Paper

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Proactive dairy cattle disease control in the UK: veterinary surgeons' involvement and associated characteristics

H. M. Higgins, J. N. Huxley, W. Wapenaar, M. J. Green

Characteristics of 94 veterinary surgeons associated with delivering preventive herd-level strategies to control mastitis, lameness and Johne's disease were investigated using two multinomial models. The response variables were 'Gold Standard Monitoring' (including on-going data analysis, risk assessments and laboratory testing), and a lower level of involvement called 'Regular Control Advice'. Although the sample was biased towards those who spend the majority of their time with dairy cows, 69 per cent currently had no involvement in Gold Standard Monitoring for lameness, 60 per cent no involvement with Johne's, and 52 per cent no involvement with mastitis. The final model predicted that an assistant without a postgraduate cattle qualification, who had spent no time on dairy cattle continuous professional development (CPD) in the last year, had an 88 per cent chance of having no involvement with Gold Standard Monitoring for any disease, versus <5 per cent chance for a CPD 'enriched' partner with a postgraduate cattle qualification; there was <1 per cent chance this assistant would be involved with Gold Standard Monitoring of all three diseases on one or more farms, versus a 58 per cent chance for this partner. CPD and employment status were also associated with markedly different probabilities for delivering Regular Control Advice. Increased postgraduate education may further veterinary involvement of this nature.

Introduction

Taking a proactive approach to reduce and control endemic diseases on dairy farms is important to improve animal health and welfare, and for sustainable food production, both environmentally and economically. Veterinary surgeons are ideally placed to help dairy farmers prevent and control endemic diseases. This study focused on what could be termed 'preventive herd-level veterinary involvement throughout the year'.

There is a lack of current literature reporting this type of veterinary input in the UK, despite the fact that this information is likely to be of interest to many stakeholders, including farmers, government, consumers and retailers. Some insight may be gained from the work of Bell and others (2006) who reported that 87 per cent (53/61) of dairy farms in the UK had 'some form of written herd health plan', 68 per cent of which had been 'prepared with direct veterinary involvement'. However, they also reported that '48 per cent of farmers stated that their plan was no longer an active document, 48 per cent did not consider the plan was of any benefit, and 18 per cent considered that the plan did not have to reflect what was happening on the farm'.

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H. M. Higgins, BSc, BVSc, CertCHP, MSc, PhD, MRCVS
J. N. Huxley, BVetMed, DCHP, DipECBHM, PhD, MRCVS
W. Wapenaar, DVM, Dip ABVP-Dairy, PhD, MRCVS
M. J. Green, BVSc, DCHP, DipECBHM, PhD, MRCVS
University of Nottingham, School of Veterinary Medicine and Science, Sutton Bonington Campus, Loughborough, Leicestershire LE12 5RD, UK

E-mail for correspondence: helen.higgins@nottingham.ac.uk or aitch.higgins@btinternet.com

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Furthermore, the authors can find no data that reports how the existence or use of a written farm health plan by farmers correlates to preventive herd-level veterinary involvement throughout the year.

The first aim of this study, therefore, was to capture the current proactive involvement of veterinary surgeons with the herd-level control of three key endemic diseases of dairy cattle: mastitis, lameness and Johne's disease. Without data on the current position, it is difficult to have an appreciation for future involvement by the profession. The second aim was to investigate characteristics of veterinary surgeons associated with preventive and sustained veterinary input.

Methods

Identification and recruitment of veterinary surgeons

Veterinary surgeons who provided healthcare to dairy cattle in England during their normal working hours, and were employed by a veterinary practice that contained at least one veterinary surgeon possessing a 'post-graduate cattle qualification' (ie, the Royal College of Veterinary Surgeons (RCVS) Certificate or Diploma in Cattle Health and Production, the University of Liverpool Diploma in Bovine Reproduction or the European College of Bovine Health Management Diploma), were eligible for selection.

A two-stage cluster design stratified by geographic location was used. First, 20 practices were selected with probability proportional to the number of veterinary surgeons they contained. Subsequently, if the practice had greater than five eligible members, then five were selected using the random number generator function in the software program R V.2.15.2 (R Core Team 2012). All veterinary surgeons were recruited in practices that contained five or less members. With this sampling strategy, every individual had approximately the same probability of being selected irrespective of the size of the practice they worked in (Kalton 1987). The online database (http://www.rcvs.org.uk/)

supplied by the RCVS provided a sampling frame of practices. The first author conducted individual face-to-face interviews between June 8 and September 1, 2011, and used a standard script (available on request) to capture characteristics of the veterinary surgeons and their current involvement in dairy herd health. The interview questions concerning the veterinary surgeons' characteristics are summarised in Table 1. For each of mastitis, lameness and Johne's disease, veterinary surgeons were asked for the number of farms for which they currently had preventive herd-level veterinary involvement throughout the year, at two different levels. The definitions of these two levels, as described to participants, are summarised in the next section.

Definitions of veterinary involvement

The first level of input is subsequently referred to as 'Gold Standard Monitoring', and for all three diseases this was taken to mean the following. An initial assessment of any currently available farm data in conjunction with a farm walk to assess the risks in order to achieve a working diagnosis; for mastitis and Johne's disease, this was additionally taken to include some strategic laboratory testing, and for lameness, some mobility scoring. As a result, a list of farm-specific recommendations are made, based on current best evidence where possible, prioritised and discussed with the farmer. During (at least) quarterly farm revisits, the farm data and risks are reassessed, allowing the control measures to be reviewed and modified in a timely manner in consultation with the farmer, and support to implement the control measures provided. The second level of input is subsequently referred to as 'Regular Control Advice', and was defined as veterinary advice and discussion relating to the prevention and control of disease at a herd level, at least three times per year, but not to the level of Gold Standard Monitoring.

It was stipulated that for both levels of input, involvement related to what the veterinary surgeons themselves were currently doing, and if they were involved at either level in conjunction with a colleague, this counted; thus, they did not have to be the primary or sole provider of the service. The two levels of input were distinct, that is, providing Gold Standard Monitoring for mastitis did not also count as giving Regular Control Advice for mastitis; although on the same farm, a veterinary surgeon could have been involved with Gold Standard Monitoring for one disease and Regular Control Advice for another. Veterinary input that solely revolved around the treatment or culling of diseased animals, one-off investigations into a disease outbreak, or reactive advice (ie, short-term input triggered by an emergency), were not considered.

Data analysis

Veterinary surgeon characteristics were used as covariates in two ordered multinomial models, specifically, cumulative logit models with a proportional odds assumption. The two response variables were Gold Standard Monitoring and Regular Control Advice. Each response variable had four categories: (a): 'no involvement', (b) 'one out of three diseases', (c) 'two out of three diseases', (d) 'all three diseases', where the numbers relate to involvement with mastitis, lameness and Johne's disease control on one or more farms. Thus, for the purpose of data analysis, for each response variable, the number of farms the veterinary surgeon reported their involvement for the three diseases was combined and collapsed to produce the data for the four categories (a–d). For example, for Gold Standard Monitoring, a veterinary surgeon falling in the category 'one out of three' would have been currently involved in delivering Gold Standard Monitoring on at least one farm for one disease, which could have been either mastitis, lameness or Johne's disease. In terms of order, the response category 'no involvement' is subsequently referred to as being the 'lowest', and 'all three diseases' as the 'highest' category. The reference category used for both models was 'all three diseases'.

The two models were fitted in a Bayesian framework, primarily because this is recognised to provide less biased estimates compared with alternative frequentist approaches (Rodriguez and Goldman 2001). MLwiN software V.2.26 (Rasbash and others 2009) was used to implememt Markov Chain Monte Carlo (MCMC) stochastic simulation for parameter estimation with flat (ie, 'vague') priors (Browne 2012). Starting values for parameters were based on frequentist estimations using marginal quasi-likelihood and iterative generalised least squares. Chains were run for a generous 100,000 iterations with a conservative burn-in length of 5000, which was sufficient in all instances to meet the Raftery-Lewis diagnostic (Raftery and Lewis 1992) for estimating the 0.025 and 0.975 quantiles to an accuracy of 0.05 with a 0.95 probability. Chains were inspected visually for convergence to the joint posterior distribution; the Brooks-Gelman-Rubin multiple-chain diagnostic (Brooks and Gelman 1998) was also used to check convergence by exporting models from MLwiN to WinBUGS software, V.1.4.3 (Lunn and others 2000). Parameters were summarised by their posterior mean and 95 per cent credible intervals, calculated from the 0.025 and 0.975 quantiles of their posterior distribution.

Univariate analysis was conducted, and covariates with regression coefficients whose posterior 95 per cent credible intervals excluding zero are reported. Covariates that achieved 90 per cent credible intervals excluding zero were carried forward for model building. The Deviance Information Criterion, (Spiegelhalter and others 2002), is a Bayesian generalisation of Akaike's Information Criterion that measures both the 'fit' and 'complexity' of a model, and was used to find a parsimonious solution; covariates were retained in the final model when their inclusion reduced the Deviance Information Criterion by more than three (Spiegelhalter and others 2002) and their posterior 95 per cent credible intervals excluded zero, having adjusted for the other covariates. Since veterinary surgeons were clustered within practices, veterinary practice was included in all analyses as a normally distributed random effect, with a common effect for each response category. However, exclusion made negligible difference to the inferences that were drawn. All figures were produced using the software program R.

The exponentiated regression coefficients of an ordered multinomial model can be interpreted as odds ratios (ORs) (Steele 2011a); for example, for a binary covariate X (eg, X=1 for males X=0 for females), the OR is calculated by working out the odds of being in a specified response category or lower (rather than a higher category) for an individual with X=1, and then dividing this by the corresponding odds but for an individual with X=0. An OR equal to 1 implies that there is no difference between individuals with X=1 compared to those with X=0, with respect to the response variable. The proportional odds assumption means that when calculating the odds it does not matter which response category (a, b, c or d) is specified, because the OR is assumed to be the same regardless of this choice. In other words, any difference that exists between X=1 and X=0 individuals, is assumed to be the same for all the response categories. The validity of this assumption was checked using Wald tests in a frequentist setting, and the Deviance Information Criterion in a Bayesian setting (Steele 2011b).

TABLE 1: Characteristics of veterinary surgeons (n=94)

Characteristic	Category (%)
Gender	Male: 59 (63); female: 35 (37)
Employment hours	Full-time: 88 (94); part-time: 6 (6)
Job status*	Partner: 36 (38); assistant: 58 (62)
Years qualified	0–≤3 years: 22 (23)
	4–≤7 years: 26 (28)
	8–≤15 years: 21 (22)
	15+years: 25 (27)
% Current time dealing with dairy cattle	0–<25: 6 (6)
	25–<50: 16 (17)
	50–<75: 27 (29)
	75–100: 45 (48)
Days spent on dairy cattle continuing professional development (CPD) in the last year	0 days: 11 (12)
	1–3 days: 26 (27)
	3–5 days: 19 (20)
	5–10 days: 27 (29)
	>10 days: 11 (12)
Postgraduate cattle qualification	Yes: 19 (20); no: 75 (80)
Other postgraduate qualification	Yes: 10 (11); no: 84 (89)
Total number of veterinary journals read regularly	0 journals: 9 (10)
	1 or 2 journals: 36 (38)
	3 or 4 journals: 41 (44)
	5 or 6 journals: 8 (8)

*'Partner' included principals and directors, 'assistant' included locums

Results

Veterinary practice response rate was 95 per cent (19/20) because not all the veterinary surgeons in one practice agreed to participate; another practice was selected from the same region and consented. Of the 96 selected veterinary surgeons from the consenting practices, all were interviewed except two who were unavailable during the data collection period. Of the 20 practices, seven were located in the north, two in the Midlands, and 11 in the south of England. Descriptive statistics for the veterinary surgeons' characteristics are provided in Table 1. The 'total number of journals read' was tallied from an open question that asked: 'Which, if any, veterinary journals or articles do you read regularly?' (Fig 1).

Fig 2 presents the number of farms that veterinary surgeons were currently actively involved with Gold Standard Monitoring and Regular Control Advice. It reveals that for both levels of veterinary input, and for each disease, the modal (ie, most popular) answer was zero farms.

The distributions of veterinary surgeons by the response categories Gold Standard Monitoring and Regular Control Advice are shown in the margins of the cross-tabulation between these two categorical variables in Table 2. Table 2 reveals that 13 (13.8 per cent) of veterinary surgeons currently had no involvement of any kind (regular or gold standard) for any disease, on any farm.

The ordered multinomial univariable analysis for Gold Standard Monitoring is presented in Fig 3, and Regular Control Advice in Fig 4; the same seven covariates were associated with both response variables.

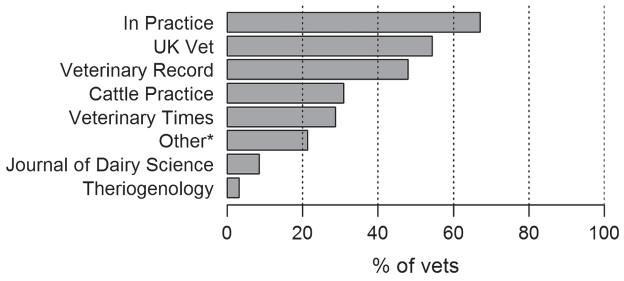

FIG 1: The veterinary articles or journals self-reportedly 'read regularly' by veterinary surgeons working with dairy cattle (n=94). *Other covers a wide variety of journals, each was read by two or fewer veterinary surgeons

The final models produced by the multivariable analysis for Gold Standard Monitoring and Regular Control Advice are reported in Table 3, and can be interpreted as follows. Using the Gold Standard Monitoring model and the covariate 'job status' as an example, then having adjusted for the effects of both undertaking dairy cattle-specific continuous professional development (CPD) and possession of a postgraduate cattle qualification, there was a statistically significant difference between assistant and partners with respect to their involvement in Gold Standard Monitoring. The odds of a partner being in a given response category or lower (rather than higher categories) was 0.21 times the odds of an assistant; in other words, partners were more likely to be involved with Gold Standard Monitoring of one or more diseases, on at least one farm, compared with assistants. Similarly, having adjusted for the effects of job status and postgraduate cattle qualification, there was a general trend for increasing days spent on dairy cattle CPD to be associated with increased involvement with the Gold Standard Monitoring of one or more diseases.

The bar graphs in Figs 5 and 6 show how the ORs in Table 3 translate into the more easily interpretable predicted probabilities for Gold Standard Monitoring and Regular Control Advice, respectively. These can be interpreted as follows: for the Gold Standard Monitoring model, a veterinary assistant who has not undertaken any dairy cattle-specific CPD in the last year, and who does not possess a postgraduate cattle qualification, is predicted to have an 88 per cent chance (0.88 probability) of not being involved with the Gold Standard Monitoring of any of the three diseases (row 1, black shading, Fig 5). By contrast, a CPD 'enriched' partner with a postgraduate cattle qualification is predicted to have less than a 5 per cent chance of having no involvement (black shading, row 8, Fig 5). Similarly, for involvement with all three diseases on one or more farms, there was less than a 1 per cent chance for this assistant, versus a 58 per cent chance for this partner (white shading, rows 1 and 8, Fig 5). Thus, our results predict that these three characteristics combined are associated with greatly different chances of veterinary involvement in Gold Standard Monitoring. Similarly, our results predicted that cattle-specific CPD and job status are associated with markedly different probabilities for delivering Regular Control Advice (Fig 6).

Discussion

While it is important to emphasise that the ordered multinomial analysis only describes associations between covariates and the response variable, it is worthwhile speculating on potential underlying reasons for the observed associations. In the univariate analysis, gender was associated with both levels of veterinary input. However,

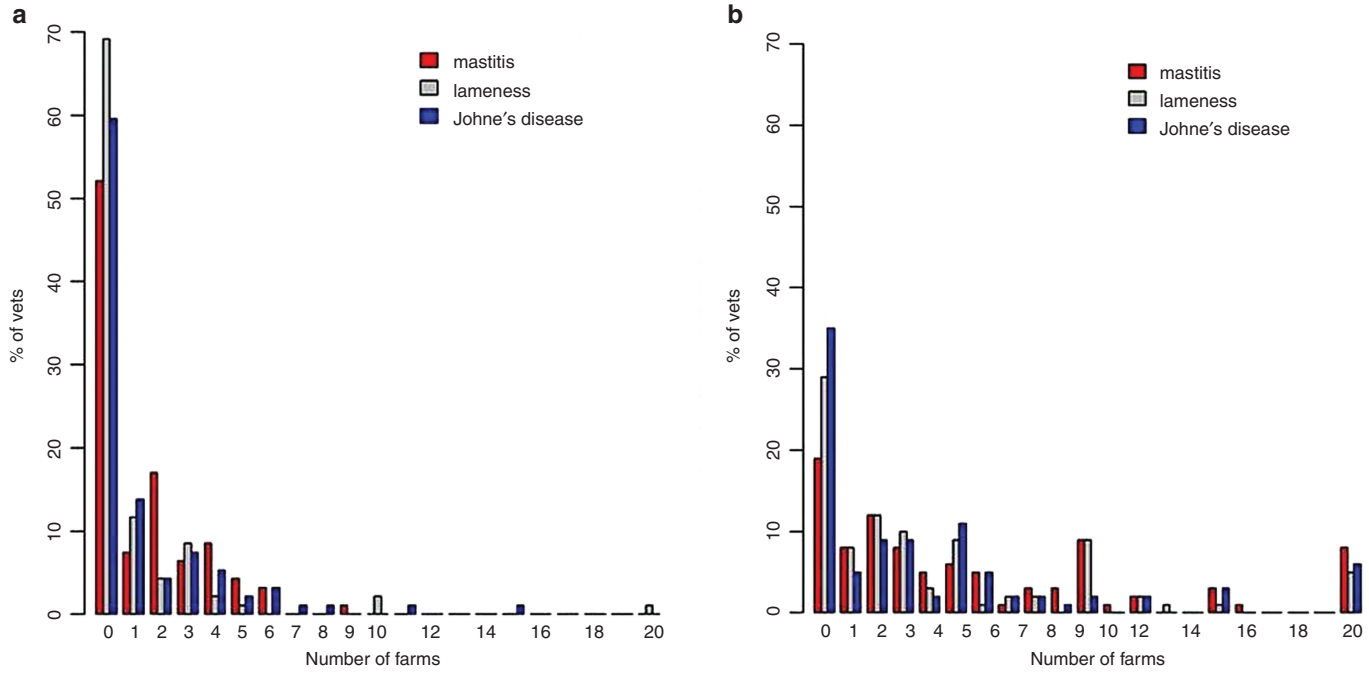

FIG 2: The number of farms veterinary surgeons are currently involved with (a) Gold Standard Monitoring, and (b) Regular Control Advice (n=94)

TABLE 2: Cross-tabulation of the number of veterinary surgeons involved with Gold Standard Monitoring by Regular Control Advice

	Gold standard monitoring				
	No involvement (%)	One of three diseases (%)	Two of three diseases (%)	All three diseases (%)	Row totals (%)
Regular Control Advice					
No involvement	13 (13.8)	1 (1.1)	0 (0.0)	0 (0.0)	14 (14.9)
One of three diseases	3 (3.2)	4 (4.3)	0 (0.0)	0 (0.0)	7 (7.4)
Two of three diseases	11 (11.7)	8 (8.5)	6 (6.4)	2 (2.1)	27 (28.7)
All three diseases	8 (8.5)	10 (10.6)	13 (13.8)	15 (16.0)	46 (48.9)
Column totals (%)	35 (37.2)	23 (24.5)	19 (20.2)	17 (18.1)	94 (100)

%s Refer to the grand total (94)

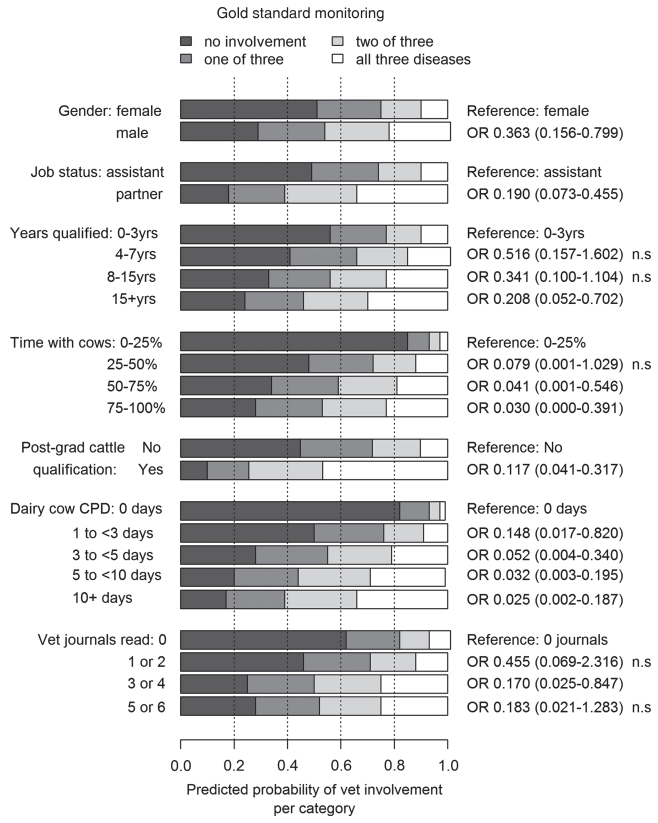

FIG 3: Univariable ordered multinomial results for Gold Standard Monitoring. OR=posterior mean OR with 95 per cent posterior credible interval in brackets; n.s=not significantly different to the reference level. 'Dairy cow CPD'=continuous professional development, i.e., training events, specifically devoted to dairy cattle, in the last year

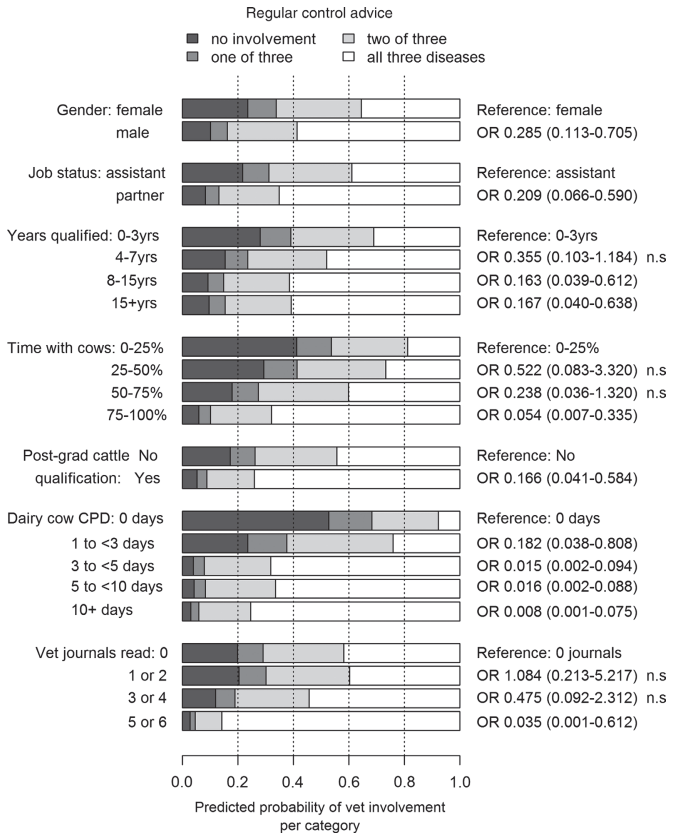

FIG 4: Univariable ordered multinomial results for Regular Control Advice. OR=posterior mean OR with 95 per cent credible interval in brackets; n.s=not significantly different to the reference level. CPD=continuous professional development in the last year

TABLE 3: Final multivariable ordered multinomial results describing the characteristics of veterinary surgeons associated with providing Gold Standard Monitoring and Regular Control Advice on dairy farms in the UK

Gold Standard Monitoring				Regular Control Advice			
Covariate	Category	OR	95% credible interval	Covariate	Category	OR	95% credible interval
Job status	Assistant	Reference		Job status	Assistant	Reference	
	Partner	0.208	0.066–0.590		Partner	0.145	0.039–0.472
CPD* (days)	0	Reference		CPD* (days)	0	Reference	
	1–≤3	0.134	0.013–0.850		1–≤3	0.122	0.022–0.593
	3–≤5	0.067	0.005–0.557		3–≤5	0.008	0.001–0.063
	5–≤10	0.022	0.002–0.156		5–≤10	0.009	0.001–0.056
	>10	0.044	0.003–0.395		>10	0.006	0.000–0.060
Postgraduate cattle qualification	No	Reference		–	–	–	–
	Yes	0.214	0.031–0.722	–	–	–	–

*Dairy cattle-specific continuing professional development within the last year

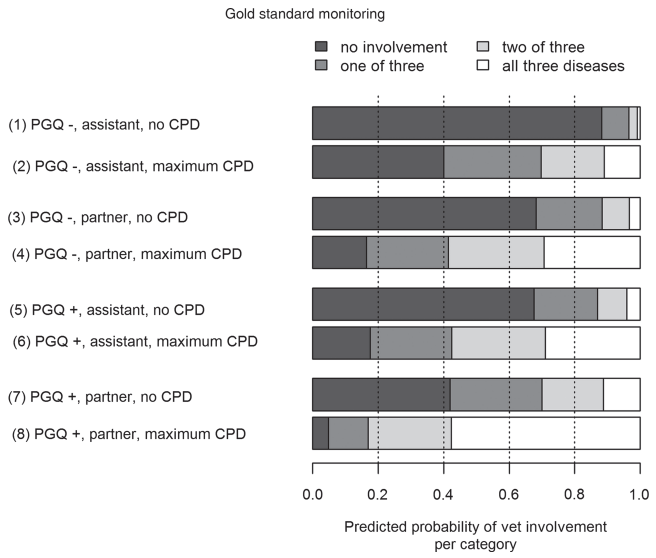

FIG 5: Predicted probabilities for involvement with Gold Standard Monitoring for veterinary surgeons with different combinations of characteristics (1–8). 'PGQ' denotes those with (+) and those without (–) a postgraduate cattle qualification, 'maximum CPD' is >10 days of dairy cattle specific continuous professional development within the last year, and 'assistant/partner' relates to job role in the veterinary practice

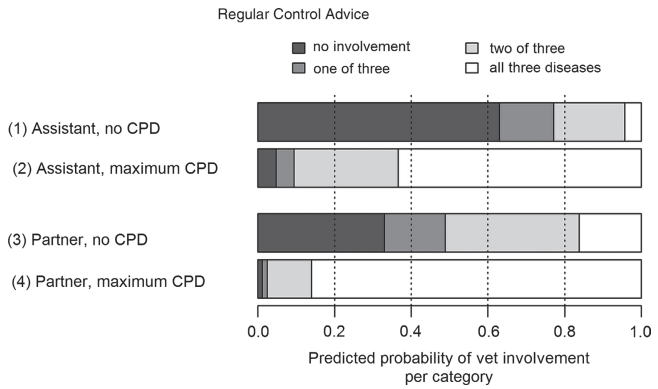

FIG 6: Predicted probabilities for involvement with Regular Control Advice for veterinary surgeons with different combinations of characteristics (1–4). 'Maximum CPD' is >10 days of dairy cattle specific continuous professional development within the last year, and 'assistant/partner' relates to job role in the veterinary practice

gender was strongly associated with employment status (women were much more likely to be assistants), and gender did not feature in either of the final models, that is, having adjusted for employment status, there was no longer any difference between males and females. There is no obvious reason why gender should be associated with proactive veterinary involvement. However, compared with assistants, partners have made a more concrete commitment to the veterinary practice, and there are several possible reasons why this may be associated with increased veterinary involvement, even when once adjustments have been made for postgraduate qualifications and CPD. For example, partners may have worked at the practice for longer, know the clients better, have a more vested interest in keeping clients, or be in a position to preferentially allocate this type of work to themselves.

Interestingly, cattle-specific postgraduate qualifications featured in the final model for Gold Standard Monitoring, but not Regular Control Advice. A plausible explanation for this association is that those veterinary surgeons who have invested the time in obtaining further qualifications seek out this type of more intensive involvement, and/or they are better at persuading and maintaining farmers' participation in it. Moreover, this finding lends weight to the view that initiating and sustaining Gold Standard Monitoring on dairy farmers is particularly challenging and requires a high level of technical knowledge and clinical skills.

There are two key implications of these findings. First, there appears to be considerable scope for further veterinary involvement of this nature, particularly with respect to Gold Standard Monitoring; this dataset was biased towards those who spend most of their time working with dairy cattle, yet 69 per cent of the veterinary surgeons interviewed had no involvement in the Gold Standard Monitoring of lameness, and the equivalent figures for Johne's disease and mastitis were 60 per cent and 52 per cent, respectively (Fig 2). There is also some evidence to suggest that, historically at least, this has also been the case in other countries (Giger and others 1994). While challenging, a proactive approach is, in the authors' opinion, highly rewarding, and there is evidence to suggest that it can be cost-effective, improve animal health and welfare, and facilitates sustainable food production (Hogeveen and others 1992, Green and others 2007). Of course, not every dairy farmer may see the need (Derks and others 2012), or actually need, on-going pre-emptive veterinary input. Furthermore, some farmers may not be able, or be prepared, to pay for it. In the case of Gold Standard Monitoring, there is also a requirement for the farmer to record disease and mobility scoring data, and pay for laboratory testing. However, given the current high prevalence of these endemic diseases in the UK, it seems reasonable to suggest that on many dairy farms, sustained veterinary involvement to help farmers prevent and control disease is desirable and important, especially in the face of a 'perfect storm', and nine billion people to feed (Godfray and others 2010). Future research could build on existing work (Lievaart and others 1999, Hall and Wapenaar 2012), to obtain an in-depth understanding from the perspective of veterinary surgeons, the reasons, motivations and obstacles for this type of veterinary service.

The second implication is that furthering proactive and on-going veterinary involvement in dairy cattle endemic disease control is likely to be related to facilitating and promoting postgraduate education, both formal postgraduate qualifications and CPD. This may be particularly important for those veterinary surgeons who have other characteristics that are associated with less involvement, such as those who spend less of their time working with dairy cattle, or who do not have the employment status of a partner. However, it should be noted that the acquisition of further knowledge per se is not necessarily sufficient to successfully implement and sustain this type of veterinary involvement on farms. Our results also bring to the fore the question of veterinary tracking and specialisation at any early career stage. While in many respects desirable, an important question is whether the veterinary profession and farming community can continue to afford omni-competent veterinary surgeons at graduation.

Limitations of this study include the fact that the results are based on veterinary surgeons self-reports of their involvement. Thus, although we defined the two types of input in detail, and provided clarification if required during the face-to-face interviews, it is still possible that some veterinary surgeons may have misreported their involvement, either due to misinterpretation of the definitions, memory recall, or a desire to appear more involved than they actually were–interestingly several veterinary surgeons commented on the fact that they wished they had more veterinary involvement of the type described. Furthermore, although the sample size was relatively small, veterinary surgeons were spread over a large geographical area, thereby mitigating bias relating to a specific locality. Additionally, it should be noted that there may be other types of characteristics and perceptions that we did not capture in this study that are associated with the type of veterinary involvement described, for example, personality traits.

In terms of data analysis, the category of involvement 'all three diseases' was the highest, and hence the assumption was that this is better than involvement with 'two out of the three diseases', and so forth. Preventive strategies aimed primarily at controlling one of the endemic diseases will almost invariably have implications for, and overlap with, strategies aimed at controlling the other two; thus, it would seem desirable that veterinary surgeons are holistically involved when necessary. Additionally, the data was analysed based on whether a veterinary surgeon had involvement on one or more farms, rather than using the actual number of farms, for two reasons. First, if a veterinary surgeon is delivering proactive herd-level

disease control on one farm, it seems reasonable to assume that if the opportunity arose they could do so on more farms; hence, a key point is involvement or not. Secondly, there are many possible reasons why a veterinary surgeon may be involved on only a few farms, rather than many, that do not pertain directly to characteristics of the veterinary surgeon, for example, their practice may have a charging structure that discourages farmers from taking up this type of veterinary involvement, or the practice may have a high ratio of veterinary surgeons to farming clients compared with another practice, and so forth. Capturing this type of information was beyond the scope of this study, but could be explored in future work.

While it was also beyond the practical and logistical remit of this study, it would be very useful to have data on proactive veterinary involvement at a farm level in absolute terms. Currently, DEFRA conducts an annual farm practices survey, and has historically gathered information pertaining to written herd health plans (DEFRA 2012). However, as commented previously, we can find no data that reports how the existence or use of a written plan correlates to proactive veterinary involvement throughout the calendar year. We suggest that during the next farm practices survey, DEFRA could gather farm-level information relating to our two definitions of proactive and on-going veterinary involvement.

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