concerned	3	13	5	2	—	18
Neither concerned nor	—	10	14	3	—	19
Unconcerned	—	5	1	1	—	5
Very unconcerned	—	1	—	—	—	3
Total	3	30	20	6	—	52
	Very concerned	Concerned	Neither concerned nor	Unconcerned	Very unconcerned	0.125
	5	27	11	7	—	52

¹Tallies in bold represent those that did not change between pre- and postassessments. Tallies above represent answers that increased from pre- to postassessment, and tallies below represent answers that decreased from pre- to postassessment.

Table 5. Comparisons between the item-pair responses used to indirectly measure the theory of planned behavior constructs (attitude, subjective norms, perceived behavioral control) among 65 Ontario Focus Farm respondents and 52 control respondents (November 2011–January 2013; Ontario, Canada)¹

Item	Focus Farm respondents					Control respondents					P-value
	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	Mean	SD	
Attitude statements: behavioral belief statement (scale of 1 to 5); outcome evaluation statement (scale of -2 to +2)											
I am concerned about the health effects of JD on my herd. Being concerned about the health effects of JD on my herd is:	5	-2	10	5.97	3.43	7	0	10	6.69	3.28	0.234
I am concerned about the financial costs of JD. Minimizing the financial costs of JD is:	5	-2	10	5.82	3.64	6	-3	10	6.52	3.39	0.358
I am concerned about the possible human health risks of JD. Being concerned about the possible human health risks of JD is:	5	-2	10	5.58	3.71	6	-2	10	5.98	3.79	0.570
I currently use many of the recommended prevention and control strategies for JD on my farm. Preventing and controlling JD on my farm is:	8	-4	10	6.31	3.33	7	-3	10	6.42	3.08	0.859
Prevention and control strategies for JD are very effective. Having effective prevention and control strategies for JD is:	8	-4	10	6.46	3.23	6	0	10	6.29	2.97	0.692
Preventing and controlling JD makes me a good manager. Being a good manager of herd health is:	8	-6	10	6.77	3.19	8	0	10	7.00	2.79	0.841
Preventing and controlling JD improves herd health. Improving herd health non my farm is:	10	-2	10	7.57	3.09	10	0	10	7.73	2.85	0.872
Total attitude score	43	-22	70	44.48	19.23	45.5	14	70	46.63	16.12	0.627
Subjective norms statements: normative belief statement (scale of -2 to +2); motivation to comply statement (scale of 1 to 5)											
My fellow producers think it is important to prevent and control JD. What my fellow producers think is important matters to me.	3	-3	10	3.48	3.46	3	-4	10	2.60	3.29	0.195
My fellow producers made changes to prevent and control JD. What my fellow producers do on their farms matters to me.	1	-3	10	2.18	3.03	0	-5	10	1.21	2.90	0.143
My herd veterinarian thinks it is important for me to prevent and control JD. What my herd veterinarian thinks I should do matters to me.	8	-10	10	7.34	3.50	8	-5	10	6.87	3.60	0.464
Ontario dairy organizations think it is important for me to control JD. What Ontario organizations think is important matters to me.	8	-4	10	6.18	3.58	8	-2	10	6.54	3.17	0.661
Dairy consumers think it is important for me to prevent and control JD. Consumer approval of my management matters.	4	-6	10	4.06	4.40	4	-8	10	3.98	4.90	0.973
Total subjective norm score	22	-19	50	23.25	13.14	19.5	-5	48	21.19	11.95	0.249
Perceived behavioral control statements: control belief statement (scale of 1 to 5); power statement (scale of -2 to +2)											
Changing to control JD is too time consuming. When changing is time consuming, I am (more or less likely) to change.	0	-6	0	-1.08	1.51	-1	-6	0	-1.48	1.85	0.197
Changing to prevent and control JD is too expensive. When changes are expensive, I am (more or less likely) to make them.	0	-6	0	-1.66	1.92	0	-6	0	-1.25	1.96	0.256
Recommendations to control JD are not realistic. When they are not realistic, I am (more or less likely) to change.	-2	-6	0	-2.23	1.26	-2	-6	0	-2.36	0.97	0.527
I am (more or less likely) to change.	0	-8	6	0.42	3.04	0	-8	8	0.73	3.53	0.605
Preventing and controlling JD is difficult because I cannot see signs or symptoms of it being present. When signs and symptoms of disease are not visible, I am (more or less likely) to make changes.	0	-10	8	-1.03	4.08	0	-8	8	0.06	2.84	0.105
The tests for JD do not provide me with accurate enough results to make changes. When tests are not accurate, I am (more or less likely) to make changes.	-5	-17	8	-5.58	5.54	-4	-19	11	-4.31	6.48	0.253
Total perceived behavioral control score											

¹Min. = minimum; Max. = maximum; JD = Johne's disease.

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)¹

RAMP section (score)	FF respondents							Control respondents						
	n	Mean	SD	Med.	Min.	Max.	Pre-Post P-value	n	Mean	SD	Med.	Min.	Max.	Pre-Post P-value
Section 1: cattle-addition risks (/60)														
Presurvey	82	33.70	22.62	41	0	60	—	47	27.57	23.85	27	0	55	—
Postsurvey	78	32.59	23.19	40	0	60	0.478	32	31.44	22.55	41	0	55	0.471
Section 2: calving-area risks (/80)														
Presurvey	82	31.30	10.84	32	11	68	—	47	34.43	12.58	35	11	62	—
Postsurvey	78	28.49	9.00	26	8	47	0.020	32	33.75	13.25	33	7	74	0.804
Section 3: heifers—preweaned risks (/70)														
Presurvey	82	19.77	9.64	19	7	46	—	47	19.77	9.56	19	7	52	—
Postsurvey	78	17.38	8.66	16	7	49	0.008	32	17.13	6.88	16	6	34	0.700
Section 4: heifers—weaned to first calving risks (/40)														
Presurvey	82	16.55	7.93	16	4	34	—	47	17.21	7.45	16	4	34	—
Postsurvey	78	14.41	7.57	13	0	31	0.007	32	17.03	7.98	16	4	34	0.924
Section 5: cows—risks (/50)														
Presurvey	82	15.04	8.09	15.5	4	38	—	47	18.38	8.59	20	4	41	—
Postsurvey	78	13.87	7.85	13	4	35	0.026	32	15.03	8.33	16	3	32	0.218
Total score (/300)														
Presurvey	82	116.35	31.50	114	38	189	—	47	117.36	40.11	111	50	207	—
Postsurvey	78	106.74	32.89	111	39	188	0.001	32	114.38	32.07	116	59	186	0.861
Gain scores	71	-13.13	25.67	-11	-75	59	—	23	-4.35	36.06	-8	-78	60	—

¹RAMP = Risk Assessment and Management Assistance Plan; RAMP1 = preintervention RAMP; RAMP2 = postintervention RAMP; Med. = median; Min. = minimum; Max. = maximum.

Table 7. Final logistic regression model assessing the factors associated with making at least one on-farm change to address Johne's Disease among 70 Ontario Focus Farm and 52 control respondents (October 2010–January 2013; Ontario, Canada)¹

Predictor variable (likelihood ratio test <i>P</i> -value ²)	Odds ratio	SE	<i>t</i> -test	<i>P</i> -value	95% CI
Producer group					
Control (referent)					
Focus Farm	33.72	29.38	4.04	<0.001	6.11–186.06
Herd size ³	1.01	0.01	1.44	0.149	0.99–1.04
DHI management score (<i>P</i> = 0.036)					
<500 (referent)					
500–750	14.84	15.95	2.51	0.012	1.81–121.94
>750	13.40	15.18	2.29	0.022	1.45–123.47
Perceived practicality of recommendations for JD control (<i>P</i> = 0.041)					
Neutral (0; referent)					
Slightly negative (–1 to –3)	0.41	0.67	–0.55	0.585	0.02–10.19
Moderately negative (–4 to –6)	0.07	0.13	–1.50	0.134	0.01–2.26
VARK learning preferences (<i>P</i> = 0.034)					
Multimodal preference (i.e., V, A, R, K; referent)					
Aural preference	95.02	164.63	2.63	0.009	3.18–2,835.49
Read–write preference	21.09	28.16	2.28	0.022	1.54–288.82
Kinesthetic preference	38.54	49.44	2.85	0.004	3.12–476.41
Bimodal preference (i.e., V, A)	2.98	3.68	0.88	0.378	0.26–33.59
Trimodal preference (i.e., V, A, R)	2.77	3.36	0.84	0.402	0.26–29.89
Model constant	0.01	0.16	–2.27	0.023	0.01–0.51

¹*n* = 98 farms, likelihood ratio $\chi^2(11) = 56.98$, Prob $>\chi^2 = 0.0000$, pseudo $R^2 = 0.4602$. JD = Johne's disease; VARK = visual, auditory, read–write, kinesthetic, respectively.

²Significance of categorical variables (*P* < 0.05) based on likelihood ratio tests.

³Herd size forced into model as confounder.

and read–write learning (e.g., fact sheet), respectively. In addition, respondents with a preference for 2 and 3 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 (i.e., V, A, R, K).

DISCUSSION

On-Farm Change and JD Risk

Overall, 81% of FF respondents reported making at least one on-farm management change to address JD, as compared with only 38% of control respondents. More than 50% of those FF respondents that made at least one management change reported making more than 2 on-farm changes to address JD, compared with only 15% of control respondents. Interestingly, whereas a significantly higher proportion of FF respondents made on-farm management changes, several control respondents also reported making at least one management change. This change in behavior may be a result of the provincial JD program, OJEMAP, which was running during this study. This change may also be a result of participation in this study, as producers may have completed Q1 and been influenced to consider addressing JD on their farm as a result. Importantly, the significantly higher proportion of FF respondents implementing changes suggests that the FF process

was effective at influencing behavior beyond that of the provincial program, which was implemented for that very purpose.

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., 2010b). 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., 2010b). Hence, the changes made by study respondents are expected to be useful in preventing further on-farm spread of MAP. Although, it is important to consider that the relative magnitude of each change, in terms of effect on JD spread, cannot be judged here without a more detailed look at the reference situation on each respondent's farm. Furthermore, what might be considered a relatively small change (i.e., increased bedding in calving pen) for one farm might actually be a more significant change, with respect to JD spread, on another farm. As such, this study specifically sought to measure the change in behavior and used the RAMP scores to assess relative effect.

The average RAMP1 score among FF and control respondents did not significantly differ and represented a medium level of risk with respect to on-farm JD transmission. These values were only marginally lower (i.e., representing lower risk) than the average Ontario RAMP score (120 of 300 total points) obtained from more than 2,000 completed RAMP between 2010 and 2013 (L. Pieper, University of Guelph, Guelph, Ontario, Canada, personal communication). Thus, they appear to reflect the scores of the general Ontario population. The average RAMP2 score among FF respondents significantly decreased from the average RAMP1 score and represented a low level of risk with respect to on-farm transmission. The RAMP scores among control respondents did not change. It is important to consider that an individual might be more likely to make a change if there are more opportunities to improve (i.e., if the RAMP1 score is high, then there is more opportunity to make a change, compared with someone with a low RAMP1 score to begin with). However, upon investigation, those with higher RAMP1 scores were not more likely to implement on-farm changes in this study. Overall, almost 90% 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 2 sequential RAMP (Raizman et al., 2006; Wells et al., 2008; Sorge, 2010a). Additionally, FF respondents significantly decreased their RAMP2 score in almost every subsection of the assessment; the one section that did not significantly change was related to the purchase of animals in the past 5 yr. Given the RAMP marking scheme, and the temporal proximity of the 2 RAMP, even if purchasing behavior changed between RAMP, the section score for a producer who had purchased an animal within the previous 5 yr would not have changed during this study period, as it was less than 5 yr.

The Antecedents of On-Farm Change

Another key objective to the evaluation of FF was to assess the effect of FF on respondents' knowledge and attitudes with respect to JD control. In this study, knowledge was measured in 2 ways: (1) by asking producers to report how much they think they know about JD control, and (2) by administering a knowledge assessment to assess how much they actually know. More than 50% of FF respondents believed 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. Similar findings were re-

ported by Jansen et al. (2010a), who identified that an increase in an individual's perceived level of knowledge of mastitis (i.e., how much they think they know about mastitis) was positively associated with a decrease in bulk-milk SCC. 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 behavior (Chiou, 1998). Furthermore, 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 (Roche, 2014). This high level of self-confidence may suggest a feeling of empowerment in the sense that they now believe they have the knowledge and skills to perform the behavior, which may have resulted from participation in, and experiences from, the FF process. This is an important consideration, because other studies have shown that participation in processes such as FF can lead to improved self-confidence and empowerment (Wilcox, 1994; Jupp, 2007). Thus, the influence of increases in subjective knowledge on producer behavior may have more to do with an increase in respondents' level of self-confidence to control JD, and a feeling of empowerment, rather than an explicit increase in their level of knowledge.

A review of the results of the knowledge assessment (i.e., quiz), to understand how much producers actually knew about JD control before and after the intervention period, showed that the knowledge score of FF respondents significantly increased during the study period, whereas the knowledge score of control respondents did not. Furthermore, 70% of FF respondents who reported making an on-farm change exhibited increased knowledge scores at Q2. However, both FF and control respondents displayed a moderate to good knowledge score before any intervention. This suggests that the majority of respondents possessed sufficient knowledge, as measured by the knowledge assessment, with respect to JD and JD control before 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 behavior, suggesting that knowledge is not the barrier in improving udder health among Dutch dairy farmers. Therefore, although the increases in knowledge score observed in this study are important, we expect that it may not have been a significant driver of change among study respondents.

The TPB assessment showed that both the FF and control groups displayed similar attitudes, subjective norms, and perceived behavioral control. Although 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 toward 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. These particular attitudes provide useful insights in respondents' self-identity (i.e., an individual's view of themselves in a social context, ex., "I am a good manager if I control JD on my farm") and suggest that the belief that "controlling disease on the farm makes producers a good herd manager" is an important driver of on-farm behavior. Similar findings are reported by Wauters et al. (2014), who identified self-identity as a significant contributor to behavior change toward adopting biodiversity conservation practices among Belgian farmers. Typically, JD extension focuses on producer awareness of the production, financial, and human health effects of JD to motivate change. Interestingly, perceptions about 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, and supporting the view that JD prevention and control equates to being a good manager of herd health, will be effective influencing 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 behavior (Kuiper et al., 2005; Jansen et al., 2009; Lam et al., 2011). However, veterinarians' ability to influence behavior 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 proactive approach toward 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 behavior 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 behavior.

Both groups of respondents also felt that producer organizations highly influenced their decision to make changes. This is an important consideration, because 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 in the sources of the information. Thus, industry-led initiatives need to ensure they are conveying the same message with respect to JD. 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 2 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. Although communication at both of these levels is relatively commonplace among Ontario 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 behavior and ensuring that all sources are relaying the same message in a clear and consistent way.

Focus Farm 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 subclinical phase, 3 to 6 yr in many cases (Tiwari et

al., 2006), also seemed to negatively affect 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 behavioral intention and behavioral 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, because of the chronic nature and long incubation period of JD. This delayed effect may result in producers questioning whether the changes have had, or will have, a positive effect. 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 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-orally transmitted diseases, such as *Escherichia coli*, *Campylobacter* spp., *Salmonella* spp., and *Cryptosporidium* spp. (McKenna et al., 2006), may serve to more drastically influence producers' behavior.

When considering the influence of TPB factors, it appears that PBC was not as influential as it has been shown to be in other studies (Jansen et al., 2009, 2010a; Kuiper et al., 2005). We might therefore expect that the positive attitudes toward JD control, and moderate amount of social pressure, played a larger role 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 behavior is that these 2 populations may differ with respect to factors that were not measured (e.g., motivation, moral

and ethical drivers, and so on). Although the TPB is useful for measuring many of the key factors contributing to behavioral change, it does not explicitly measure motivation as a construct and, as such, presents a limitation of this theory as it applies to understanding the influence of motivation on behavior in this study. Producer motivation has been shown to be an important factor influencing behavior (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 certain perceptions measured in this study may be explained by another theory, called the health belief model (HBM). The HBM suggests that a set of constructs (i.e., perceived seriousness, perceived susceptibility, perceived benefits, and perceived barriers) and modifiers (e.g., education level, motivation) affect an individual's preventive health decisions and behaviors (Hayden, 2008). When compared with control respondents, a higher proportion of FF respondents exhibited increased concern regarding JD on their farm at Q2 compared with Q1. The level of concern about JD on the farm discussed in this study may represent the HBM construct "perceived seriousness," which suggests that the more serious an individual feels a given health issue is (i.e., JD on the farm), the more likely they are to change their behavior to address it. When this perception is considered among FF respondents who reported a change in behavior, 80% of those who expressed a greater level of concern also reported making an on-farm management change. Unlike the level of concern about JD on the farm, a larger proportion of FF respondents expressed a lower perceived risk of JD on their farm at Q2 compared with Q1. The perceived level of risk of JD on the farm discussed in this study may represent the HBM construct "perceived susceptibility," which suggests that the more susceptible an individual feels toward a given health issue (i.e., JD on the farm), the more likely they are to change their behavior to address it. Importantly, 87% of those who reported a lower perceived risk of JD on their farm at Q2 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. Overall, from

the perspective of the HBM, FF respondents would be more likely to adopt changes because they appeared to express greater concern for JD, had greater awareness of JD, perceived themselves as more knowledgeable, felt empowered (i.e., subjective knowledge), and thought JD measures were practical (reduced barriers, increased benefits). Thus, the HBM provides a useful, comprehensive framework for understanding why FF respondents exhibited more behavioral change.

Study Limitations

In this study, FF appears to be effective at changing producer perceptions about JD and JD control favorably, as a higher proportion of FF respondents reported changes in their perception, compared with control respondents. Furthermore, a significant increase in knowledge-assessment scores, as well as subjective knowledge, among FF respondents indicates that FF was effective in increasing the knowledge of participants with respect to JD control. It is difficult to observe the effect FF had on the TPB-construct measures without a pre- and postintervention comparison; however, FF may not have had a dramatic effect 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 toward making on-farm changes to control JD (Roche, 2014). Thus, the power of this study to detect differences between these groups may have been limited because of 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 behavior. Although the measurement of the TPB constructs provides 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 effect of interventions on these measures.

Overall, the significant increase in the adoption of on-farm management practices observed among FF respondents, as compared with control respondents, suggests that FF was effective. The level of adoption observed here was larger than other studies (Wraight et al., 2000; Jubb and Galvin, 2004; Ridge et al., 2005; Sorge et al., 2010b). However, it is important to note that behavior in this study was defined as the uptake or adoption of at least one on-farm management practice specifically for JD control, and as such there is no opportunity to assess the retention and sustainability of the behaviors that were reported to have changed.

Importantly, poor retention of these behaviors will limit their efficacy. Future studies seeking to assess behavioral change among producers would benefit from a longer-term follow-up period to assess behavior retention and sustainability.

Pratt and Bowman (2008) suggest that actual behavioral change occurs when the cognitive, social, psychological, and emotional dimensions of the behavior 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 behavior change is the goal, then extension programs must include personally relevant, problem-focused, experiential, active learning practices focused on skill building. Given this recommendation, and the demonstrated improvement in the adoption evidenced in 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.

One limitation of this study is that the TPB constructs were only measured indirectly; Francis et al. (2004) suggests that when possible, TPB constructs should be measured using both direct and indirect methods. However, given the already large size of Q1 and Q2, and a specific interest in the individual beliefs and subsequent outcome evaluations of each item pair within each TPB construct, an indirect measure TPB instrument was solely used. As a result, comparisons between indirect and direct measures cannot be performed to assess consistency between questions. Additionally, given that FF respondents were asked to report on their attitudes about, and the effect 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. It is also particularly important to be reflexive about the fact that the knowledge assessment used in this study is based on questions and content that are defined as important by the researchers and research team with respect to JD control, and although piloted with a group of producers, it may not comprehensively address the complete knowledge level of respondents in this study as it relates to JD control. Furthermore, as a comparison group, control respondents were meant to

represent the typical Ontario dairy producer; however, the low response rate (17%) for the Q1 control group may have contributed to selection bias, in the form of nonresponse bias, in this study. Because no reliable data currently exists on demographic characteristics of all Ontario dairy producers, 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, suggesting that FF producers may have been more progressive and had superior herds from the start. However, comparisons between FF and control groups showed no significant differences with respect to herd-level production and reproduction characteristics. Moreover, both FF and control respondents tended to have better production and reproduction than all CanWest DHI herds, indicating that study participants, regardless of group, are different from the average CanWest DHI herds in Ontario. These differences are similar to other studies, which identified higher production among participants than nonparticipants (Raizman et al., 2006; Sorge, 2010a). Therefore, the participants in this study may be more progressive and informed than the overall Ontario 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 focused on the importance of the factors underlying dairy producers' on-farm behaviors. 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. Extension efforts must routinely, and consistently, communicate the importance of JD control at producer and industry levels. Future communication with dairy producers must also focus on the efficacy of recommended changes with respect to effects on fecal-orally transmitted diseases and the long-term persistence needed to effectively control JD. 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 toward JD control, exhibited improved knowledge levels, and a significant proportion made on-farm changes for JD control. Other RA-based JD control programs should consider the implementation of self-directed,

peer-learning processes, such as FF, to effectively influence the antecedents of behavioral change and improve the success of industry-wide JD control efforts.

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