TITLE: Implementing biosecurity measures on dairy farms in Ireland

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A survey investigating implementation of, and opinions towards, biosecurity measures on commercial Irish dairy farms.

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Abstract

Irish dairy farmers are expanding in preparation for a new era of unrestricted milk production with the elimination of EU milk quotas in 2015. Countries experiencing a changing agricultural demographic, including farm expansion, can benefit from documenting the implementation of on-farm biosecurity. The objectives of this study were to document and describe influences on biosecurity practices and related opinions on commercial Irish dairy farms.

A telesurvey was carried out, a response rate of 64% was achieved, and participants were shown to represent the national population. A 20% discrepancy was recorded between self-declared closed herds and those actually closed based on official records, indicating a lack of understanding of the closed herd concept. Over 72% of farmers surveyed considered biosecurity important, but 53% stated that a lack of information might prevent them from improving biosecurity. Logistic regression highlighted regional, age, and farm-size related differences in biosecurity practices and opinions. Regional differences existed with regard to implementation of certain biosecurity practices with the most dairy cattle dense region three times more likely than the least dense region to always quarantine purchased stock (P=0.012) . Younger farmers, in general, were over twice as likely than middle-aged farmers to have intent to implement biosecurity guidelines (P=0.026). Large Irish dairy farmers were almost five times more likely to join a voluntary health scheme (P=0.003), and were over three times more likely to pay a premium price for such cattle (P=0.02) than the smallest farmers. The baseline data recorded in this study can form the basis for more detailed sociological and demographic research which can further characterise biosecurity training opportunities within this farming community.

Keywords: Biosecurity; Survey; Dairy Herds; Herd Expansion, Ireland.

Introduction

Approximately 18,000 dairy farmers operate commercially within the Republic of Ireland, a member of the European Union (EU) since 1973 (Teagasc, 201 1a). Dairy farmers within the EU are now preparing to move into an unsupported and unrestricted global market with the elimination of EU restrictions on milk production (milk quotas) in 2015 (Areal et al., 2012). Irish dairy farmers, in the expectation of substantially increased dairy exports subsequent to quota elimination, are planning significant herd expansion (DAFM, 2011; Dillon, 2011). Inadequate attention to planning herd expansion, including biosecurity implementation, can lead to severe consequences for a dairy herd in terms of animal health (Faust et al., 2001). Additionally, sub-optimal herd health will lead to economic losses both at farm level and nationally (van Schaik, 2002).

Biosecurity is an essential tool in the control of infectious diseases. It can be described as the management systems implemented to reduce the risk of introducing infectious disease to a herd (Caldow, 2004). While this description can be expanded to include the concepts of bio-exclusion and bio-containment (Villarroel et al., 2007; Charisis, 2008), for the purposes of this survey, the main focus was between-herd spread of infectious disease (bioexclusion) with examination of a single biocontainment measure (vaccination). Many studies have been carried out internationally examining implementation of biosecurity on a variety of farming enterprises, (Faust et al., 2001; Delabbio, 2006; Hoe and Ruegg, 2006; Brandt et al., 2008; Gunn et al. 2008; Heffernan et al., 2008; Schemann et al., 2011) and the evidence supporting bioexclusion recommendations has recently been reviewed (Mee et al., 2012). The majority of these studies highlighted that, while awareness of biosecurity may exist, implementation of biosecurity measures at farm level was often poor.

The importance of implementing biosecurity to aid in controlling infectious disease at farm level continues to be recognised internationally (More, 2007; EC, 2007; Maunsell & Donovan, 2008; Conraths et al., 2011; Negrón et al., 2011). It can be particularly relevant to countries experiencing a changing agricultural demographic, including farm enterprise expansion. In such cases documenting the implementation of fundamental on-farm biosecurity measures may be beneficial, and collection of such baseline data contributes to monitoring future progress of biosecurity uptake amongst farmers. Biosecurity baseline data can also form the basis for detailed sociological, demographic, and progress-reporting studies which can further characterise biosecurity training opportunities within a farming community (Gunn et al., 2008; Heffernan et al., 2008; Merkel & Gipson, 2011; Schemann et al., 2011).

Baseline data on the level of biosecurity implementation at farm level on Irish dairy farms is currently lacking. The objectives of this study, therefore, were to document and describe farmer implementation of, and opinions towards, biosecurity practices on commercial Irish dairy farms.

Materials and methods

Questionnaire

A survey questionnaire to assess dairy farmer implementation and opinions towards biosecurity was developed. An initial pool of 120 biosecurity-related questions was compiled based on information from peer-reviewed publications, on-line resources from government bodies, and Teagasc research experience of Irish dairying systems. From this, a total of 19 questions (variables) were prioritised by consensus for inclusion in the final questionnaire by a biosecurity expert group (Irish-based scientists with recognised expertise in biosecurity). This yielded a survey consisting of an interview of approximately ten minutes duration. A copy of the questionnaire is available as electronic supplementary material with this publication.

The questionnaire was pre-tested by dairy researchers at Teagasc (Irish Agricultural and Food Development Authority) AGRIC, Ireland, and subsequently piloted to seven commercial dairy farmers. Based on pre-testing and interviews with pilot survey participants, definitions were supplied on the questionnaire [e.g. herd-type (Rauff et al., 1996), quarantine (Pritchard, 1996)], and minor modifications made to ensure complete understanding of each question before distribution to the study population.

Survey

Participation in the survey was voluntary with no incentive offered to participants. The study population was selected from the Teagasc client database of 11,390 dairy farmers. A minimum of 372 respondents was deemed necessary (CL=95%, CI = 5%) to ensure sufficient observations to cover the estimation of the coefficients for each response. Based on an expected response rate of 55%-60%, a total of 703 farmers were required for the study. Using the PROC SURVEYSELECT procedures in SAS (Version 9.1, USA), random proportional sampling was carried out using a regional and milk-quota stratification (Table 1 a & b). Seven geographical regions were used based on Irish Central Statistics Office (CSO, 2007) survey procedures. These regions were subsequently combined into three regions for chi-squared and logistic regression analysis to better reflect dairy farm demographics in Ireland (Figure 1, Table 1).

The questionnaire was administered by telesurvey. Hardcopy questionnaires were posted to each participant and responses subsequently recorded by telephone, at which point three additional questions were posed to each participant, (i) supply of national herd identifier, (ii) decade of birth, and (iii) name of veterinary practitioner. Farmer responses were recorded onto hardcopy questionnaires before transfer to a web-based survey tool (www.surveymonkey.com). Electronic entries were manually checked against hardcopy versions.

Data analysis

Coded responses to each survey question were downloaded from SurveyMonkey. Excel (Version MS Office 2003) was used for the purposes of data collation, fixing variables for directionality, and generating graphical representations. Descriptive analysis was carried out using PROC FREQ procedures on SAS (Version 9.1, USA). Chi-squared, logistic regression, Pearson correlation, and Cronbach coefficient alpha analyses were completed using PROC CHI, PROC LOGISTIC, PROC CORR, and PROC CORR ALPHA procedures, respectively, on SAS (version 9.1, USA). A rating scale was automatically generated in SurveyMonkey for question 14 to rank the preference for sources of biosecurity information amongst Irish dairy farmers.

For the purposes of survey validation, a standardised Cronbach coefficient alpha analysis was performed to check within questionnaire response consistency (Young et al., 2010a). Those respondents indicating they operated a closed herd (question 1) were examined for consistency of reply when asked about their purchasing strategy (question 2, which contained 'I don't buy cattle' as a choice), and quarantine (question 7, which contained 'No cattle enter my farm' as a choice). A chi-squared analysis was carried out on regional and farm size distribution to ensure the study population represented the national population. Respondent identity authentication was examined by comparison of voluntarily supplied national herd identifiers with those recorded on the official national animal identification and movement database (AIM) held by the Irish Ministry of Agriculture (DA FM). The true cattle movement status (herd-type) of each herd in the survey from 1st January 2005 to 30th June 2008 was also extracted from AIM. To facilitate direct comparison between survey and AIM data, a new herd-type variable was created; OPEN (open plus controlled herds) and CLOSED (closed plus restricted herds) (Table 2).

Dependent variables (survey questions) were categorised as either 'biosecurity practice' or 'biosecurity opinion' (Tables 2 & 3, respectively). All non-binary dependent variables were dichotomised. The effect of four independent variables [quota category (B, C, D, or E), region (1, 2, 3), decade of birth (1920/1930's, 1940's, 1950's, 1960's, 1970/1980's) and future farming plans (increasing herd size, remaining unchanged, decreasing herd size, exiting dairying)] on biosecurity practice variables was assessed. Herd-type (OPEN, CLOSED) was added as a fifth independent variable to the biosecurity opinion logistic regression model to assess its effect on those variables.

As a first step analysis, associations between the independent and dependent variables were identified by a Chi-squared analysis. Where an association with a *P* value of 0.15 or less was identified, a second step regression analysis was completed to describe the association. This consisted of a manual stepwise backward logistic regression analysis. Results of regression analysis were regarded as significant at the 5% level. Pearson correlation tests were used to assess for multicollinearity.

Results

Survey

A total of 450 responses were collected representing a response rate of 64%. Of these, six herd identifiers were found to be inaccurate and were excluded from the study. Visual representation of respondent locations with regard to the density of animals in dairy herds nationally is presented in Figure 1 and the decade of birth of respondents is outlined in Figure 2. Of farmers surveyed, 54.3% are planning to increase herd size with 37.9% remaining unchanged. The remainder are planning to decrease herd size (6.7%) or exit dairying (1.1%).

Questionnaire and survey validation

The standardised Cronbach coefficient alpha analysis yielded a value of 0.65 across the three variables examined (herd-type, purchasing strategy, quarantine) indicating acceptable questionnaire internal consistency. Table 4 outlines the results of Chi-squared analyses between the national dairy farmer population, the Teagasc database and survey respondents. The populations were not significantly different as indicated by *P* values of over 0.22. Approximately, 99% of respondents supplied accurate national identifiers.

Biosecurity practice variables

The self-declared cattle movement profile of survey farms (herd-type) is outlined in Figure 3 and Table 5. Analysis of dichotomised OPEN and CLOSED herds revealed that 32% of survey herds were self-declared closed, while AIM data indicated a true value of 12% (Table5). Examination of AIM data for cattle movement according to self-declared herd type revealed that, of the 114 self-declared closed herds, only 27 were truly closed within the specified time period (Table 5). Conversely, of those reporting that they operated an open herd policy (n=237), 17 could be classified as closed herds based on AIM data. Only two of the 26 self-reported restricted herds could be accurately classified as such when analysed against AIM data (Table 5). Additional biosecurity practice variables are outlined in Table 2.

Logistic regression analysis of biosecurity practice variables highlighted that relative to farmers in Region-1, farmers in Regions-2 and -3 were approximately two and five times more likely to have biosecure boundaries, respectively. Farmers in these regions were also up to three times more likely than Region-1 farmers to always implement quarantine. Region-3 farmers were more likely than Region-1 (OR 1.68) and Region-2 (OR 1.56) farmers to require farm visitors to be clean. Younger farmers (born 1970's/1980's) were less likely than almost all other age categories to seek biosecurity information from their veterinarian and agricultural advisor (Table 6). Similarly, those farmers born in decades 1970 and 1980 were between two and four times less likely to have a CLOSED herd than farmers in older age categories.

With regard to vaccination practices in Ireland, the breakdown of vaccine use amongst dairy farmers is outlined in Table 7. Ranking of preferred sources of biosecurity information is outlined in Table 8 with the veterinary practice (rati ng=2.07) and Teagasc (rating=2.1 9) clearly favoured over additional sources of information.

Biosecurity opinion variables

Opinions relating to biosecurity and preventative health strategies are summarised in Table 3. Lack of information and advice were cited as the most common reasons for non-implementation of biosecurity. The majority (83%) of dairy farmers surveyed stated that they would implement biosecurity if it prevented disease introduction or resulted in an improvement to cattle health and welfare on their farms as opposed to the remainder who would require external motivation to do so (i.e. mandatory programme or economic benefit).

Logistic regression analysis of biosecurity opinion variables highlighted that CLOSED herds were twice as likely to consider biosecurity important than OPEN herds (Table 9). Regional differences in the primary reason governing the implementation of biosecurity were identified. Relative to farmers in region-2, farmers in region-3 are twice as likely to be influenced by animal-related factors (prevention of disease introduction or improvement in cattle health and welfare) than by external factors (economic benefit or mandatory implementation).

Chi-squared analysis highlighted an association between decade of birth and whether or not a farmer would implement biosecurity if guidelines were supplied (P=0.05). In general, relative to those farmers born in the 1940's and 1950's, the youngest groups (born 1960's, 1970's/1980's), are over two times more likely to use biosecurity guidelines if supplied (Table 9).

Farmers with larger herds indicated they were more likely to voluntarily join a health scheme, with those in quota category E, 4.6 times more likely to join a scheme than farmers in category B. Farmers in category E were also 3.5 times more likely to pay a premium price for cattle from such a scheme (Table 9).

Discussion

The purpose of this study was to document and characterise the level of implementation of fundamental biosecurity practices on Irish dairy farms. In addition, as it is useful to know the reasons underlying farmer participation in health control programmes (Nielsen, 2011), some information regarding farmer opinions of biosecurity was also collected.

Cattle movements play a significant role in the dissemination of disease (Févre et al., 2006; Robinson et al., 2007), and as such, maintenance of a closed herd ranks amongst the most important biosecurity measures in achieving disease prevention (Wells et al., 2002; Caldow, 2004; Fevre et al., 2006; Lindström et al., 2010; Nöremark et al., 2011; Mee et al., 2012). The extent of the discrepancy between self-reported closed herds and actual closed herds (Table 5) in this study was unanticipated, although it is interesting to note that an almost identical discrepancy was recorded by Davison et al. (2003) in the United Kingdom (UK). It is unlikely that the recorded inconsistency is due to deliberate misrepresentation of closed herd status based on the Cronbach Coefficient Alpha analysis. A possible explanation for the discrepancy between self-reported and actual closed herds may be the operation of both dairy and beef-rearing enterprises under a single herd identifier. In such cases animals move freely into the beef-rearing herd, while the dairy enterprise is considered a closed unit. As a single herd identifier represents a single epidemiological unit regardless of its component elements, this farmer perception of a closed dairy unit is flawed. It is also possible that a small number of these farmers may rear heifers in a standalone unit under a different herd identifier with or without the involvement of a contract rearer. The AIM database does not distinguish such return-movements from general inward movements; however, this practice is relatively uncommon in Ireland. The number of cattle management units within each farm was not examined in this study and further studies are required to establish the disease risk posed to the dairy unit of such herds.

Should a farmer not be in a position to operate a closed herd, two additional cornerstones of biosecurity can be employed i.e. quarantine and testing of purchased animals. Only one in five farmers surveyed in this study implements correct quarantine procedures and the majority of dairy farmers do not test newly-purchased cattle for diseases other than those under statutory control. A lack of knowledge and advice would appear to be the main underlying reasons for the underutilization of such procedures similar to international findings (Hoe and Ruegg, 2006; Ellis-Iversen et al., 2010; Merkel and Gipson, 2011). It is concluded from this study, therefore, that the ‘closed herd’ concept is neither well understood nor implemented by Irish dairy farmers and that the three most important aspects of biosecurity (Duncan, 1990; Pritchard, 1996), closed herd, quarantine, and testing of purchased animals, remain largely underutilized by Irish dairy farmers.

Multivariate logistic regression analysis highlighted regional differences in both biosecurity practices and opinions towards biosecurity amongst study farmers. Costard et al. (2009) reported regional differences in pig management and biosecurity practices in Madagascar and cited culture, climate, and a variation in the training and technical support between regions as possible reasons for this. The regional differences recorded in this study may be reflective of the differing densities of dairy herds between the regions studied, Region-3 having the highest density of animals on dairy farms (Figure 1). The results may also be indicative of the relatively lesser importance of dairying in Regions 1 and 2 which have a greater proportion of beef, sheep, and tillage enterprises (CSO, 2007) possibly leading to a reduced focus on dairy technical support. Regardless of the underlying reason, the study highlights that regional differences in both biosecurity implementation and opinions do exist amongst relatively small dairy farming populations and regions. Future research studies and biosecurity education programmes should be designed to both investigate and reflect this. It should also be noted from the analysis that although economic pressure does have an important role to play in promoting biosecurity (Gunn et al., 2008; Moore et al., 2008), it should not be viewed as the sole driver of biosecurity implementation as evidenced by Region-3 farmers in this study. These farmers were almost two times more likely than Region-2 farmers to be influenced to implement biosecurity practices by health-related factors rather than external factors such as economic benefit or a mandatory requirement.

Ellis-Iversen et al. (2010) report that having intent to implement zoonotic control programmes is most likely amongst younger cattle farmers. Conversely, additional international studies across both human and animal disciplines, highlight that younger people have a lower compliance with recommended practices, older people being more likely to adopt self-protective behaviours (Barr et al., 2008; Bish and Michie, 2010; Schemann et al., 2011). Interestingly in this study, middle aged farmers (born 1940's, 1950's), representing over 40% of the study population, in general, tended to be less likely than younger age categories to have intent to implement biosecurity guidelines. However, although the intent to implement guidelines exists amongst younger farmers in this study, those born in the 1970's/1980's were less likely than all other age categories to report having a closed herd. An additional age-related finding of this study was that younger farmers were less likely to seek biosecurity information from their veterinarian and advisor than older farmers. This finding may be as a result of improved farm management education amongst younger Irish farmers since 1983 (Teagasc, 2011b) possibly leading to a reduced reliance on external advice. Veterinarians were chosen, however, as the preferred source of biosecurity information in this study similar to UK farmers (Gunn et al., 2008).

Patterns of age-related findings can be difficult to interpret and are often not consistent across research studies, results differing depending on geographical location and perceived risk at a particular point in time (Barr et al., 2008; Bish and Michie, 2010). This stresses the importance of generating baseline data which can act as a benchmark for continuing research into the demographic influences on farmer intentions and compliance with guidelines.

This survey did indicate a willingness amongst the majority of farmers to adopt an integrated herd health programme, including biosecurity, to minimise on-farm disease risk. Larger farming enterprises, however, were more likely to voluntary join a health scheme. Larger herds have also been identified in Canada and the United States (US) as more likely to implement good management practices (Hoe and Ruegg, 2006; Young et al., 2010b) and may reflect the fact that large dairy herds tend to be more business-driven and innovative, and concerned with seeking efficiencies (Rauff et al., 1996; LeBlanc et al., 2006). It may also, however, relate to the fact that many of these larger farmers would have expanded their herds over the last decade in line with continuing Irish trends (Dillon, 2011). Herd expansion does pose a greater risk of disease introduction (Maunsell and O’Donovan, 2008; Faust, 2001) and the findings of this study may highlight a recognition amongst this group of the importance of biosecurity and herd health control based on losses experienced during the expansion process.

Conclusion

Biosecurity is a cornerstone of disease control and suitably designed and demographically-relevant education programmes are required to ensure optimal farmer participation. This survey highlights regional, age, and herd-size related differences in implementation of, and opinions towards, biosecurity on Irish dairy farms. Such differences require further investigation to ensure correct design of targeted educational tools and optimal success when disseminating biosecurity information to farming communities.

Conflict of interest statement

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

Acknowledgements

This paper is an output from a Teagasc research programme funded by the Irish Dairy Levy. The authors acknowledge assistance from Dr. Laurence Shalloo and Dr. Kevin Heanue, Teagasc; Prof. Simon More, Ms. Isabella Higgins and Mr. Daniel Collins, CVERA; and Dr. Mary Canty, DAFM. The authors thank Una Hanrahan for her dedication throughout the survey process. Finally, the authors wholeheartedly thank the participating farmers.

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Table 1 (a & b)

Geographical regions and quota categories used for proportional sampling stratification.

(a)

Survey Region[a]	CSO Region	Counties represented
Region 1	Border	Donegal, Sligo, Leitrim, Cavan, Monaghan, Louth
	West	Galway, Mayo, Roscommon,
	Midlands	Laois, Offaly, Longford, Westmeath
	Dublin & Mid-East	Dublin, Meath, Kildare, Wicklow
Region 2	South-East	Wexford, Carlow, Kilkenny, South Tipperary, Waterford
	Mid-West	Clare, Limerick, North Tipperary
Region 3	South-West	Cork, Kerry

[a]Regions were chosen, to equalise the number of herds represented in each region, to correspond with CSO-defined regions, and to represent a natural geographical spread.

(b)

Milk quota categories	Quota Size (L)[a]	Approximate herd size[b]
Quota A[c]	<50,000	< 10 cows
Quota B	> 50,000 - 150,000	> 10-30 cows
Quota C	>150,000 - 250,000	>30-50 cows
Quota D	>250,000 - 500,000	>50-100 cows
Quota E	>500,000	>1 00cows

[a] Milk quota categories were defined based on construction of a cumulative relative frequency plot of milk quota size across the dataset

[b] Approximation based on 1 Irish dairy cow = 5,000 litres annually.

[c] Excluded from study as were deemed to represent non-commercially viable holdings

Table 2

Biosecurity practice variables and responses of surveyed farmers (%).

Question	Practice Variable	n	Response Options	Outcome (%)	Binary Variable*
Q1	Cattle movement pattern / herd-type	442	Open	53.6	Closed and Restricted (CLOSED)
			Closed	25.9	vs.
			Restricted	5.8	Open & Controlled
			Controlled	14.7	(OPEN)
Q2	Purchasing Strategy	260	Talk to the seller	68.5	
	(for those farms that		Look at the cattle	55.8	
	purchased cattle only)		Request test results for the cattle	37.3	Not analysable by
			Talk to the seller's vet	1.1	regression
			Request health cert for cattle	2.7	
			No purchasing strategy	11.2	
Q3	Testing of animals following	317	Yes	7.6	
	purchase		No	89.3	Yes & Sometimes
			Sometimes	3.2	vs. No
Q5	At least one vaccine	441	Yes	85.9	
	Administered		No	14.1	Yes vs. No
Q6	Biosecure land boundaries	441	Yes	81.7	
			No	16.8	Yes vs. No
			No cattle on neighbouring land	1.6	Excluded due to low response rate
Q7	Quarantine of purchased stock	440	No cattle enter	30.0	Excluded due to multicollinearity
			Yes	14.5	
			No	47.5	Yes vs.
			Sometimes	8.0	No & Sometimes
Q8	Accurate health records kept	441	Yes	89.5	
			No	10.5	Yes vs. No
Q9	Farm visitor cleanliness	441	Yes	45.8	
	Required		No	54.2	Yes vs. No
Q10	Frequency of request for	439	Regularly	22.3	
	biosecurity information from		Rarely	43.9	Regularly & Rarely
	Vet		Never	33.7	vs. Never
Q10	Frequency of request for	439	Regularly	6.8	
	biosecurity information from		Rarely	33.2	Regularly & Rarely
	agricultural advisor		Never	59.9	vs. Never

*Binary variable used for the purposes of logistic regression

Table 3

Biosecurity opinion variables and responses of surveyed farmers (%).

Question	Opinion Variables	n	Response Options	Outcome (%)	Binary Variable*
Q4	If no post-purchase testing done, why?	238	It is of no benefit	21.4	Excluded due restricted response rate
			Don't know what to test for	20.1	
			Was never advised to	44.9	
			Too expensive	13.4	
Q11	Is biosecurity important?	441	Yes	72.3	Yes vs. No
			No	22.2	
			I don't know	5.4	Excluded due to low response rate
Q12	Why would farmer implement biosecurity?	425	For economic benefit	12.2	Health/disease vs. external factors (economics, mandatory)
			If mandatory only	4.7	
			If disease introduction is prevented	52.7	
			If cattle health and welfare improved	30.4	
Q13	Would guidelines be implemented if supplied?	420	Yes	86.2	
			No	13.8	Yes vs. No
Q15	Factors preventing biosecurity implementation	424	Would cost too much	19.3	Cost & Time vs. Lack of information & No effect on disease
			Don't have the time	15.6	
			Don't have enough information	53.3	
			Don't feel it would reduce disease	11.8	
Q16	Voluntarily join health scheme	434	Yes	61.5	
			No	38.5	Yes vs. No
Q17	Pay a premium price for health scheme stock	435	Yes	63.5	
			No	36.5	Yes vs. No
Q18	Should herd health schemes be a requirement at farmers' own cost?	431	Yes	27.8	
			No	43.6	Yes vs. No & Only if a member of scheme
			Only if a member of quality scheme	28.5	

*Binary variable used for the purposes of logistic regression

Table 4

Regional and farm size chi-squared analysis.

Comparison	Region*	Farm Size*
Survey vs Teagasc	0.24	0.22
Survey vs CSO	0.23	0.22

* Stated values represent statistical *P* values.

Analysis was carried out between survey respondents and the Teagasc dairy database, and between survey respondents and CSO records (i.e. national dairy farmer population).

Table 5

Comparison between self-declared herd type and data extracted from AIM database.

Survey data		**Comparison of Survey and AIM data**			
Herd Type	**n (Survey)**	**Dichotomised Herd Type**	**n (%) (Survey)**	**n (%) (AIM)**	**Breakdown of AIM data by self-declared herd type**
Open	237	OPEN (Open+Controlled)	302 (68%)	389 (88%) of which	87 misclassified closed by farmer 24 misclassified restricted by farmer 220 correctly classified open by farmer 58 correctly classified controlled by farmer
Controlled	65				
Closed	114	CLOSED (Closed+Restricted)	140 (32%)	53 (12%) of which	27 correctly classified closed by farmer 2 correctly classified restricted by farmer 17 mis-classified open by farmer 7 mis-classified controlled by farmer
Restricted	26				

Table 6

Significant associations between independent (region, quota category, decade of birth, future farming plans) and dependent (survey questions) variables.

Question	Biosecurity practice variables	Response	Odds Ratio	95% Confidence Interval	*P* value	Model* (*P* value)
Q1	Herd-type					
	Born 1920/1930's vs. 1970/1980's	CLOSED	3.44	0.94, 12.59	*P*=0.062**	Decade of Birth
	Born 1940's vs. 1970/1980's	vs.	4.32	1.99, 9.39	*P* <0.0001	Future Plans
	Born 1950's vs. 1970/1980's	OPEN	2.41	1.19, 4.87	*P* =0.014	(*P* =0.009)
	Born 1960's vs. 1970/1980's		2.31	1.17, 4.55	*P* =0.015	
Q6	Biosecure land boundaries					
	Region 2 vs. Region 1		1.88	1.06, 3.33	*P* =0.031	Region
	Region 3 vs. Region 1	Yes vs. No	5.27	2.49, 11.10	*P* <0.0001	Future Plans
	Region 3 vs. Region 2		2.80	1.36, 5.79	*P* =0.005	(*P* =0.0001)
Q7	Quarantine of purchased stock					
	Region 2 vs. Region 1	Yes vs.	2.66	1.14, 6.19	*P* =0.023	Region
	Region 3 vs. Region 1	No & Sometimes	2.95	1.25, 6.89	*P* =0.012	(*P* =0.01 9)
Q9	Farm visitor cleanliness required					
	Region 3 vs. Region 1	Yes vs. No	1.68	1.00, 2.81	*P* =0.050	Region
	Region 3 vs. Region 2		1.56	1.00, 2.44	*P* =0.050	Decade of Birth
						(*P* =0.083)
Q10	Request information from advisor					
	Born 1920/1930's vs. 1970/1980's		4.00	1.18, 14.29	*P* =0.027	Quota
	Born 1940's vs. 1970/1980's	Regularly & Rarely	2.04	1.01, 4.09	*P* =0.046	Decade of Birth
	Born 1950's vs. 1970/1980's	vs.	2.13	1.13, 3.83	*P* =0.018	(*P* =0.022)
	Quota B vs. Quota E	Never	2.90	1.14, 7.37	*P* =0.025	
Q10	Request information from vet					
	Born 1920/1930's vs. 1970/1980's		10.86	1.35, 87.49	*P* =0.025	
	Born 1940's vs. 1970/1980's	Regularly & Rarely	1.98	1.01, 3.90	*P* =0.048	Decade of Birth
	Born 1950's vs. 1970/1980's	vs.	2.6	1.44, 4.7	*P* =0.002	(p=0.002)
	Born 1920/1930's vs. 1960's	Never	7.22	0.91, 57.18	*P*=0.061 * *	
	Born 1950's vs. 1960's		1.7	1.02, 2.92	*P* =0.039	

*Outlines the independent variable(s) included in the final logistic regression model.

* * Association with *P* value greater than 0.05 included for the purposes of highlighting a trend.

Table 7

Vaccine use amongst surveyed farmers (n=441).

Disease Vaccinated For	%	Disease Vaccinated For	%
BVD	41.1%	Pneumonia	7.5%
Calf scour	15.2%	Ringworm	2.3%
Clostridial diseases	43.9%	Salmonella	27.3%
IBR	6.6%	No vaccines used	13.0%
Leptospira	60.7%		

Table 8

Preferred sources of biosecurity information ranked in order of preference.

Source of information	Ranking	Rating*	Preference
Veterinary practice	1	2.07	Most preferred
Teagasc	2	2.19	
Ministry of Agriculture	3	3.72	
Farmer discussion group	4	4.23	
Other farmers	5	4.68	
MEDIA (radio/TV/internet/newspaper)	6	5.29	
Farm assurance/quality scheme	7	5.33	
Other	8	7.61	Least preferred

*Rating scores automatically generated by SurveyMonkey based on percentage of survey respondents ranking first, second, and subsequent choices for sourcing biosecurity information. Lower values indicate increased preference.

Table 9

Significant associations between independent (region, quota category, decade of birth, future farming plans, herd type) and dependent (survey questions) variables.

Question	Biosecurity practice variables	Response	Odds Ratio	95% Confidence Interval	*P* value	Model* (*P* value)
Q11	Is biosecurity important?					
	CLOSED vs. OPEN herds	Yes vs. No	2.01	1.17, 3.43	*P* =0.010	Herd Type (*P* =0.008)
Q12	Why implement biosecurity?					
	Region 3 vs. Region 2 farmers	Health related vs. external factors	1.95	1.06, 3.59	*P* =0.032	Region (*P* =0.091)
Q13	Would guidelines be implemented?					
	Born 1960's vs. 1940's		2.82	1.21, 6.58	*P* =0.016	Quota
	Born 1960's vs. 1950's	Yes vs. No	2.25	1.05, 4.80	*P* =0.036	Decade of Birth
	Born 1970/1980's vs. 1940's		2.44	0.94, 6.36	*P*= 0.067* *	(*P* =0.026)
Q16	Voluntarily join health scheme					
	Quota E vs. Quota B	Yes vs. No	4.6	1.65, 12.80	*P* =0.003	Quota (*P* =0.001)
Q17	Pay a premium price for health scheme stock					
	Quota E vs. Quota B	Yes vs. No	3.53	1.24, 10.08	*P* =0.02	Quota (*P* =0.021)

*Outlines the independent variable(s) included in the final logistic regression model.

**Association with *P* value greater than 0.05 included for the purposes of highlighting a trend.

Figure legends

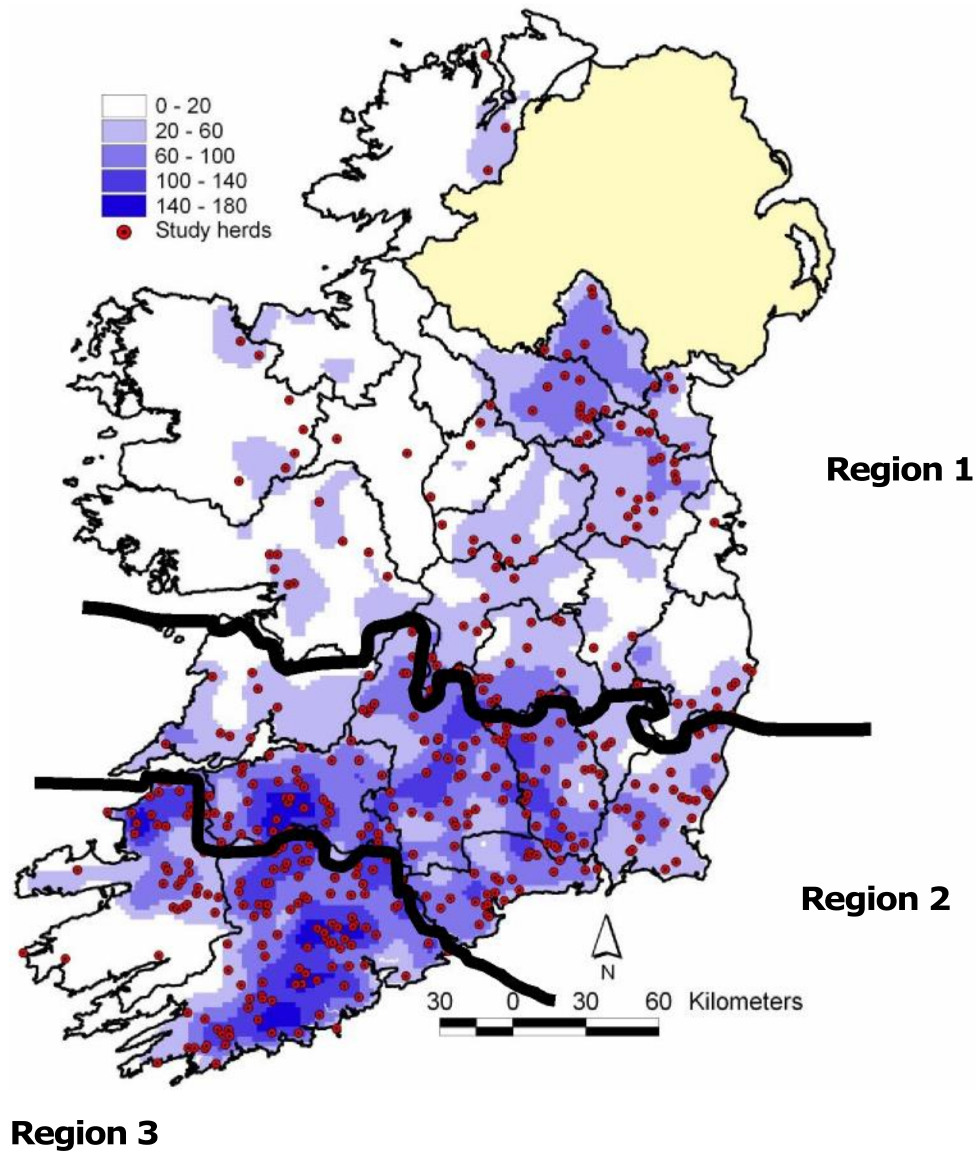

Fig. 1. The location of study herds and density of animals in dairy herds per square km during 2008 (kernel density with search radius of 10km). The three regions for chi-squared and logistic regression analysis are also presented.

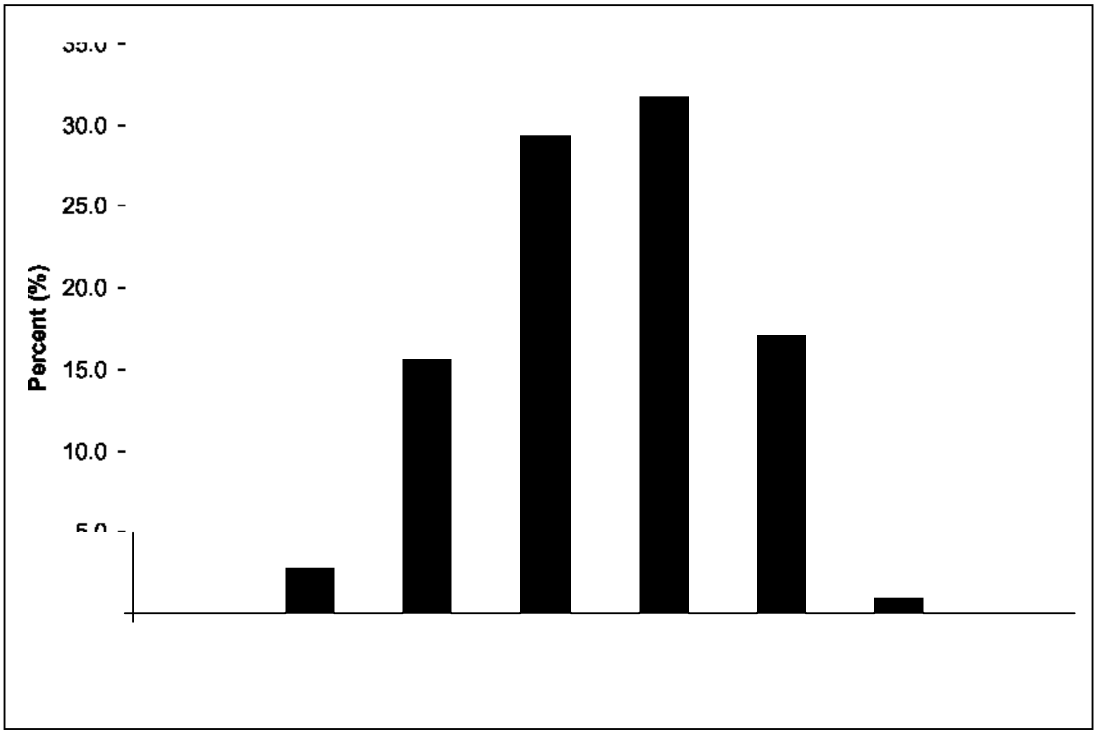

Fig. 2. Decade of birth of survey respondents (n=433).

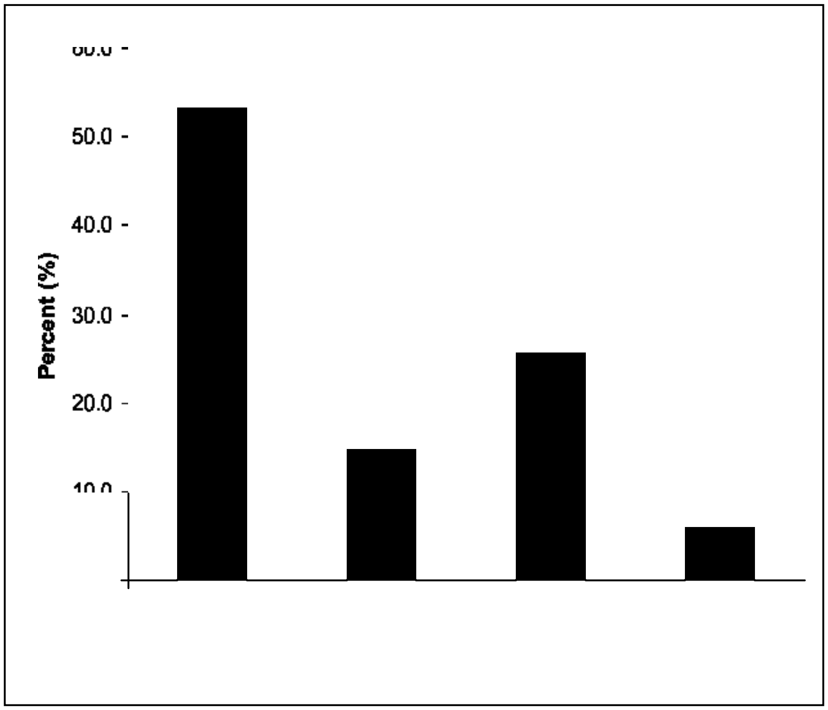

Fig. 3. Self-reported cattle movement profile (herd-type*) of surveyed dairy herds (*n*=442)

***Herd Type (Survey)**	**Definition** (Adapted from Rauff et al., 1996)
Open herd	free movement of cattle onto the farm
Controlled herd (Variant of open herd)	a written health history is required for all newly purchased cattle moving onto the farm
Closed herd	no movement of cattle onto the farm
Restricted herd (Variant of closed herd)	only re-entry of existing farm cattle onto the farm allowed e.g. return from mart, show

Fig. 3. Self-reported cattle movement profile (herd-type*) of surveyed dairy herds (n=442).