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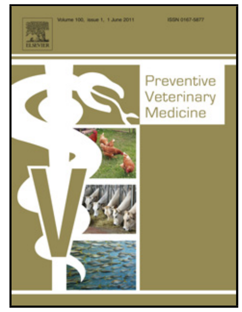

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Changes in Perceptions and Motivators that Influence the Implementation of On-farm *Salmonella* Control Measures by Pig Farmers in England

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Highlights:

- Farmers' perception of implementing *Salmonella* control on pig farms studied
- Successful interventions on a demonstration farm would motivate farmers.
- Positive attitude, responsibility towards control and support from peers confirmed.
- Farmers had low confidence in their ability to control *Salmonella* over time.
- Farmers trusted their veterinarian as a source of advice for implementing changes.

Abstract [max 400, currently 397]

This study presents British farmers' perception of, and barriers to, implementing *Salmonella* control on pig farms. Four farms that had implemented interventions and their 33 close contacts (known to the intervention farmers) took part in interviews before (phase 1) and after (phase 2) intervention trials to assess the difference in perception over time. Their results were compared against those from nine randomly selected control farms. The hypothesis was that farms implementing interventions whether or not successful, would influence their close contacts' opinion over time.

Based on a 'pathway to disease control' model, three intrinsic factors known to influence motivation—attitudes, social norms and self-efficacy—were evaluated.

Farmers mentioned that successful interventions on a farm would attract their attention. The use of an appropriate communication strategy is therefore recommended to stimulate farmers' intent to implement control measures. Both before and after the intervention trials, all farmers had a positive attitude towards *Salmonella* control and felt that their peers and authorities were supportive of controlling *Salmonella* on farms. In phase 2, however, farmers were more likely to want to share the burden of control with other stakeholders along the food chain and their belief in self-efficacy had weakened. Whilst social norms were not associated with an intention to take action on control, a positive attitude towards *Salmonella* control and a belief in self-efficacy were more likely to result in an intent to control. In phase 2, farmers with an intent to implement an intervention appeared to have a greater, but not significant positive belief in self-efficacy ($p=0.108$).

This study confirmed that farmers recognised their responsibility for controlling *Salmonella* in pork—even though their confidence in their ability to control *Salmonella* decreased over time—and believed that responsibility should be shared with the rest of the production chain. It showed that farmers trusted their veterinarian as a source of advice to guide them during the process of implementing change, though an increase in farms' *Salmonella* seroprevalence score (Zoonosis National Control Programme (ZNCP) score) especially for those with a low ZNCP score was also likely to influence their behaviour. Getting concrete feedback from customers or a tangible benefit from their action was a strong incentive especially for farms with a ZNCP score higher than 50%. The study also revealed a need to validate which measures are effective as farmers did not perceive that the current advised interventions were worth the additional effort.

Keywords: Disease control, *Salmonella*, motivators, social epidemiology, pig

1. Introduction

In 2006-2007, a European Union (EU) baseline study estimated the prevalence of *Salmonella* in slaughter pigs sampled in abattoirs (Anon, 2008). In the United Kingdom (UK), lymph nodes of 21.2% of slaughtered pigs were infected with *Salmonella* (Anon, 2008, Marier et al., 2014). Another EU survey assessed the presence of *Salmonella* in breeding herds in 2008. The prevalence of *Salmonella* in the UK breeding pig holdings was the fourth highest of all participating countries (Anon, 2009a). In 2013, a third survey in UK abattoirs confirmed the presence of *Salmonella* in 30.5% of the caecal content of slaughtered pigs (Powell et al., 2015). Since pig meat products are a potential source of human salmonellosis (Hald et al., 2003), these results highlighted the need to reduce *Salmonella* prevalence in the UK pig herd.

In 2007, the British Pig Executive (BPEX, now AHDB Pork) commissioned a set of intervention trials, in which individual farmers could propose and apply for funds to support interventions against *Salmonella* (intervention trial). Farms with successful interventions would be used as demonstration farms to others. Separately, to monitor the seroprevalence of *Salmonella*, meat juice samples were tested (ELISA) periodically from each batch of pigs sent to the abattoir, as part of the Zoonoses National Control Programme (ZNCP score, 2008-2012, (BPEX, 2012)).

Implementation of *Salmonella* control on pig farms faces several challenges. Firstly, *Salmonella* is seldom associated with clinical disease (Alban and Stark, 2005; Wales et al., 2011; Wales and Davies, 2016) or apparent (perceived) production loss in pigs (Andres and Davies, 2015; Loughmiller et al., 2007), therefore control is believed to benefit public health rather than the farmer who has to implement interventions . Secondly, farmers may be unable to assess the effect of additional control efforts that they undertake (Evangelopoulou et al., 2015). Therefore, whilst farmers may accept a moral responsibility (Van Dam et al., 2010), the outcome appears remote from the primary producers' perspective. Thirdly, the potential exists to mitigate or aggravate contamination risk at other stages along the food chain (Dickson et al., 2013), from abattoir through processing to consumption. Finally, whilst there is convincing evidence that some human cases of salmonellosis are caused by *Salmonella* strains that are found in pigs (Kirchner et al., 2011), the overall proportion of human salmonellosis that can be attributed to pigs remains uncertain. However, based on a "contribution of food sources to human salmonellosis" study using 2007-2009 data, it was estimated that, 26.9% and 11.7% of cases of human salmonellosis were attributable to pigs in the EU and in the UK respectively (Pires et al., 2011), while a more recent study estimated that 57% of the human salmonellosis cases were attributed to pigs in the EU (Hald et al., 2012).

This paper presents the outcomes of a two-phased study which aimed to use the intervention trials and the ZNCP scores as anchor points to investigate how pig farmers' intention to control *Salmonella* changed in response to evidence of the effectiveness of interventions. The authors relied on a behavioural model according to which (i) intrinsic motivators (attitudes, perceived social norms and self-efficacy) affect the intent to take action and (ii) extrinsic circumstances (community and industry, culture and society, knowledge and skills) influence the step from intent to implementation (Ajzen, 1991; Ellis-Iversen et al., 2010). This paper focuses on the intrinsic factors that impeded farmers' intention to control *Salmonella* before (phase 1) and after (phase 2) the intervention trials and describes the impact of the ZNCP score on these factors. It draws upon the data collected to identify strategies that may promote an intention amongst pig farmers to control *Salmonella* in the future.

2. Material and methods

2.1. Study population

Four farmers recruited by BPEX into the intervention trials (table 1) were invited to participate in this study. For each of them, up to nine close-contact farms (referred to as 'contact farms') were enrolled to test whether the intervention farm influenced the uptake of control on the contact farms (figure 1). These contact farms were first identified by the intervention farmer as individuals with whom they had regular social or professional contact and at least occasionally discussed pig husbandry and farming. Secondly, each farmer's private veterinarian suggested additional farmers to whom they might recommend interventions. Finally, if more farms were needed, BPEX also suggested a list of pig farmers that were part of the same geographical region and therefore, more likely to attend the same pig discussion meetings and receive the same information material as the applicable intervention farm.

To generate an equally large 'control-cluster', up to nine control farms were randomly selected from geographical regions (counties) in which no intervention farms were present, using lists supplied by BPEX. Another eligibility criterion was that the farmer did not personally know any of the intervention farmers.

The (i) intervention farms, (ii) contact farms and (iii) control farms are referred to herein as the three “types” of farms.

2.2 The interventions

The four intervention farms implemented interventions as agreed with BPEX’s study. One farm added Bio-Mos® to the lactating and dry sow ration to reduce *Salmonella* levels in piglets. The second intervention farm switched from pelleted to coarsely ground meal feed in the grower pigs. The third farm used a live-attenuated *Salmonella* Typhimurium vaccine for the sows (Salmoporc STM®) and fed weaned piglets & grower pigs with liquid acidified feed. The fourth farm vaccinated piglets at weaning using a live *Salmonella* vaccine (AviPro® vac T) given orally by mixing the vaccine with their gruel (table 1).

2.3 Intrinsic factors

A “pathway to disease control” model, recently applied to describe livestock farmers’ perception, motivators and barriers in relation to disease control (Ellis-Iversen et al., 2010), was used to measure farmers’ motivations, intentions and behaviour. This was based on the model of reasoned behaviour that was later expanded to include the extrinsic factors as influencers for livestock farmers (Ajzen, 1991, Panter-Brick, 2006). The model’s three intrinsic factors were investigated using a structured questionnaire (table 2):

Attitude. The farmers were asked to rate how important it was to control *Salmonella* in pigs for them, for public health and for the pig industry and whether control of *Salmonella* in pigs was a necessity. Their answers were rated between strongly agree and strongly disagree.

Social norms. The farmers were asked how they thought various peers would feel if they applied an intervention on their farm and whether they would be supportive. Their answers were rated between very positive (approve) to very negative (disapprove).

Belief in self-efficacy. The farmers were asked about how an intervention would affect the burden of *Salmonella* in pigs if it was implemented. They were asked to consider whether the intervention would have an effect on their ZNCP scores in the short and long term and how the implementation of an intervention would affect public health in subsequent years. Their answers were rated on a scale between very positive (large reduction) and very negative (large increase).

2.4 Data collection

All farmers were first visited between August 2008 and May 2009 (phase 1). The second visits were carried out between June and October 2010, once the intervention trials were completed (phase 2). At each visit, two structured questionnaires were completed and one semi-structured interview was conducted and recorded on a Dictaphone to be fully transcribed. The same questionnaires were used during both visits to compare the data between the two phases.

The first questionnaire gathered information on the characteristics of the herd and information on the interviewee (attribute data). It also collected the previous three monthly ZNCP scores (BPEX, 2012) when available, to provide a comparative measure of *Salmonella* seroprevalence over time using meat juice ELISA results. The second questionnaire gathered information on 'intrinsic factors' as described in section 2.3. For each of the three factors, various questions were asked and rated on a five-category verbal Likert scale such as 'strongly agree' to 'strongly disagree' to assess respondents' opinion (table 2).

A semi-structured interview technique was used to allow the conversation to develop naturally between the interviewer and the farmer. This method, previously used with cattle farmers (Ellis-Iversen et al., 2010) allowed the interview to lead into and to address areas important to the farmer rather than the interviewer. Farmers were asked to discuss their concerns about *Salmonella* in pigs, actions that they had taken or planned in connection with the control of *Salmonella*, their motivations to control *Salmonella* and barriers undermining these motivations, their sense of responsibility towards *Salmonella* control and how they thought a successful intervention would influence their actions.

Overall, five people were recruited to conduct the interview with the farmers. Three were used during the first phase whilst two carried out the interviews of the second phase. Three interviewers were veterinary PhDs, one was a veterinarian and one an agronomist with pig farming expertise. Detailed instructions on the interview technique and the objectives of the study were provided to and discussed in-depth with each interviewer to standardise how interviews were conducted.

2.5 Data management and analysis

Completed questionnaires were entered into a Microsoft® Access (Microsoft corp., 2003) database. The recorded interviews were transcribed and quotes were sorted using the software

MAXQDA (www.maxqda.com) for Qualitative Data Analysis. All data were cleaned and analysed using Microsoft® Excel (Microsoft corp., 2007) and STATA 10 (Stata, 2007).

The transcript of the interviews was interpreted and responses to each question were split into defined categories of answers based on key words and subjects mentioned. Each answer was then translated into binary results (e.g. zero when the idea was not mentioned during the interview and 'one' when mentioned). Before analysis, the certainty in interpretation of the free text data collected during the interview was assessed. Four randomly selected interview transcripts and twelve variables were scored independently by two veterinary epidemiologists, and an assessment was made on the agreement of their interpretation of the text using kappa statistics. This evaluation—supported by McNemar analysis—helped to ensure the analysts did not bias the scoring with their own opinions . Disagreements according to the McNemar statistics were investigated and discussed at an advisory meeting. Overall, the agreement between analysts was high and it was concluded that analyst bias was unlikely to affect the interpretation and conclusion of the study.

The data collected were described and comparative analyses conducted using the appropriate statistical models according to variable type. Chi-squared tests were used for comparisons of two categorical variables. Student t-tests were used to compare the means of continuous normally distributed variables. Data transformation of numeric variables was used before modelling to ensure that data approximated normality for the multinomial regression analysis. Nonparametric K-sample tests were used to compare the equality of medians. The Kruskal-Wallis test of equality-of-populations was applied to compare distributions of ranked variables.

From the structured questionnaire and for each respondent, the sum of the scores given to each question relating to a specific intrinsic factor was calculated. The frequency of the sum of scores from the study population was used to produce the distribution of opinions between 'very positive' and 'very negative' answers. To compare the "control farms" against the "contact and intervention farms", the median of the scores for a group of related questions was determined for each farm and then the percentage of farms having the same median was compared between the two farm types.

3 Results

3.1 Study population

A total of 46 farms were included in the study: four intervention, nine control and 33 contact farms. These were divided into three clusters of eight contact farms and their intervention farm and one cluster of nine contact farms with their intervention farm (figure 1).

The herd sizes of the clusters were compared at both visits and none of them varied significantly from the control group (p>0.05) (table 3).

The respondents were managers (22 %) and owners (78 %), mostly males (98 %) and over 45 years old (67 %). The majority of owners also managed the farm. All farmers but one confirmed that they were the main person making key decision about the farm system and changes in the management system, and had the power to implement an intervention. The one farmer who answered "no" kept finishing pigs for a large integrator and therefore had little control over the management of the farm.

The distributions of farm characteristics of the study population are described in table 4. The respondents were predominantly indoor farrow-to-finish farms registered to a quality assurance scheme and also had a crop enterprise. Nearly half the farms had other livestock enterprises. The farm characteristics (herd size and category) remained unchanged between both visits.

3.2 Intervention results

At the second interview, the four intervention farms were asked whether they thought the intervention trialled had worked and helped to reduce the *Salmonella* level in their pigs. None of them believed that convincing improvements were obtained. This result was based on farmers' perception. It was not possible to measure improvement on the farm using *Salmonella* prevalence results or ZNCP scores as proxies for change due to scores not being available for some farms.

Thirty out of 33 contact farmers did not know about the results of the intervention farm in their cluster when interviewed. The other three had heard that it may not have been successful. Results from the intervention farm that chose to use a vaccine in weaners were published in Pig World (Anon, 2009b) and suggested that the vaccine had a limited effect on the weaners' faecal *Salmonella* level.

3.3 Zoonoses National Control Programme(ZNCP) scores

The ZNCP sampling system took an average of four meat-juice samples in abattoirs per month for testing to determine the score (presented as a prevalence in percentage) per farm. At the second interview (2010), 39% of the farms (18) did not have a ZNCP score and these farmers were not aware of their farms' *Salmonella* status. The main reasons for not having a score were: "score not monitored", "no finishers of slaughter weight", or "abattoir not part of the ZNCP scheme". Amongst the farms that had a ZNCP score available for both interviews (27: two intervention farms, 18 contact farms and seven control farms), the overall average at each interview stage (34 % versus 31 %) and average score per type of farm remained stable over time. In both interviews, contact farms had a higher average score than the control farms (phase 1: $p_{t\text{-}test}$=0.003; phase 2: $p_{t\text{-}test}$=0.001). Control farms were significantly more likely to have a ZNCP < 10 % than contact farms in phase 2 (p_{chi^2}=0.002), but this was not the case in phase 1 (p_{chi^2}=0.063).

3.4 Intrinsic motivation of pig farmers to control Salmonella

3.4.1 Attitude towards Salmonella control

In both phases, farmers had a positive attitude towards *Salmonella* control. In phase 1, only three farmers did not think that they, or pig farmers in general, had any responsibility for *Salmonella* control in pigs; 93% of respondents had some positive attitude towards *Salmonella* control. This positive attitude was reported in 96% of the respondents in phase 2. There was no evidence of any important difference between attitude in phase 1 and phase 2 nor between the three types of farms (table 5).

> *"How do we obtain the 10% or below figure which the industry is requiring, to get our platinum reward? Now, it's a goal for us to work on but how do we get there? That's what I want to know, I am keen to get there..."*

> *"I haven't got a problem with it [Salmonella], as I've said before. I would have to be concerned if the ZNCPs started to creep up, yes - you've got to take whatever action necessary."*

Whilst farmers thought that they had the primary responsibility to control *Salmonella*, they also believed that the responsibility had to be shared by the rest of the industry to prevent reintroduction of *Salmonella* along the food chain, as summarised by this farmer's assertion:

"It should be down to the farmer; it's their responsibility. Once it's left the farm then it becomes the processors' responsibility if there is contamination at the slaughterhouse; then it becomes the butchers' responsibility. The same for the retailer and then it becomes the house holder's responsibility to make sure that it is cooked and prepared properly and there is no contamination at that level."

3.4.2 Perception of supportiveness of social norms

At the first interview (2008), farmers felt that their peers and authorities were supportive of *Salmonella* control on farms. The government, their pig company, their private veterinarian and BPEX were perceived as being very supportive of *Salmonella* control, albeit with four outliers. The farmers were more uncertain about the support from consumers and from the EU. These results were maintained at the second interview but this time the government was perceived as less supportive. Respondents' perceptions did not significantly vary between the two interviews or between the three types of farms (table 5).

3.4.3 Perception of self-efficacy

Belief in self-efficacy was measured by the perceived effect that any intervention adopted by the farmer would have on *Salmonella* and could be positive, negative or uncertain. At the first visit in 2008, 28% (13) farmers felt that their actions would have no influence on their ZNCP score while 37% (17) felt that they could induce a small reduction and 20% (9) thought their actions could induce a large reduction in the long term. On public health, 54% (25) were not convinced that implementing control measures would have any effect at all, while 30% (14) thought it may help contribute to a slight reduction in human salmonellosis . No respondent thought that *Salmonella* control in pigs would increase salmonellosis in humans.

"…my vet would repeat exactly what I've just said to you, there is very little you can do about it, you are outdoors and that's it…"

"…but the trouble is I can't control it [Salmonella], whatever they might say by and large, it is very difficult, I believe still, to control Salmonella."

At the second interview in 2010, 37% (17) of the farmers thought that implementing *Salmonella* control would not change their ZNCP score (or *Salmonella* level) both in short and long term perspective and near 20% (9) thought they could induce a small reduction. On public health, 52%

(24) thought it would not have an effect on public health while 15% (7) – a reduction from phase 1 – thought that *Salmonella* control could reduce *Salmonella* level in humans a little. The average ZNCP score for these farmers was lower than for those who did not know or did not believe in any changes. Two farmers thought that implementing control could help reducing their score substantially. About a third of the farmers gave no opinion on how their ZNCP or *Salmonella* level would vary if they were to implement *Salmonella* control on their farm.

Figure 2 shows that the distribution of belief in self-efficacy in the population in both phases was positioned between a vague positive effect and a 'no change' perception. Farmers' belief in self-efficacy moved significantly ($p_{t\text{-test}}$=0.0099) towards a less positive perception, between the two interviews, leaving farmers more uncertain of how their action towards *Salmonella* control could affect their *Salmonella* level or, to a further extent, *Salmonella* in humans. The lack of answers from twelve farmers in phase 2 may also reflect this uncertainty . The belief in self-efficacy did not vary significantly between the three types of farms (table 5).

3.5 Motivators and referents

All farmers were asked to whom they would listen or who or what would encourage them to develop an intention to implement *Salmonella* control on their farm (table 6). In both interviews and for all three types of farms, recommendations from farmers' veterinarians were the best way to stimulate to try something on their farm or deter them from doing so. A change in their ZNCP score would also trigger an action to at least consult someone about the issue. During the second phase, nearly half (41%) of the farmers also mentioned "a problem with their pigs due to *Salmonella*" as a key motivation to take action. It was mentioned that the business was about selling the pigs. Farmers would be motivated to take action on their farm if they could not sell to their direct customer (finisher farm or abattoir): *"If I can't sell my pigs, I have a problem".*

Scientific evidence that an intervention would have significant positive results to reduce *Salmonella* in pigs would attract the attention of at least a third of the farmers:

> *"…yes, if it's proved that methods, that I could put in place, could significantly reduce Salmonella and that Salmonella would not be transmitted to humans, then yes, I think as an industry we should feel responsible…".*

Farmers with a low ZNCP score (<10%) identified the ZNCP score and their veterinarian as their main motivators in both phases (data not shown). Farmers with higher ZNCP scores identified their veterinarian, a problem with their pigs, scientific evidence that a measure is effective and a variation in the ZNCP score as their main motivators. Customer demand was also mentioned as a motivator by farmers with the highest ZNCP scores (>50%).

The attitude, the belief in self-efficacy and the intent towards *Salmonella* control were compared between farmers that have no ZNCP score and the ones with a ZNCP score. Having a ZNCP score did not influence farmers' attitude towards *Salmonella* control. Also farmers with a ZNCP score had a higher intent (not significant; p=0.11) to control *Salmonella*.

3.6 Barriers to implementations

At the second interview, farmers were asked to identify the main barrier to implementing an intervention on their farm. Most of the farmers (79%) agreed that the cost or a lack of benefits, of implementing an intervention of uncertain efficacy on their premises was their greatest barrier. After being prompted, the impracticality of implementing some interventions, the lack of time or knowledge and the lack of scientific evidence were also mentioned by a few farmers as barriers:

> *"There are all sorts of things I would love to do if I had the money but most of them have to be cost benefit."*

> *"If it was relatively easy to implement and didn't take a lot of time and cost involved, and it was going to help our Salmonella scores then we would be interested in doing it."*

> *"Being somebody that is skeptical and has to see it working I would feel it necessary to actually see it working before I did anything."*

4 Discussion

Farm characteristics were similar during both phases, indicating that the farms were generally stable over the period covered by this study. There was no significant difference between the geographical clusters and farm types at both visits. Whilst differences between the farms could have affected their answers, the sample size was relatively small and may have been insufficient to detect any modest association. Enrolment to the study was opportunistic and these results cannot be extrapolated to any wider population of pig farmers.

The type of intervention differed between farms and this may have affected the success of the intervention. However, the authors do not believe that the variation in intervention used would have affected the communication results. None of the interventions were controversial.

4.1 Intervention results

The hypothesis was that the outcome of intervention trials would influence the opinion of other farmers in the region . A successful intervention would motivate farmers to implement the intervention whilst a negative or inconclusive outcome would deter adoption . It was assumed that the intervention farmers and their private veterinarians would be trusted disseminators of the outcome to other farmers and could enhance uptake of successful interventions . However, the intervention yielded inconclusive results , and there was scant evidence of the anticipated dissemination of information through the networks . Consequently, the perceptions that were observed in Phase 2 were not informed by new knowledge from these trusted sources. Instead, farmers reached their own conclusions about the impact from these interventions and this may have adversely affected their confidence in self-efficacy . Results from one intervention trial were published anonymously in Pig World (Anon, 2009b). It is possible that respondents read these results and were influenced by them.

The study provides insight into farmers' subjective beliefs relating to the causal link between information and intention. At least a third of the farmers reported that successful interventions on a farm would attract their attention, which suggests that a structured and planned communication strategy to disseminate results from effective disease control initiatives is important.

4.2 Zoonoses National Control Programme score.

It is important to note that the variation observed for each farmer's average ZNCP score between phase 1 and phase 2 may not be significant. Insufficient information was available to confirm that a lower score in phase 2 indicated a significant reduction in seroprevalence . The accuracy of the score is dependent on the sensitivity and specificity of the test, the number of batches of pigs tested and the number of samples taken per batch (Snary et al., 2010). Nevertheless, the ZNCP scores provided a crude estimate of *Salmonella* prevalence amongst those farms that supplied pigs to abattoirs that were participating in ZNCP.

Control farms were consistently and significantly more likely to have a ZNCP score below 10% than contact farms (p<0.003). Farms with a higher ZNCP (intervention and contact farms) may have been more willing to participate in an intervention trial. Furthermore, a selection bias may have arisen as control farms were chosen from geographical regions outside those covered by clusters of intervention farms and their contacts. These areas, e.g. Devon, Wiltshire, Shropshire, have lower pig populations which may be associated with a reduced risk for *Salmonella* contamination (Hotes et al., 2010; Smith et al., 2011a).

Respondents from control farms were more likely to be motivated to control Salmonella by a rise in their ZNCP score . Possibly, these farmers might be proud of their ZNCP scores and have an incentive to protect them . Farmers with a higher ZNCP score reported a lower belief in self-efficacy to influence *Salmonella* level and were less likely to seek to improve it. These farmers showed a low intention to act unless the *Salmonella* prevalence on their farms was flagged as a problem or perceived to be an enhanced risk. This reluctance to tackle a seemingly intractable problem is not an unusual human response. Indeed, *"We have a natural preference for the status quo (inertia). When faced with a difficult or complex choice, our tendency is to carry on doing what we have always done and avoid making a decision. Strategies for overcoming inertia include making the behaviour seem easier to undertake than people perceive it to be"* (COI, 2009).

It is important to emphasise that the intervention trials and the ZNCP scoring were separate endeavours, so some farmers did not have a ZNCP score and many were unaware of their *Salmonella* level. However, the study provides some evidence that access to a ZNCP score may enable farmers to monitor change despite their limited trust in the score. Provision of an indicator of the level of *Salmonella* to those farms without a ZNCP score could improve awareness of their situation.

4.3 Attitude, Perception of Social Norms, Belief in Self-Efficacy

The most important intrinsic factors for the farmers in the study were their attitudes and their belief in self-efficacy. In both phases, social norms had no observable effect on intent to take action to control *Salmonella*.

Whilst the farmers' attitude remained generally positive in both phases, there was a shift in views as to whom should bear responsibility at the second interview. In both phases, farmers believed they had some responsibilities towards *Salmonella* control in pigs , but in phase 2, more farmers believed that their pig company, consumers and the retailers should be responsible for controlling *Salmonella*. This emphasis on shared responsibility with the rest of the chain corroborates observations made in an earlier study (Bahnson et al., 2001). However, the government's role is perceived to have changed and farmers reported that they no longer considered the government mainly responsible for control.

Farmers' greater willingness to place the onus for control on the rest of the food chain in phase 2 may be related to their lack of confidence in their ability to control *Salmonella* at farm level. Farmers' belief in self-efficacy was significantly more negative at the second interview. Belief in self-efficacy has two components: it consists both of farmers' trust that measures they take on their farms can have a positive impact on their enterprise and also that whatever success they achieve will be preserved through to the end of the food chain. Farmers' shift of some responsibility onto other stakeholders in the "attitude" category discussed above reflects the second component of self-efficacy. It could indicate that farmers did not believe that if they took effective measures on their own farm *Salmonella* would not be reintroduced further along the food chain.

As to the first component of self-efficacy, it may be that respondents' expectations were influenced by the first interview, which raised their awareness of a *Salmonella* issue in pigs. Two years later, due to the apparent lack of communication between intervention farms, their private veterinarians and contact farms, actions may have appeared less successful than anticipated and this may have affected their confidence and perception of possible success at the farm level. Whilst this inference is speculative, other farmers' experiences have been found to be a valuable source of information which may influence the decision making process (Alarcon et al., 2014). Additionally, poor communication or a belief that only positive news stories are shared whilst negative results are kept quiet may hinder uptake of control measures (Alarcon et al., 2014).

Consequently, whilst farmers may value support from their peers, the key intrinsic factors that had an effect on their behaviour were their belief in self-efficacy and, in a related way, their attitude. This corroborates observations made in a survey conducted in 2007, where farmers interviewed had little faith that their actions would help reduce the level of salmonellosis in people (Van Dam et al., 2010).

4.4 Motivators

Results from the study indicate that farmers already believe that social norms would be supportive of actions to control *Salmonella* on their farms. Therefore, to boost farmers' intent to implement control measures, it is likely that it would be most effective to focus on motivators that affect their attitudes and their belief in self-efficacy.

As to farmers' attitudes, control farms were likely to be influenced by an adverse change in their ZNCP score, which would make the *Salmonella* problem more tangible to them and spur them into action. For intervention and contact farmers, complaints from direct customers or visible problems with their pigs were more likely to translate into an intention to control *Salmonella* on their farms. This showed that tangible and visual factors or those that are perceived as having an effect on the business's performance may affect farmer's attitude and may need to be taken into consideration when drafting a disease control plan. Alarcon (2014) also reported influential factors such as observation of ill pigs, reputation of the farm leading to difficulties selling pigs and pressure from abattoirs or contractors (customers) as drivers to control a disease (Alarcon et al., 2014).

As to farmers' belief in self-efficacy, the most trusted source of information regarding *Salmonella* control amongst the respondents was their private veterinarians. This has also been observed in other studies (Ellis-iversen et al., 2010; Alarcon et al., 2014; Laanen et al., 2014). Along with direct advice coming from their veterinarians, scientific evidence that an intervention can efficiently control *Salmonella* on farms—more specifically on their farm—was also mentioned by a third of the farmers as likely to boost their intrinsic motivation.

Therefore, whilst farmers agreed in principle to some responsibility, voluntary uptake of control measures in the absence of tangible problems with farmers' pig businesses or direct advice from veterinarians or other members of the scientific community would likely be poor. The most promising avenues of influence would be more systematic ZNCP scoring combined with targeted information campaigns to disseminate the most up-to-date scientific findings relating to *Salmonella* control.

Another approach may be to consider control measures that may have other benefits, such as controlling diseases with no known zoonotic potential, but that have a visible impact on pig performance (and therefore on the farmers' perception of the wellbeing of their pig businesses) as well as *Salmonella*. Recently published work (Smith et al., 2011b) has shown that ZNCP status may be associated with other health issues.

5 Conclusion

This study showed that the use of demonstration farms may not be farmers' preferred knowledge transfer tool but could still have a positive effect on farmers if they were accompanied by appropriate communication strategies to disseminate results (including, in particular, positive results). Indeed, many farmers agreed that hearing of a successful intervention on a farm would be a motivation to consider adoption of the intervention themselves .

The study also highlighted that communication was important and played a role in farmers' motivation. A successful plan to tackle *Salmonella* on farms should therefore provide scientific evidence that interventions have succeeded in reducing *Salmonella* levels, provide tangible benefit to farmers, show that the rest of the industry is also taking actions and provide general information on *Salmonella* and its risks. This information should be disseminated via private veterinarians. Farmers have a positive attitude and appreciate the industry's support but more action is needed to make them believe that their own actions are worthwhile and have an effect on human health.

This study suggests that farmers are unlikely to adopt control measures voluntarily, which may render the compliance with any target in reducing *Salmonella* in pigs challenging for the UK.

As the aim in controlling *Salmonella* in pigs isubmit to protect public health, it may be beneficial to use a whole farm-to-fork approach including better education for consumers, which may improve pig farmers' motivation to take some actions if they trust they are not the only ones putting efforts into *Salmonella* control. Equally, it would be constructive to look into practices adopted by farms that sustained a very low prevalence of *Salmonella* over many years.

The ZNCP for *Salmonella* in pigs was to prepare the industry for the proposed EU legislation on reducing *Salmonella* in pig meat. The ZNCP suspended its meat juice testing on 1 July 2012 to introduce an on-farm *Salmonella*-risk assessment tool. The proposed legislation has not materialised but work on *Salmonella* control continues.

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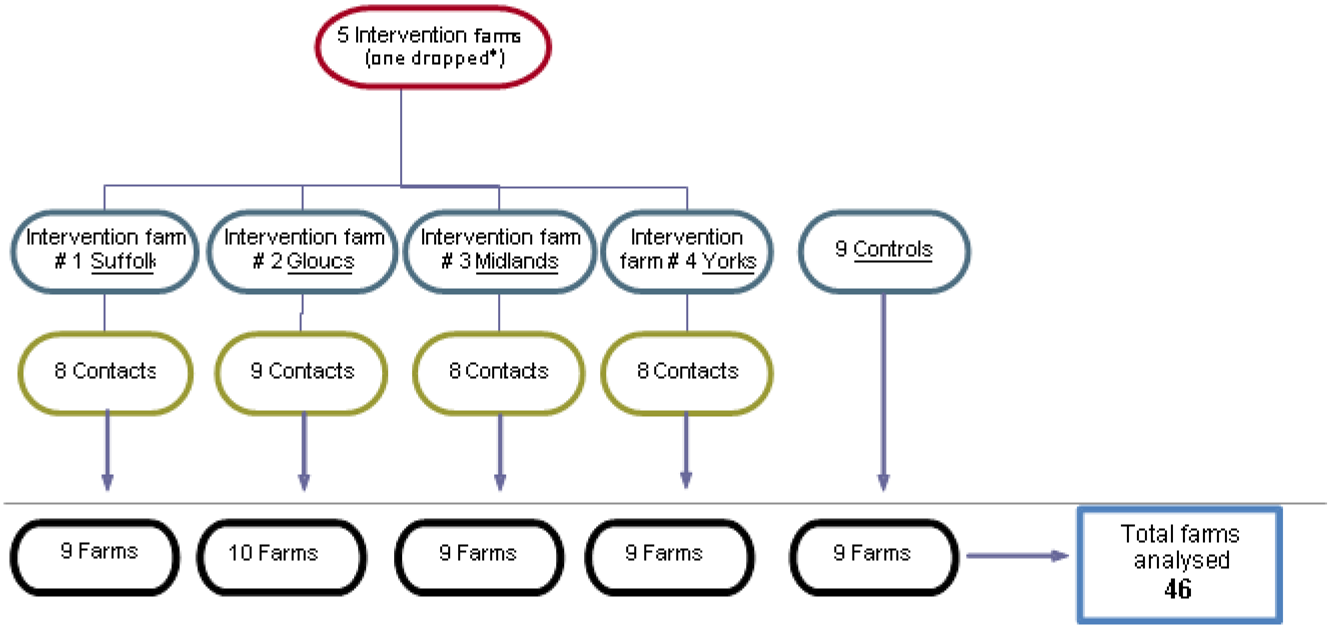
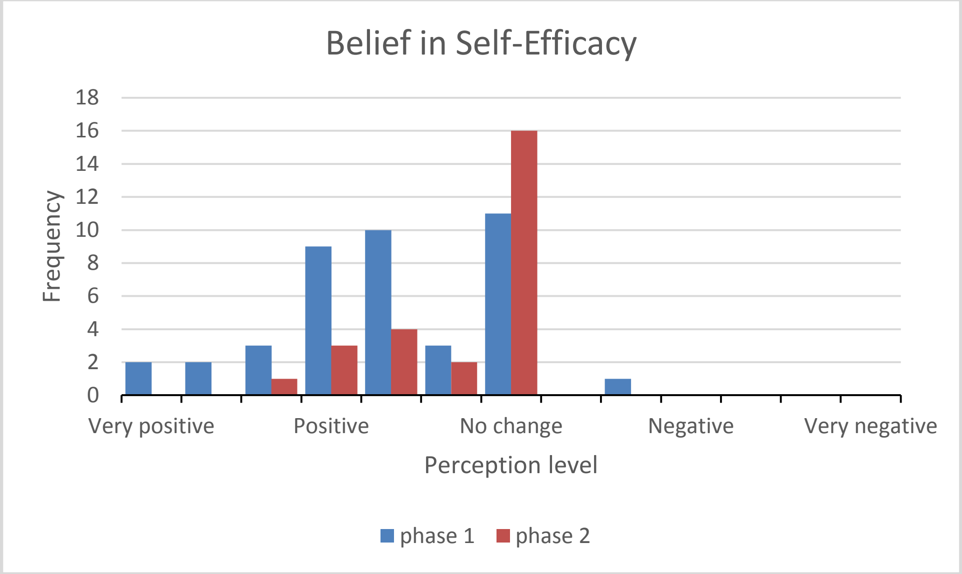


Figure 1: The number of farms per cluster and total number analysed.

*the farm dropped as an intervention farm was included as a close contact for intervention farm #3.



Phase 1: n=41; incomplete set of answers=5
Phase 2: n=27; incomplete set of answers=7; No answer =12

Figure . 2 Distribution of how positive or negative the farmers' belief in self-efficacy was in phase 1 and phase 2. Frequency of the sums of the score was used.

Table 1: Description of the interventions, farmers' perceived results of the interventions and ZNCP* score.

N	Intervention	Farmer's observation	Has it worked?	ZNCP score
1	Bio-Mos added to the feed	No change observed. Farmer didn't hear about any change in ZNCP score.	Unsure	Not monitored
2	Change pellets to meal feed	Pigs didn't grow as well. Farmer didn't see any change in ZNCP score.	"It didn't work at all"	Small Reduction (58% to 55%)
3	Live-attenuated *S.* Typhimurium vaccine for sows	No change observed and no changes in his ZNCP score.	Unsure	No change (17% to 17%)
4	Live *Salmonella* vaccine for weaners	Farmer believes that the intervention led to a small reduction in *Salmonella*. ZNCP score not monitored.	Unsure	Not monitored (60% to NK)

*Zoonosis National Control Programme

Table 2. List of questions asked to farmers to evaluate each of the three intrinsic factors and the score range using a structured questionnaire.

	Attitudes	Social Norms	Belief in Self-Efficacy
Questions	Control of *Salmonella* is: a. important for me b. important for public health c. important for pig industry d. needed in pigs	How would the following feel about you applying intervention: a. Defra[1] b. Your vet c. Your company d. BPEX[2] e. Consumers f. The European Union g. Your assurance scheme (phase 2)	Because of the intervention, the ZNCP score showed: a. in the next few batches b. in the next years c. in the human population
Score	1= Strongly agree 2= Agree 3= Undecided 4= Disagree 5= Strongly disagree	1= They would like that 2= They would most likely to approve 3= They will not care either way 4= They would most likely to approve 5= They will disapprove	1= large reduction 2= small reduction 3= no difference 4= small increase 5= large increase
Sum score (and all scores in between)	4= very positive 8= positive 12= undecided 16= negative 20= very negative	7= very supportive 14= supportive 21= indifferent 28= unsupportive 35= very unsupportive	3= very positive 6= positive 9= no change 12= negative 15= very negative

1. Defra: Department for Environment, Food and Rural Affairs (UK)

2. BPEX: British Pig Executive (now called AHDB pork – Agriculture and Horticulture Development Board)

Table 3. Comparison of the herd sizes of growing/finishing pigs between each of the three types of farms—intervention farm, control farm, contact farm—and between clusters—Gloucester, Midlands, Suffolk, Yorkshire (UK counties).

Types of farms	number of farms	Smallest herd size	Median herd size	Average herd size	Largest herd size	p- value for heterogeneity (Regression)
Control	9	9	1400	2000	5400	Baseline
Intervention	4	3235	3672	3740	4380	0.294
Contact	33	200	3000	3207	14500	0.246
Clusters						
Gloucester	10	200	2200	2543	6200	0.670
Midlands	9	240	2400	3116	11500	0.395
Suffolk	9	550	3000	3965	14500	0.137
Yorkshire	9	2200	3600	3516	4500	0.249
all farms	**46**	**9**	**3000**	**3017**	**14500**	

Table 4. Characteristics of the farms recruited for the study. (Mutually exclusive results except for "Other enterprises" where a farm can have more than one type of enterprise).

Farm Characteristics	Details	Number of farms	% of farms in study population (n=46)
Main production	Specialist finishers[1]	10	21.7
	Farrow to finish	30	65.2
	Farrow to grower	1	2.2
	Farrow to weaner	5	10.9
Finishers housed outdoors	All/ some	6	13.0
	Never	35	76.1
	No finishers[2]	5	10.9
Certification	Quality assured (QA) only	30	65.2
	QA + Other certification	14	30.4
	None	2	4.3
Other enterprises	None	7	15.2
	Crops	30	65.2
	Livestock	21	45.7
	Public access[3]	10	21.7

1- "Specialist finishers" includes: farms keeping weaners to finish; weaners to growers; growers to finish

2- "No finishers" includes: farm where pigs were weaned at 4 weeks old (+/- 2 weeks) and sent away to be finished.

3- "Public access" includes farms that offer access to their premise such as school visits, farm shop, Bed & Breakfast.

Table 5. Difference between the mean response of farmers between phase 1 and phase 2 and difference between the median response of control farms versus intervention farms and contact farms at phase 1 and phase 2.

	Difference between	
	Phase 1 and phase 2	*Control versus Intervention and contact farms*
Attitude	No significant difference ($p_{t\text{-}test}$=0.151)	No significant difference phase 1 (p_{kw*}=0.740) phase 2 (p_{kw}=0.299)
Social Norms	No significant difference ($p_{t\text{-}test}$=0.981)	No significant difference phase 1 (p_{kw}=0.446) phase 2 (p_{kw}=0.917)
Belief in Self-Efficacy	Significant difference ($p_{t\text{-}test}$=0.001)	No significant difference phase 1 (p_{kw}=0.489) phase 2 (p_{kw}=0.177)

*P value from Kruskal-Wallis test.

Table 6. Motivators that would influence farmers to form an intention to implement control on their farms. Control farms compared to contact and intervention farms for phase 1 and phase 2. (Multiple answers possible)

	Phase 1		Phase 2	
	Control farms (n=9)	**Number of contact + intervention farms (n=37)**	**Control farms (n=9)**	**Number of contact + intervention farms (n=37)**
Private veterinarian	5 (55%)	20 (54%)	6 (67%)	18 (49%)
Increase in ZNCP score	8 (89%)	15 (41%)	5 (56%)	11 (30%)
Direct customers	2 (22%)	16 (43%)	3 (33%)	11 (30%)
Scientific evidence	2 (22%)	13 (35%)	1 (11%)	13 (35%)
Government	4 (44%)	3 (8%)	0	3 (8%)
Financial penalties or rewards	1 (11%)	7 (19%)	0	9 (24%)
Demand from consumers	0	7 (19%)	1 (11%)	1 (3%)
Their pig company	0	4 (11%)	1 (11%)	1 (3%)
Other farmers	0	4 (11%)	2 (22%)	2 (5%)
Quality assurance scheme	0	4 (11%)	0	1 (3%)
BPEX/levy body	0	4 (11%)	1 (11%)	1 (3%)
Own experience	0	2 (5%)	0	2 (5%)
Problems with pigs			1 (11%)	18 (49%)