A combination of differentiation and consolidation theory and risk-benefit analysis to examine decisions on mastitis prevention

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ABSTRACT

Mastitis infections cause severe pain in dairy cows and are the most costly illness to farmers. This study combined differentiation and consolidation (Diff-Con) theory with risk-benefit analysis to explore how risky decisions are perceived and justified after a decision has been taken. More specifically, using survey data from 428 Swedish dairy farmers, their decisions about adopting preventive measures to control mastitis (mastitis control options, MCO) in dairy herds were examined. The analyses included group comparisons with non-parametric rank tests and use of both ordinary least squared regression and seemingly unrelated regression analysis to examine how prior adoption of MCO affects farmers’ attitudes to the MCO. The results showed that MCOs already adopted were rated higher in perceived riskiness (if not implemented) and in expected benefit (for illness prevention) than non-adopted MCOs. Having made the decision to implement a strategy increased the likelihood of that decision being perceived as more beneficial (reducing mastitis) and risky (in terms of disease increase if not implemented), irrespective of the combination of strategies used on the farm, during the post-consolidation stage. No difference in perceived illness prevalence could explain the farmers’ rating of the MCOs. These findings suggest that there may be a path dependency in farmers’ decision-making with respect to MCO. This implies that novel MCOs may have difficulty in achieving wider implementation. These results have implications for the development of strategies to communicate best practices for use of MCOs and for new research on MCOs and farmers’ decision-making.

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Introduction

Mastitis, which is a common illness among dairy cows, is increasingly becoming a public health concern (Siivonen et al. 2011; LeBlanc et al. 2006) as it is a major cause of increased use of antibiotics in dairy herds, which in turn increases the risk of resistant bacteria spreading from cattle to humans through direct contact, food, and water (Prescott 2000; Teuber 2001). Mastitis also
causes severe pain in the animal and therefore impairs animal welfare ambitions. Furthermore, previous research has shown that actions at the farm level to prevent actual outbreaks are the most costly animal health-related action to farmers because of foregone revenues (Rollin, Dhuyvetter and Overton 2015; van Soest et al. 2016).

Dairy farmers have an array of possible measures to adopt in helping to prevent mastitis infections or limit their impact. Deciding which mastitis control options (MCOs) to adopt and implement on the farm can be considered risky, however, because the actual outcome in terms of disease reduction or prevention of mastitis cannot be guaranteed ex ante. This is partly because the farmer faces uncertainty about the actual future effects of the MCOs available, but also because there is no quick and easy way of checking the effectiveness of each measure in the specific farm situation.

Previous research has shown that farmers may experience cognitive dissonance when receiving advice on herd health management, resulting in them either complying with the recommendation or convincing themselves that it is impossible to implement (Kristensen and Jakobsen 2011a). Poor on-farm adoption of recommendations is common (Bell et al. 2009; Brennan and Christley 2013; Sayers et al. 2013), which may explain why not every management decision farmers make appears logical (Kristensen and Jakobsen 2011a). Rather, studies have found that farmers’ adoption of recommendations is driven by for example, social and political factors (Gunn et al. 2008; Heffernan et al. 2009; Kristensen and Jakobsen 2011b; Lam et al. 2011), individual farmer traits (van den Borne et al. 2014) or compensation systems or penalties (Ellis-Iversen et al. 2010; Lam et al. 2011). This in turn may explain why, despite world-wide efforts, mastitis control programmes are not used by all farmers (Jansen et al. 2009).

For mastitis specifically, studies have suggested that many farmers are not convinced of its importance beyond the visible level. This can lead to consequences such as increased somatic cell counts (SCC) on the farm that do not lead to a change in (preventive) behaviour (Jansen et al. 2009). It may also be the case that the level at which mastitis is perceived as problematic differs significantly between farmers (Huijps et al. 2009; Jansen et al. 2009). This means that there may be a level of mastitis prevalence with which farmers are comfortable, without altering preventive measures. This can be a result of farmers not being aware of the actual effect of each MCO, as studies have shown that use of individual strategies does not have a good effect in reducing mastitis (Emanuelson and Nielsen, 2017). Taken together, previous studies have shown that, on its own, awareness of the presence of a disease, such as mastitis, is not sufficient to motivate change and is not the sole recommendation of best management practices. The main objective of the present study was to examine how decision-making with regard to risky choices may be affected after a decision has been taken. To this end, we combined differentiation and consolidation (Diff-Con) theory (Svenson 1992, 2003, 2006) with risk-benefit analysis of attitudes to risk options (Weber et al. 2002), with the aim of exploring possible reasons why certain MCOs are perceived as more beneficial or risky than others and in particular how an already made decision is perceived in comparison with non-chosen options. Diff-Con theory has been tested in numerous studies (Salo and Svenson 2001) from exploring the decision-making process (Svenson and Hill 1997) to post-decision memory (Mather, Shafir, and Jonhson 2000, 2003). Svenson and Hill (1997) found that decided alternatives were rated higher throughout the whole decision-making process, but that most of the change occurred during the post-decision phase. Similarly, when studying post-decision memory, Mather, Shafir, and Johnson (2000, 2003) found that chosen alternatives were more often positively rated than the non-chosen alternative. Diff-Con theory postulates a four-step process in which a decision is differentiated and strengthened during a decision phase. Next, according to Weber et al. (2002), individuals’ attitudes to (or in their words ‘preferences for’) risky options are determined as a trade-off between the benefit and risk associated with those options, where these attitudes may differ across domains, or types, of risky options. There are multiple ways in which characteristics of the decision maker and the situation can affect choices under risk. Apparent risk taking by the same person may differ in two situations, for example, because the decision maker perceives the risks and benefits to differ in
magnitude in the two domains, while their attitude to perceived risk remains basically the same for both domains (Weber and Milliman 1997; Weber and Hsee 1998). Attitudes are important constructs in decision-making, as they guide people’s behaviours and behavioural intentions (Ajzen 1991; Conner and Abraham 2001; Siegel Levine and Strube 2012). A combination of Diff-Con theory and risk-benefit analysis may therefore provide important insights into how decision-making in risky choices is directed by previous choices and help explain changes in attitude which may affect future choices.

The results are of practical importance for agribusiness, which can apply them to raise awareness among agricultural advisors and farmers of how decision-making may be influenced by prior decisions, but also to understand decision-making under risk in general. This is likely to lead to more informed decision-making on implementation of MCOs. In particular, understanding farmers’ decision-making under risk may have a direct impact on actual illness frequency and animal welfare in general, which in turn can have an effect on human wellbeing and on society.

**Conceptual framework**

Diff-Con theory (Svenson 1992, 2003, 2006) is a process theory which suggests that decision makers separate alternatives during the decision process to enable an easier decision and to avoid post-decision regret. Such regret links to cognitive dissonance theory, which might induce the decision maker to experience psychological stress when performing an action that contradicts personal beliefs, ideals, and values (Festinger 1962). Diff-Con theory shares similarities in the decision-making process with a number of other models of human decision-making, for example, in that the decision maker restructures their mental representation in order to favour one alternative prior to decision-making (Brownstein 2003; Carlson and Pears 2004), and that the decision maker’s preference for an alternative is shifted in order to provide stronger support for the emerging decision (Simon, Krawczyk, Bleicher, and Holyoak 2008). The ultimate goal of all this is for the decision maker to make the best decision by separating alternatives and to avoid a feeling of having made the wrong choice.

Using Diff-Con theory, through a four-stage process one alternative is differentiated from others in order to make it appear sufficiently better. The process entails: i) detection of the decision problem (here MCOs that should be adopted for the farm), which leads to initiation of ii) a process of differentiation of an initially chosen alternative from the other alternatives, where more important measures are differentiated to make them appear superior, following which iii) a decision is made and the chosen measures are adopted on the farm, which leads to iv) the post-decision consolidation stage, in which an evaluation of the measures occurs. During the consolidation stage, which supports implementation of the decision and protects the decision maker from regret about having made the wrong choice, the chosen alternative is upgraded in attractiveness or in diagnostic value of evidence for that alternative (Simon, Krawczyk, and Holyoak 2004), and/or the non-chosen alternative is downgraded before and after the decision.

Following Weber et al. (2002), attitudes to risky options may be specific to domains. In the specific case of how farmers’ attitudes to risky MCOs are affected by previously implemented MCOs, this implies that those attitudes may be specific to domain or type of MCO/s under consideration. The idea of domain-specific attitude (Weber et al. 2002) assumes that people differ in the way in which they resolve decisions involving risk and uncertainty, and these differences are often described as differences in risk attitude.

In the literature, studies of risk perception suggest that risk and benefit tend to be positively correlated in the world, whereas they are negatively correlated in people’s minds (Fischhoff et al. 1978). In line with this, Alhakami and Slovic (1994) show that there is an inverse relationship between perceived risk and perceived benefit, and that people’s judgments are based not only on what they think about the situation or subject, but also their feelings. If the feeling is favourable, there tends to be a judgment of low risk and high benefit, while if the feeling is
unfavourable, the judgment is the opposite. This means that decision makers base their decision more on their feelings in combination, rather than merely their thoughts (Slovic 1987; Slovic et al. 2004).

Accordingly, we posited that risky options, such as decision-making on adopting MCOs, can be grouped according to the domains to which they belong, based on type and certain characteristics. Attitudes to risky options, considered in terms of benefits and risks, can then be evaluated at domain level to study the effect on decision-making.

Integrating the aspects of domain-specific risk-benefit analysis with Diff-Con theory, we further posited that attitudes, which are a combined result of the perceived risk and benefit from the decision-making process on possible MCOs, are shaped as the choices are upgraded and downgraded within the Diff-Con process. Once the decision already made has gone through the four-stage process, it can then be expected to be considered superior in terms of evaluated benefit in prevention, or degree of risk if not implemented. It has been suggested that perceived attractiveness and importance of the various attributes of alternatives favour the actual alternative chosen (Svenson and Jakobsson 2010). Diff-Con theory also suggests that during the post-decision phase, a decision that receives a positive evaluation in previous stages can be bolstered to make it seem even better when a decision has been reached. After the post-decision consolidation phase, this process continues to strengthen the decision when afterthoughts and outcomes follow. This may be compared with search for a dominance structure (SfDS) theory by Montgomery (1983, 1989; Montgomery and Willén 1999), which suggests that the decision process is performed in order to find a dominance structure in which the chosen alternative dominates the other alternatives as it is superior to all other alternatives.

Integrating theory about domain-specific attitudes with Diff-Con theory leads to the expectation that attitudes to previous decisions taken with respect to risky options affect decision makers’ future attitudes to implementing those options by affecting the expected benefits and perceived risks associated with the options. The process leading to this is primarily the consolidation stage of the Diff-Con process, which further upgrades and strengthens the alternative chosen and downgrades the non-chosen alternatives (Simon et al. 2004), although the attitudes to the MCOs are shaped throughout the whole decision process. In the long-term, this may have effects on future situations, as the decision may be re-made by the decision maker when faced with a similar problem, since an option they have already decided upon may be viewed more positively than a non-chosen option.

Based on the review above, our assumption was that decisions already taken (here referring to farmers’ adoption of MCOs) are considered more beneficial (experienced as benefit) and associated with a belief that they reduce the risk of illness more (perceived risk), as a result of the consolidating stage (according to Diff-Con theory) of the decision-making process, than actual perceptions of mastitis prevalence on the farm or information about the benefits of other MCOs. We assumed we would find the same results when combining the MCOs into domains (subtypes), with higher perceived benefit of adopted domains than non-adopted, irrespective of mastitis prevalence and combinations of MCOs available. This raised two research questions: 1) Do adopters of MCOs rate their benefit (expected benefit) and risk (perceived risk) differently than non-adopters? and 2) Is the rated benefit (expected benefit) and risk (perceived risk) explained by the decision already made, rather than for example, characteristics of the decision maker or the farm?

Materials and methods

Study population

The study sample consisted of Swedish dairy farmers and was drawn from the Swedish official milk recording scheme, run by the Swedish Dairy Association. The sample was stratified
according to housing and milking system: included in the study were farms with free-stalls and an automatic milking system (AMS) \((n = 298)\), farms with tie-stalls and pipeline milking \((n = 300)\) and farms with free-stalls and parlour milking \((n = 300)\), which were selected randomly from all farms in the respective populations (see Table 1 for descriptive statistics).

Farmers in the study sample were sent a self-administered (pen and pencil) postal questionnaire. After one reminder, a total of 428 answers were received (response rate 48%) of which all responded to questions concerning risk and benefit for all 22 MCOs listed (see BLINDED for full list of statements). For MCOs, farmers were offered an opt-out alternative if the option was not applicable to their farm, so the number of responders for each MCO may differ. In general, the respondents were mainly male (68%), aged around 50 and with some kind of agricultural education (60%). All respondents evaluated the incidence of clinical mastitis to be quite low on their own farm (see Table 1).

**Questionnaire instrument**

The questionnaire included questions pertaining to demographics, such as age, sex, and education, as well as a description of the income from milk production and perceived incidence of clinical mastitis (see Table 1 for descriptive information on all participants).

The questionnaire was part of a larger research project (see Nielsen and Emanuelson, 2013) and comprised a total of nine pages and 23 questions, several of which involved sub-questions. Farmers were also asked about the incidence of mastitis on the farm, together with the type of milking system used (see Table 1).

Each participant was asked which of 22 MCOs had been implemented in the herd for mastitis prevention only (i.e. some of the MCOs may also be used as general strategies to keep the farm clean). As a second step, in order to assess the perception of benefit and risk associated with the MCOs and to measure possible effects of post-decision justification by the farmer for the different measures, respondents were asked to rate each MCO under two classes of questions; one on the benefit of the MCO for reducing mastitis (expected benefit) and one on the risk of increased incidence of mastitis if the MCO if not implemented (perceived riskiness). This scale was developed as an attempt to measure domain-specific attitudes to risky options, as suggested by Weber et al. (2002). In particular, the first class assessed farmers’ beliefs about how important the suggested MCOs might be in reducing the incidence of mastitis on their farm and the second class assessed their beliefs about the risk of increased mastitis incidence associated with not implementing the MCO, both on a 5-point Likert scale.

The questions on attitudes to MCOs were formulated to be the opposite to each other, with the risk version phrased as the negative of the questions in the benefit version. Each response

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**Table 1.** Descriptive statistics on the participants, presented according to milking system and all together.

|                              | Automatic milking system \((n = 156)\) | Pipeline milking \((n = 129)\) | Parlour milking \((n = 143)\) | All \((n = 428)\) |
|------------------------------|----------------------------------------|--------------------------------|-------------------------------|-----------------|
| Percentage of male respondents | 57.5                                   | 74.5                           | 73.4                          | 68.0            |
| Age, year (mean ± SD)        | 48.6 ± 10.0                            | 48.9 ± 11.4                    | 51.2 ± 10.0                   | 49.5 ± 10.5     |
| Agricultural education (any level; %) | 62.8                                   | 60.8                           | 55.8                          | 60.0            |
| Total household income from milk production >50% (% of farms) | 88.2                                   | 77.5                           | 81.0                          | 82.5            |
| Size of herd (mean ± SD)     | 113.7 ± 82.0                           | 71.7 ± 53.2                    | 132.3 ± 82.0                  | 107.3 ± 75.9    |
| Self-assessed incidence of clinical mastitis in the herd 2010a (mean ± SD) | 3.5 ± 0.9                              | 3.5 ± 0.7                      | 3.4 ± 0.8                     | 3.5 ± 0.8       |

*a1 = very high; 5 = very low.*
The set of 22 MCOs, provided by the Swedish Dairy Association, was selected to reflect Swedish farming practices and recommendations from advisory services about feasible ways to reduce the incidence of mastitis. To enable analyses specific to domains, these 22 MCOs were later categorised into subtypes for the present study (see Table 3 for domains and all MCOs). The MCO domains represented various types of strategies which the farmer could adopt for prevention, at subtype level. By categorising the MCO into different domains, perceived benefit and expected risk were measured, with the aim of capturing the perceived domain-specific attitude to risk in the farmers.

Procedure

The questionnaire was sent out to the respondents in May 2011. Dispatch and collection of the questionnaires were managed by Statistics Sweden. Each questionnaire was distributed together with a lottery ticket as an attempt to increase the respondents’ willingness to reply. Completion of the questionnaire was estimated to take approximately 30 minutes. The instructions accompanying the questionnaire specifically requested that the person responsible for udder health on the farm answer the questionnaire. The questionnaire was pre-tested on two researchers, one with experience of designing questionnaires and one with experience of mastitis research. The questionnaire was also reviewed for clarity by Statistics Sweden before distribution.

For the present study, imputation for missing values was performed for the two scales measuring benefit and risk, respectively, of the 22 types of MCOs. The imputation was performed for those participants leaving the rating for certain MCOs blank (not using the opt-out alternative) using a combination of the methods individual mean and question mean (Shrive et al. 2006). The criterion for imputation of missing values for each MCO was set to be under 5% for the total sample, which was considered feasible. This rather crude way of imputation means that the missing values were replaced with a mean unique to each MCO and whether the participant had reported adopting the MCO or not. Each of the means was computed for the MCOs separately, i.e. one mean for adopter/non-adopter for each MCO, meaning that each imputation had two values for each strategy of MCO (in total 44 values were calculated). Only one of the MCOs had missing values above 5% for the total sample (7.5%), which was considered an exception and was therefore included in the imputation. The imputation was performed to increase the number of observations for the final analyses. Respondents using the ‘opt out’ option were not included.
Table 3. Rated mean and standard deviation, median, and interquartile range (IQR) for perceived benefit and perceived risk separately, presented for non-adopters and adopters.

| Perceived benefit | Overall analysis (U-value) | Perceived risk | Overall analysis (U-value) |
|-------------------|---------------------------|----------------|---------------------------|
|                   | n | Mean (SD) | Median (IQR) | n | Mean (SD) | Median (IQR) | n | Mean (SD) | Median (IQR) |
| Environmental     | Non-adopter | 22 | 3.8 (0.8) | 4.0 (1.5) | 23 | 3.3 (0.7) | 3.5 (1.0) | 1746.0*** |
|                   | Adopter | 405 | 4.4 (0.7) | 4.5 (1.0) | 356 | 4.1 (0.7) | 4.0 (1.5) | 2353.5*** |
| Houses cleaned and fresh bedding material provided at least twice a day | Non-adopter | 22 | 3.8 (1.0) | 4.0 (2.0) | 23 | 3.8 (1.0) | 4.0 (2.0) | 2353.5*** |
|                   | Adopter | 404 | 4.8 (0.5) | 5.0 (0.0) | 401 | 4.6 (0.6) | 5.0 (1.0) | 2353.5*** |
| Yards cleaned at least twice a day | Non-adopter | 18 | 3.7 (0.8) | 4.0 (1.0) | 23 | 2.9 (0.9) | 3.0 (1.0) | 2353.5*** |
|                   | Adopter | 350 | 4.0 (1.1) | 4.0 (2.0) | 357 | 3.7 (1.2) | 4.0 (2.0) | 2353.5*** |
| General hygiene   | Non-adopter | 64 | 3.9 (0.7) | 3.7 (1.1) | 68 | 3.8 (0.6) | 3.8 (0.3) | 3833.5** |
|                   | Adopter | 288 | 4.2 (0.7) | 4.3 (1.3) | 179 | 4.0 (0.7) | 4.0 (0.9) | 2353.5*** |
| Dirty udders washed with water and dried before attaching the cluster | Non-adopter | 58 | 3.9 (0.9) | 4.0 (1.5) | 73 | 3.8 (0.9) | 3.6 (0.7) | 9117.0** |
|                   | Adopter | 262 | 4.5 (0.6) | 5.0 (1.0) | 277 | 3.9 (1.0) | 4.0 (2.0) | 2353.5*** |
| Teats cleaned before attaching the cluster, one cloth per cow | Non-adopter | 48 | 4.5 (0.6) | 5.0 (1.0) | 65 | 4.2 (0.8) | 4.1 (1.0) | 7135.0** |
|                   | Adopter | 277 | 4.8 (0.5) | 5.0 (0.0) | 281 | 4.6 (0.6) | 5.0 (1.0) | 7135.0** |
| Teats cleaned before attaching the cluster, one cloth for multiple cows | Non-adopter | 28 | 2.2 (0.8) | 2.2 (1.0) | 59 | 3.6 (1.0) | 3.8 (1.0) | 4274.5** |
|                   | Adopter | 98 | 2.3 (1.1) | 2.2 (2.0) | 184 | 3.8 (1.2) | 4.0 (2.0) | 2353.5*** |
| Biosecurity       | Non-adopter | 27 | 3.5 (0.6) | 3.6 (0.86) | 16 | 3.4 (0.6) | 3.5 (0.5) | 1077.5*** |
|                   | Adopter | 399 | 4.2 (0.5) | 4.25 (0.72) | 257 | 3.9 (0.6) | 3.9 (0.8) | 2353.5*** |
| Cows in milk grouped according to udder-health status | Non-adopter | 18 | 3.3 (1.0) | 3.8 (2.0) | 22 | 3.2 (0.9) | 3.6 (0.7) | 1815.5*** |
|                   | Adopter | 317 | 4.3 (0.8) | 5.0 (1.0) | 336 | 4.1 (0.9) | 4.0 (1.4) | 2353.5*** |
| Dry cows grouped according to udder-health status | Non-adopter | 19 | 2.8 (0.8) | 3.0 (1.0) | 22 | 2.9 (0.8) | 3.0 (1.2) | 2353.5*** |
|                   | Adopter | 311 | 3.4 (1.0) | 3.27 (1.0) | 334 | 3.3 (1.0) | 3.0 (1.0) | 2353.5*** |
| Gloves worn by milking staff during every milking | Non-adopter | 13 | 2.7 (0.5) | 3.0 (1.0) | 17 | 2.6 (1.0) | 2.7 (1.0) | 1857.0** |
|                   | Adopter | 287 | 3.5 (1.1) | 3.2 (1.0) | 317 | 3.2 (1.1) | 3.0 (2.0) | 2353.5*** |
| Clusters rinsed with warm water after milking cows with CMa | Non-adopter | 17 | 3.9 (1.0) | 4.0 (2.0) | 24 | 3.4 (1.0) | 4.0 (1.0) | 2220.0*** |
|                   | Adopter | 333 | 4.6 (0.7) | 5.0 (0.74) | 358 | 4.4 (0.8) | 5.0 (1.0) | 2220.0*** |
| Clusters rinsed with warm water after milking cows with high SCCb | Non-adopter | 18 | 3.5 (0.8) | 4.0 (1.0) | 24 | 3.4 (1.0) | 3.4 (1.0) | 2512.0*** |
|                   | Adopter | 330 | 4.2 (0.9) | 4.0 (1.13) | 359 | 4.0 (0.9) | 4.0 (1.3) | 2512.0*** |
| Cows with CMa milked last | Non-adopter | 16 | 4.2 (0.6) | 4.0 (0.81) | 20 | 4.0 (0.8) | 4.0 (1.5) | 2144.0** |
|                   | Adopter | 293 | 4.7 (0.7) | 5.0 (0.07) | 328 | 4.5 (0.8) | 5.0 (1.0) | 2144.0** |
| Cows with high SCCb milked last | Non-adopter | 18 | 3.5 (1.0) | 3.4 (1.0) | 20 | 3.7 (0.9) | 3.9 (1.0) | 1902.0** |
|                   | Adopter | 280 | 4.4 (0.8) | 5.0 (1.0) | 327 | 4.3 (0.8) | 4.0 (1.0) | 1902.0** |
| Calving in single pens cleaned between calvings | Non-adopter | 24 | 3.6 (0.8) | 3.76 (1.0) | 28 | 3.6 (0.9) | 3.3 (1.0) | 4773.5** |

(continued)
| Perceived benefit | Perceived risk |
|------------------|----------------|
|                  | Adopter        | Non-adopter    | Adopter | Non-adopter |
|                  | n              | Mean (SD)      | Median (IQR) | Overall analysis (U-value) | n              | Mean (SD)      | Median (IQR) | Overall analysis (U-value) |
| **Overall analysis** | **(U-value)** |
| **Milking**       |                |                |          |              |                |                |          |              |
| Adopter           | 376            | 4.1 (1.0)      | 4.0 (1.0) | 794.0*      | 391            | 3.8 (1.0)      | 4.0 (2.0)  | 291.5*      |
| Non-adopter       | 6              | 4.6 (0.6)      | 4.8 (0.75) |              | 3              | 4.1 (0.6)      | 4.0 (-)   | 4.0 (-)    |
| Adopter           | 422            | 4.3 (0.5)      | 4.4 (0.75) |              | 247            | 3.8 (0.7)      | 3.8 (0.6)  |              |
| All cows prestrippled |           |                |          |              |                |                |          |              |
| Adopter           | 380            | 4.5 (0.9)      | 5.0 (1.0) | 702.5*      | 392            | 4.0 (0.9)      | 4.0 (1.0)  |              |
| Non-adopter       | 4              | 4.5 (1.0)      | 5.0 (1.50) |              | 4              | 4.7 (0.5)      | 5.0 (0.7)  |              |
| Hard-milking cows stimulated manually at milking | | | | | | | | |
| Adopter           | 307            | 3.8 (1.0)      | 4.0 (2.0) | 231.0*      | 351            | 3.6 (0.9)      | 3.4 (1.0)  |              |
| Non-adopter       | 3              | 4.7 (0.6)      | 5.0 (1.0) |              | 4              | 4.5 (0.6)      | 4.5 (1.0)  |              |
| All cows treated with post milking teat disinfectant | | | | | | | | |
| Adopter           | 403            | 4.6 (0.8)      | 5.0 (1.0) |              | 411            | 4.2 (0.9)      | 4.4 (1.0)  |              |
| Non-adopter       | 5              | 5.0 (0.0)      | - (-)     | 685.0*      | 5              | 4.2 (0.8)      | 4.0 (1.5)  |              |
| Cows kept standing at least 30 min after milking | | | | | | | | |
| Adopter           | 267            | 3.7 (0.9)      | 4.0 (1.0) |              | 288            | 3.4 (1.0)      | 3.0 (1.0)  |              |
| Non-adopter       | 2              | 4.5 (0.7)      | 4.5 (-)   | 144.0*      | 3              | 3.3 (1.5)      | 3.0 (-)    |              |
| Teat-cup liners replaced according to manufacturer’s recommendations | | | | | | | | |
| Adopter           | 420            | 4.5 (0.7)      | 5.0 (1.0) | 1141.0*     | 419            | 4.2 (0.8)      | 4.0 (0.8)  |              |
| Non-adopter       | 6              | 4.7 (0.5)      | 5.0 (1.0) |              | 5              | 4.4 (0.5)      | 4.0 (1.0)  |              |
| Medical           |                |                |          |              |                |                |          |              |
| Adopter           | 325            | 4.2 (0.7)      | 4.49 (1.0) |              | 317            | 4.0 (0.7)      | 4.0 (1.0)  |              |
| Non-adopter       | 97             | 3.5 (0.8)      | 3.5 (1.0) | 7278.0***   | 96             | 3.2 (0.8)      | 3.3 (0.5)  |              |
| Dry cow therapy administered in consultation with veterinarian | | | | | | | | |
| Adopter           | 323            | 4.5 (0.7)      | 5.0 (1.0) |              | 322            | 4.2 (0.7)      | 4.0 (1.0)  |              |
| Non-adopter       | 92             | 3.6 (1.0)      | 3.51 (1.0) | 6932.5***   | 98             | 3.2 (0.9)      | 3.0 (1.0)  |              |
| Udder-health status of the herd regularly discussed with veterinarian | | | | | | | | |
| Adopter           | 302            | 4.0 (0.9)      | 4.0 (2.0) | 7016.0***   | 318            | 3.8 (0.9)      | 4.0 (1.1)  |              |
| Non-adopter       | 84             | 3.3 (0.7)      | 3.0 (1.0) |              | 98             | 3.2 (0.8)      | 3.0 (1.0)  |              |
| Feed-related      |                |                |          |              |                |                |          |              |
| Adopter           | 396            | 4.3 (0.8)      | 5.0 (1.0) |              | 397            | 3.8 (1.0)      | 4.0 (1.0)  |              |
| Non-adopter       | 28             | 3.8 (1.0)      | 4.0 (1.75) | 3779.5**    | 29             | 3.6 (1.0)      | 3.4 (1.0)  |              |
| Dry cows fed a mineral feed that covers their needs | | | | | | | | |
| Adopter           | 393            | 4.3 (0.8)      | 4.0 (1.0) |              | 394            | 3.8 (0.8)      | 4.0 (1.0)  |              |
| Non-adopter       | 28             | 3.5 (1.1)      | 3.37 (1.75) | 3378.0***   | 28             | 3.4 (1.0)      | 3.1 (1.0)  |              |
| Feeding plans continuously reviewed and revised when needed | | | | | | | | |
| Adopter           | 396            | 4.3 (0.8)      | 5.0 (1.0) |              | 397            | 3.8 (1.0)      | 4.0 (1.0)  |              |
| Non-adopter       | 28             | 3.8 (1.0)      | 4.0 (1.75) |              | 29             | 3.6 (1.0)      | 3.4 (1.0)  |              |

Mann-Whitney $U$ test performed separately within each type of MCO and group of MCO. Classification of respondents as adopters of the MCO subtypes was based on at least one of the options being adopted. Those individuals included in the analysis on subtype level were further examined on individual MCO level, separately within each subtype. Farmers were offered an opt-out alternative why the number of responders for each MCO may differ.

*aClinical mastitis.

bSomatic cell count.

$p < .05$, **$p < .01$, ***$p < .001$. 

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in the analysis, as those farmers considered the MCO type not applicable to their farm. Using question means only may lead to underestimation of the standard deviation, so we combined the method with individual mean, a method previously found to perform as well as multiple imputation (Shrive et al. 2006).

Rated values for benefit and risk of the MCOs were used as follows: i) total mean for all adopted and non-adopted MCOs for each farm, ii) combined mean ratings of benefit and risk for domains of MCO, iii) separate ratings for benefit and risk for each MCO, and iv) as a combined variable, separate benefit and risk ratings for all MCOs. The categorisation of the MCOs into domains was based on the action taken, rather on different combinations (here referring to the area within which the strategy was performed). As the instrument itself was developed based on multiple aspects of mastitis prevention, this was considered the most suitable procedure. The six subtypes of MCOs were based on: i) options considered environmental strategies (e.g. cleaning the yard), which were categorised as environmental MCOs; ii) options related to cleaning the udder (e.g. dirty udders washed with water and dried before attaching the cluster), which were categorised as general hygiene MCOs; iii) options related to isolation of cows based on health and precautionary actions such as using milking gloves and cleaning the teats with a cloth, which were categorised as biosecurity MCOs; iv) options related to the milking procedure, such as manual stimulation of cows, which were categorised as milking MCOs; v) options related to veterinary medicine, which were categorised as medical MCOs; and vi) options relating to feeding, such as providing specific mineral feed for dry cows, which were categorised as feed-related MCOs (see Table 3 for a full list of MCOs and categorisation into domains).

In order to further explore whether evaluations of risk and benefit are influenced by post-decision justification, we also examined how the overall evaluations of risk and benefit were affected by the strategies adopted on the farm. This was done by relating rated risk and benefit to control variables (such as subjective evaluation of mastitis prevalence on the farm, financial income from the dairy enterprise, housing type, number of stock-keepers and the farmer’s subjective evaluation of mastitis prevalence) in a statistical analysis applying seemingly-unrelated regression (SUR) on panel data.

**Statistical analysis**

**Descriptive analysis and comparisons of means**

Descriptive analysis was performed for background variables for the entire sample, see Table 1. Statistical comparisons using Wilcoxon signed rank test and Mann-Whitney U test of rated mean for rated benefit and risk were performed separately for each MCO and for benefit and risk for all MCOs combined, as a mean for adopters compared with non-adopters.

**Domain specific**

For research question 1 (Do adopters of MCOs rate their benefit and risk differently than non-adopters?), statistical analysis comparing the mean for rated benefit (here referred to as expected benefit) and rated risk (perceived risk) separately, was performed for i) total mean for all adopted MCOs and non-adopted MCOs, compared at individual level; ii) total mean for domains of MCOs (subtypes) as a comparison between those adopting a certain domain (hereafter called adopters) and those who did not adopt a certain domain (non-adopters); and iii) mean for each MCO separately compared between adopters and non-adopters. Wilcoxon’s signed rank test was used to analyse differences in 1) rated mean for benefit of all adopted MCOs in comparison with rated mean for non-adopted MCOs and 2) rated mean for riskiness of all adopted MCOs in comparison with rated mean for non-adopted MCOs rated by the same individual. For analysing the differences in rated benefit and risk of the MCOs between adopters and non-adopters of the MCOs, the non-parametric Mann-Whitney U test was applied for MCOs on both domain and item level.
Regression analysis
For research question 2 (Is the rated benefit and risk explained by the decision already made, rather than for example, characteristics of the decision maker or the farm?), ordinary least squares (OLS) regression was used to study the effect of rated benefit only (Model 1) and risk only (Model 2). This was performed to decide whether to use fixed effect, by applying farm as an effect on decision-making (e.g. if a farm with certain characteristics such as background variables or using a certain set of strategies could explain the differences), or to use random effect. The Hausman test was performed between estimates of fixed and random effect for benefit only and indicated statistically significant differences, suggesting that random effects be applied, which meant that farm was not used as a fixed effect in the further analyses. For Model 3, a regression was performed for benefit and risk simultaneously by applying SUR, a method first proposed in 1962 (Zellner 1962) that allows the error term for the dependent variables to correlate with each other. SUR uses generalised linear regression models (GLM) with multiple response variables (in the present study referred to as benefit and risk) and assumes a variance-covariance matrix where the error term is correlated (in this case between farms). Due to the data being arranged as panel data, prior to all analyses in Stata the xtset syntax was used to declare the individual farmers and MCO type, allowing us to control for repeated replies (for each MCO) from the same farmer. The command XTSUR in Stata is a statistical procedure which applies mixed model with random effects, unlike the command SURREG, so the coefficient of determination ($R^2$) is not well defined and not reproduced.

All regressions were performed using the MCOs as individual measures in which benefit and/or risk was used as the dependent variable. Explanatory variables used as independent variables were: adoption of MCO, evaluation of mastitis on the farm, income from dairy production, number of stock-keepers and housing type (see Table 2 for values for each variable).

Descriptive analyses, Wilcoxon sign rank test and Mann-Whitney U test were performed using the Statistical Package for the Social Sciences, (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Statistical analysis performed as OLS and SUR was executed using Stata (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP).

Results
Descriptive analysis and comparisons of means
A statistical comparison was made of total mean for all adopted MCOs compared with all non-adopted MCOs. This revealed a statistically significant difference between rated benefit ($p < .001$) and rated riskiness ($p < .001$), separately, for adopted MCOs (benefit: $4.59 \pm 0.34$, risk: $4.25 \pm 0.48$) and non-adopted MCOs (benefit: $3.62 \pm 0.62$, risk: $3.53 \pm 0.66$), see Figure 1.

Domain specific
Comparisons of the MCOs at domain level, each representing a group of MCOs with shared characteristics, indicated that the evaluated benefit and risk of the domains were statistically significantly higher for adopters than non-adopters in all domains (environmental, general hygiene, biosecurity, medical and feed-related). The adopters reported significantly ($p < .001$) higher benefit and significantly ($p < .001$) higher riskiness if not implementing the MCOs on the farm than the non-adopters, except for MCOs related to milking, for which differences were non-significant as almost all participants reported using these strategies. Further analyses were performed for each MCO in which ratings were compared between adopters and non-adopters. This analysis revealed a similar pattern, with adopters of a certain MCO reporting higher benefit than
non-adopters ($p < .001$). See Table 3 for descriptive statistics and results from the Mann-Whitney U test for each individual MCO and the domains for both risk and benefit.

The relationship between rated benefit (expected benefit) and rated risk (perceived risk) for adopters and non-adopters separately was statistically significant ($p < .001$) for all possible comparisons, see Figure 1 for comparison between ratings from adopters and non-adopters.

**Regression analysis**

OLS regression analysis for benefit (Model 1 in Supporting Information Appendix A) and risk (Model 2 in Supporting Information Appendix B) separately displayed a similar pattern, where being an adopter of the MCO was the main explanatory variable in terms of highest coefficient weight. Model 1 was estimated to predict benefit based on adopting the MCO, financial income from dairy production, perceived mastitis prevalence on the farm, type of milking system and housing type. A significant regression equation ($p < .001$) was found ($R^2 = .28$). For the independent variables, only the variables for adopting the MCO, financial income and system were found to be significant predictors of benefit. Model 2 was estimated to predict risk based on adopting the MCO, financial income from dairy production, perceived mastitis prevalence on the farm, housing type and having stock-keepers. A significant regression equation was found ($p < .001; R^2 = .18$). For the independent variables, only the variables for adopting the MCO and financial income were found to be significant predictors of risk.

The SUR analysis, Model 3 (Table 4), was estimated to predict benefit and risk simultaneously based on the independent variables listed for Model 1 and 2 separately. Model 3 revealed a statistically significant coefficient for all independent variables for benefit (namely: adopting the MCO, financial income from dairy production, perceived mastitis prevalence on the farm, type of milking system and housing type) and for risk (adopting the MCO, financial income from dairy production, perceived mastitis prevalence on the farm, housing type and having stock-keepers). Although all independent variables were found to be statistically significance, they had rather small coefficients (Table 4). The explanatory variable with highest coefficient weight was found to be adopter of the MCO, followed by housing type, financial income and mastitis prevalence for both benefit and risk. The analysis does not define $R^2$ well, so it is not reproduced and presented.

**Discussion**

In this exploratory study, we combined Diff-Con theory with risk-benefit analysis to explore how attitudes to risky choices can be affected by previous decisions. To exemplify risky choices, farmers’ attitudes to benefits and risks associated with the MCOs already adopted on the farm were compared, both at MCO level and across domains, with farmers’ attitudes to non-adopted options. This integration of Diff-Con theory with risk-benefit analysis is a novel approach to studying risky decision-making. It allowed us to explore how decision-making may be affected by post-decision justifications, by acknowledging that farmers’ attitudes (considered in terms of benefit and risk) to MCOs may be formed by previously taken decisions, via the consolidation mechanism described in the Diff-Con theory of decision-making. In our research case of farmers’ adoption of MCO, we could not meaningfully access pre-decision attitudes to MCOs as mastitis control is continuously ongoing on all dairy farms. Nevertheless, in this study we were able to investigate the correlation between current attitudes, risky choices and previous decisions about the same risky choices, and discuss how the initial decision had gone through the suggested decision process in which alternatives were evaluated and differentiated from each other prior to a decision being taken.
Our findings clearly indicate that farmer attitudes to risky MCOs are correlated with adoption of these MCOs, whereby already adopted MCOs are generally considered more beneficial for reducing mastitis incidence and are perceived as leading to a greater risk of increased incidence if not implemented. Our findings also indicate that the main differences between adopters and non-adopters of specific MCO domains occur in the environmental and medical domains rather than the other domains, see Table 3. This may be explained by farmers perceiving direct feedback from using MCOs in these domains in terms of mastitis prevention. For environmental strategies, immediate feedback will be given by for example, animal houses becoming dirty, leaving the farmer with visual feedback which will not only affect mastitis but also other aspects of animal welfare and health. Medical strategies, on the other hand, are more drastic in nature as they require farmers to make an active decision to call for a veterinarian, which in turn gives immediate feedback when implemented.

Our results thus indicate that the difference in perceived benefit and risk of MCOs in post-decision justification applies at both domain level and individual decision level. We found that the adopted MCOs had a pattern of differentiation compared with the non-adopted MCOs on item and domain level during what could be considered the consolidation stage. The only exception we identified was milking strategies, a finding which may be explained by almost all respondents having adopted these strategies on the farm, leaving no group with which to compare the ratings. Overall, our results are theoretically in line with Diff-Con theory (Svenson 1992, 2003, 2006; Salo and Svenson 2001) and with other theories on decision-making (Brownstein 2003; Carlson and Pearo 2004), which state that a decision made (adopted MCOs), both on item and domain level, is viewed as more superior (more important) than non-chosen options. This means that the perceived benefit, and in our case also risk, from chosen actions is rated higher than that from non-adopted alternatives, as also shown in both regression analyses. This in turn suggests that a more positive attitude from using the measure and an increased sense of uncertainty, in terms of risk if not used, may occur both during the decision process and after implementation. Connecting these thoughts and findings with the theories of domain-specific attitude proposed by Weber et al. (2002), we suggest that the attitudes to measures and to domains will strengthen this process further, by increasing the perceived benefit (and the believed riskiness if not implemented) of the decision made in comparison with non-chosen options. In line with previous results on post-decision memory (Mather, Shafir, and Jonhson 2000, 2003), our results indicate that a decision made (e.g. to implement certain MCOs) itself can affect the attitude to the decision object both with regard to benefit and risk. If, as previous studies have shown (see e.g. Emanuelson and Nielsen 2017), there is no evidence that a certain MCO has a direct effect on

Figure 1. Mean and SD for rated benefit and risk separately reported for adopters and non-adopters.
mastitis prevention, our findings may imply that farmers’ decisions are based on for example, a belief and not on solid facts about direct improvements in the mastitis situation. It can be assumed that MCOs are not solely chosen for actual effect, but based on previous decisions and attitudes, which may also explain why some MCOs were rated more important than others. It may also be the case that implemented strategies are perceived as more beneficial due to them having positive effects for the farm as a whole. Farmers have the possibility to evaluate whether the MCOs they implement have an effect or not, although the procedure takes time and effort and there is no quick and easy way to check their effectiveness, which may be one reason why appraisal is not done on a regular basis. In accordance with Diff-Con theory, throughout the decision-making process a past decision will affect future decisions by being upgraded, but also by the attitude towards it being more positive, with a potentially considerable impact on decisions made when faced with a similar problem or situation at a later time. It may be the case that farmers have adopted MCOs as part of their daily routine and that the initial decision on which MCOs to implement was based solely on benefit or risk associated with the MCO, but thereafter was a combined effect of behaviour together with other aspects such as time.

Assuming that the decision-making process of farmers participating in this study can be described in terms of Diff-Con theory when deciding which MCOs to implement on their own farm, this has consequences for implementation of new future recommendations of improved and more efficient strategies, as they will have to compete with other already used strategies perceived as more superior. Moreover, as many of the strategies may have been used for a long period (not limited to use for mastitis prevention only), the possible effect on long-term decisions may have consequences for how new recommendations are perceived by the group. As suggested by numerous theories on decision-making and post-justification, and Diff-Con theory, made decisions are more likely to be perceived as more superior than non-chosen options, probably as an attempt to avoid regret. Thus when new, more effective, targeted recommendations towards mastitis are made, measures must be taken to ensure that the group perceives the actual benefit, so that the recommendations are not directly subordinate to previous decisions taken. According to Diff-Con theory, the differentiation that occurs during the decision process continues to strengthen for a long time afterwards, which in turn increases the possibility of the same decision being taken again in a similar situation. This conforms with the theory of path dependency, in which a decision is limited to a set decision previously made, even though that alternative may no longer be relevant in the specific situation. There is reason to believe that novel MCOs will therefore have difficulties achieving wider implementation and awareness of our

| Table 4. Results from the seemingly-unrelated regressions (SUR) in panel data with random effects for benefit and risk. |
|-------------------------------------------------------------|
| Benefit (B) | Coefficient |
|----------------------------------|--------------|
| Adopter MCO | 1.048*** |
| Housing type | 0.276*** |
| Financial income | 0.098*** |
| Mastitis prevalence | 0.092*** |
| Milking system | 0.051** |
| Statistical test for B^a |
|-------------------------------------------------------------|
| Risk (R) | Coefficient |
|----------------------------------|--------------|
| Adopter MCO | 0.800*** |
| Housing type | 0.294*** |
| Financial income | 0.073*** |
| Mastitis prevalence | 0.072*** |
| Stock-keeper | 0.058*** |
| Statistical test for R^a |
|-------------------------------------------------------------|

Analysis controls for individual farmer and type of MCO. Random effects were based on statistical significance in the Hausman test.

^aThe statistical procedure in Stata does not report the constant, R^2 or Wald \( \chi^2 \).

^p < .05, **p < .01, ***p < .001.
findings should be incorporated into strategies for communication of new research on MCOs. The main function of the consolidation stage is to ensure that the chosen alternative gains superiority (Svenson, Salo and Lindholm 2009) over non-chosen alternatives. The process of choosing which MCO to adopt on a farm to prevent mastitis can itself be biased based on what has been done previously, either by the farmer or others (i.e. friends or family), which in turn can directly affect the domain-specific attitudes formed, for example, as a direct result of previous decisions.

While the sample would have allowed us to compare possible differences in decision-making and attitudes to implemented MCOs based on housing and milking system, this was not done because analysis of the descriptive variables revealed no differences between the systems and because it was not the purpose of the study. However, bearing this in mind and assuming that in future more cows will be kept in loose housing systems, our analytical approach can be used for capturing the attitudes of future farmers and better understanding their decision-making, enabling better policy making. For dairy farming in particular, these results can improve understanding of what drives farmers in their decision-making under risk on questions related to animal health and wellbeing. This is turn can allow better policies can be developed to ensure that farmers perceive the importance of new recommendations that emerge.

Conclusions

By integrating differentiation and consolidation theory with risk-benefit analysis, in this exploratory approach we highlighted that post-decision-making in risky options may cause the decision made (i.e. implemented MCOs) to be regarded as more beneficial (in preventing mastitis from occurring on the farm) than non-chosen options. This suggests that decision makers taking risky options will perceive their decisions made as superior to non-chosen options. Our results also suggest that having taken a decision (adopted MCO) also increases the perceived riskiness. These findings suggest a function whereby the decision maker may experience strengthened beliefs about the functionality of the decision itself (here exemplified by MCOs already chosen) during the consolidation stage that are mediated by perceived risk and benefit. In the long-term, this may have implications for how farmers should be presented with future recommendations on more efficient MCOs, so that these are not perceived as inferior to previously chosen options. The approach may also be suitable for other groups of decision makers who face risky options.

Disclosure statement

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References

Ajzen, I. 1991. “Theories of Cognitive Self-Regulation. The Theory of Planned Behavior.” Organizational Behavior and Human Decision Processes 50 (2):179–211.
Alhakami, A. S., and P. Slovic. 1994. “A Psychological Study of the Inverse Relationship between Perceived Risk and Perceived Benefit.” Risk Analysis 14 (6):1085–1096.
Bell, N. J., M. J. Bell, T. G. Knowles, H. R. Whay, D. J. Main, and A. J. F. Webster. 2009. “The Development, Implementation and Testing of a Lameness Control Programme Based on HACCP Principles and Designed for Heifers on Dairy Farms.” The Veterinary Journal 180 (2):178–188.

Brennan, M. L., and R. M. Christley. 2013. “Cattle Producers’ Perceptions of Biosecurity.” BMC Veterinary Research 9 (1):71.

Brownstein, A. L. 2003. “Biased Predecision Processing.” Psychological Bulletin 129 (4):545.

Carlson, K. A., and L. K. Pearo. 2004. “Limiting Predecisional Distortion by Prior Valuation of Attribute Components.” Organizational Behavior and Human Decision Processes 94 (1):48–59.

Conner, M., and C. Abraham. 2001. “Conscientiousness and the Theory of Planned Behavior: Toward a More Complete Model of the Antecedents of Intentions and Behavior.” Personality and Social Psychology Bulletin 27 (11):1547–1561.

Ellis-Iversen, J., A. J. Cook, E. Watson, M. Nielen, L. Larkin, M. Wooldridge, and H. Hogeveen. 2010. “Perceptions, Circumstances and Motivators That Influence Implementation of Zoonotic Control Programs on Cattle Farms.” Preventive Veterinary Medicine 93 (4):276–285.

Emanuelson, U., and C. Nielsen. 2017. “Short communication: Weak associations between mastitis control measures and bulk milk somatic cell counts in Swedish dairy herds.” Journal of Dairy Science 100: 6572–6576. doi:10.3168/jds.2016-12384

Festinger, L. 1962. “Cognitive Dissonance.” Scientific American 207 (4):93–106.

Fischhoff, B., P. Slovic, S. Lichtenstein, S. Read, and B. Combs. 1978. “How Safe Is Safe Enough? Apsychometric Study of Attitudes toward Technological Risks and Benefits.” Policy Sciences 9 (2):127–152.

Gunn, G. J., C. Heffernan, M. Hall, A. McLeod, and M. Hovi. 2008. “Measuring and Comparing Constraints to Improved Biosecurity Amongst GB Farmers, Veterinarians and the Auxiliary Industries.” Preventive Veterinary Medicine 84 (3–4):310–323.

Heffernan, C., F. Misturelli, L. Nielsen, G. J. Gunn, and J. Yu. 2009. “Analysis of Pan-European Attitudes to the Eradication and Control of Bovine Viral Diarrhoea.” The Veterinary Record 164 (6):163.

Huijps, K., H. Hogeveen, T. J. G. M. Lam, and R. B. M. Huirne. 2009. “Preferences of Cost Factors for Mastitis Management among Dutch Dairy Farmers Using Adaptive Conjunct Analysis.” Preventive Veterinary Medicine 92 (4):351–359.

Jansen, J., B. H. P. Van den Borne, R. J. Renes, G. Van Schaik, T. J. G. M. Lam, and C. Leeuwis. 2009. “Explaining Mastitis Incidence in Dutch Dairy Farming: The Influence of Farmers’ Attitudes and Behaviour.” Preventive Veterinary Medicine 92 (3):210–223.

Kristensen, E., and E. B. Jakobsen. 2011. “Challenging the Myth of the Irrational Dairy Farmer; Understanding Decision-Making Related to Herd Health.” New Zealand Veterinary Journal 59 (1):1–7.

Kristensen, E., and E. B. Jakobsen. 2011. “Danish Dairy Farmers’ Perception of Biosecurity.” Preventive Veterinary Medicine 99 (2–4):122–129.

Lam, T. J. G. M., J. Jansen, B. H. P. Van den Borne, R. J. Renes, and H. Hogeveen. 2011. “What Veterinarians Need to Know about Communication to Optimise Their Role as Advisors on Udder Health in Dairy Herds.” New Zealand Veterinary Journal 59 (1):8–15.

Mather, M., E. Shafir, and M. K. Johnson. 2000. “Misremembrance of Options Past: Source Monitoring and Choice.” Psychological Science 11 (2):132–138.

Mather, M., E. Shafir, and M. K. Johnson. 2003. “Remembering Chosen and Assigned Options.” Memory and Cognition 31 (3):422–33.

Montgomery, H. 1983. “Decision Rules and the Search for a Dominance Structure: Towards a Process Model of Decision Making.” Advances in Psychology 14:343–369.

Montgomery, H. 1989. “From Cognition to Action: The Search for Dominance in Decision-Making.” In Process and Structure in Human Decision Making, edited by Montgomery, H. & Svenson, O., 23–49. Oxford, England: John Wiley & Sons.

Nielsen, C., and U. Emanuelson. 2013. “Mastitis control in Swedish dairy herds.” Journal of dairy science 96 (11):6883–6893.

Prescott, F. F. 2000. “Antimicrobial Drug Resistance and Its Epidemiology.” Antimicrobial Therapy in Veterinary Medicine 3:27–49.

Rollin, E., K. C. Dhuyvetter, and M. W. Overton. 2015. “The Cost of Clinical Mastitis in the First 30 Days of Lactation: An Economic Modeling Tool.” Preventive Veterinary Medicine 122 (3):257–264.

Salo, I., and O. Svenson. 2001. “Constructive Psychological Processes Before and After A Real-Life Decision.” In Decision Making: Social and Creative Dimensions, 137–151. Netherlands: Springer.

Sayers, R. G., G. P. Sayers, J. F. Mee, M. Good, M. L. Bermingham, J. Grant, and P. G. Dillon. 2013. “Implementing Biosecurity Measures on Dairy Farms in Ireland.” The Veterinary Journal 197 (2):259–267.
Shrive, F. M., H. Stuart, H. Quan, and W. A. Ghali. 2006. “Dealing with Missing Data in a Multi-Question Depression Scale: A Comparison of Imputation Methods.” *BMC Medical Research Methodology* 6 (1):57.

Siegel Levine, D. S., and M. J. Strube. 2012. “Environmental Attitudes, Knowledge, Intentions and Behaviors among College Students.” *The Journal of Social Psychology* 152 (3):308–326.

Siivonen, J., S. Taponen, M. Hovinen, M. Pastell, B. J. Lensink, S. Pyörälä, and L. Hänninen. 2011. “Impact of Acute Clinical Mastitis on Cow Behaviour.” *Applied Animal Behaviour Science* 132 (3-4):101–106.

Simon, D., D. C. Krawczyk, A. Bleicher, and K. J. Holyoak. 2008. “The Transience of Constructed Preferences.” *Journal of Behavioral Decision-Making* 21 (1):1–14.

Simon, D., D. C. Krawczyk, and K. J. Holyoak. 2004. “Construction of Preferences by Constraint Satisfaction.” *Psychological Science* 15 (5):331–336.

Slovic, P. 1987. “Perception of Risk.” *Science* 236 (4799):280–285.

Slovic, P., M. L. Finucane, E. Peters, and D. G. MacGregor. 2004. “Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk, and Rationality.” *Risk Analysis: An Official Publication of the Society for Risk Analysis* 24 (2):311–322.

Svenson, O. 1992. “Differentiation and Consolidation Theory of Human Decision Making: A Frame of Reference for the Study of Pre- and Post-Decision Processes.” *Acta Psychologica* 80 (1–3):143–168.

Svenson, O. 2003. “Values, Affect, and Processes in Human Decision-Making: A Differentiation and Consolidation Theory Perspective.” In *Emerging Perspectives on Judgment and Decision Research*, edited by Schneider, S. L., and Shanteau, J., 287–326. Cambridge, UK: Cambridge University Press.

Svenson, O. 2006. “Pre- and Post-Decision Construction of Preferences: Differentiation and Consolidation.” In *The Construction of Preference*, edited by Lichtenstein, S., and Slovic, P., 356–371. Cambridge, UK: Cambridge University Press.

Svenson, O., and T. Hill. 1997. “Turning Prior Disadvantages into Advantages: Differentiation and Consolidation in a Real-Life Decision-Making.” In *Decision-Making: Cognitive Models and Explanations*, edited by Ranyard, R., Crozier, W. R., and Svenson, O., 218–232. London: Routledge.

Svenson, O., and M. Jakobsson. 2010. “Creating Coherence in Real-Life Decision Processes: Reasons, Differentiation and Consolidation.” *Scandinavian Journal of Psychology* 51 (2):93–102.

Svenson, O., I. Salo, and T. Lindholm. 2009. “Post-Decision Consolidation and Distortion of Facts.” *Judgment and Decision-Making* 4 (5):397–407.

Teuber, M. 2001. “Veterinary Use and Antibiotic Resistance.” *Current Opinion in Microbiology* 4 (5):493–499.

van den Borne, B. H. P., J. Jansen, T. J. G. M. Lam, and G. Van Schaik. 2014. “Associations between the Decrease in Bovine Clinical Mastitis and Changes in Dairy Farmers’ Attitude, Knowledge, and Behavior in the Netherlands.” *Research in Veterinary Science* 97 (2):226–229.

van Soest, F. J., I. M. Santman-Berends, T. J. Lam, and H. Hogeveen. 2016. “Failure and Preventive Costs of Mastitis on Dutch Dairy Farms.” *Journal of Dairy Science* 99 (10):8365–8374.

Weber, E. U., A.-R. Blais, and N. E. Betz. 2002. “A Domain-Specific Risk-Attitude Scale: Measuring Risk Perceptions and Risk Behaviors.” *Journal of Behavioral Decision-Making* 15 (4):263–290.

Weber, E. U., and C. Hsee. 1998. “Cross-Cultural Differences in Risk Perception, but Cross-Cultural Similarities in Attitudes towards Perceived Risk.” *Management Science* 44 (9):1205–1217.

Weber, E. U., and R. A. Milliman. 1997. “Perceived Risk Attitudes: Relating Risk Perception to Risky Choice.” *Management Science* 43 (2):123–144.

Zellner, A. 1962. “An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias.” *Journal of the American Statistical Association* 57 (298):348.