

An assessment of Irish farmers' knowledge of the risk of spread of infection from animals to humans and their transmission prevention practices

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SUMMARY

The aim of this study was to ascertain farmers' knowledge of the risk of spread of infection from animals to humans, and their transmission prevention practices. This was a survey of farmers who submitted material to Ireland's Regional Veterinary Laboratories in 2015. There was an 84% response rate (1044 farmers). Ninety per cent of farmers were not aware that infection can be acquired from apparently healthy animals. Over half were not aware that disease could be contracted from sick poultry or pets. Conversely, the knowledge of the risk to pregnant women of infection from birthing animals was high (88%). Four-fifths of farmers sourced drinking water from a private well, and of these, 62% tested their water less frequently than once a year. Of dairy farmers, 39% drank unpasteurised milk once a week or more frequently. Veterinarians were the most commonly cited information source for diseases on farms. The survey findings indicate that the level of farmers' knowledge and awareness of the spread of infection from animals to humans is a concern. Further education of the farming community is needed to increase awareness of both the potential biohazards present on farms and the practical measures that can be taken to mitigate the risk of zoonoses.

Key words: Farmers, infection prevention, infection control, knowledge, zoonoses.

INTRODUCTION

Ireland, with its rich fertile soils and mild moist climate is well suited to farming and, according to the Census of Agriculture, 2010, almost two thirds of the land area of the country is used for agriculture [1]. Beef and milk production account for over half of all agricultural output. Sheep, pig, poultry and tillage

farming are also important [1]. Regionally, the Border–Midland–West region has a higher proportion of specialist sheep and specialist beef production, compared with the South East region, where specialist tillage and specialist dairying tend to dominate. In 2010, the regular farm workforce was made up of approximately 140 000 farm holders, 41 000 spouses, 70 000 family members and 16 000 regular non-family workers. Eighty-seven per cent of the farm holders were male, with an average age of 54 years. The average age of the female farm holders was 58 years [1].

Infections that are naturally transmissible from vertebrate animals to humans are known as zoonoses [2].

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Previous studies have suggested that veterinarians encounter zoonotic diseases more frequently than physicians [3], and that farmers felt that family doctors' knowledge of zoonotic diseases was poor [4]. The One Health approach recognises that the health of people is connected to the health of animals and the health of the environment. The goal of One Health is to encourage collaboration between human, animal and environmental health entities in surveillance, outbreak response and prevention, to achieve an optimal human health outcome [5]. This is important because, of all human pathogens 60% are zoonotic [6].

Zoonoses are transmitted by ingestion, bite, scratch, inhalation or skin contact. Indirect transmission of zoonotic gastrointestinal pathogens has been documented in outbreak settings, with illness being associated with contact with contaminated clothing or shoes, animal bedding, flooring, barriers and other environmental surfaces [7]. Farmers, because of their work with livestock, in an environment often contaminated with animal faeces or by-products, may be at higher risk for zoonotic disease. Other members of farming households, even if not working on the farm, may also be at higher risk through their direct and indirect contact with animals. Consistent, thorough hand hygiene is the single most important measure that can be taken to reduce the risk of disease transmission [8], most particularly gastrointestinal infections, but also respiratory tract and skin infections [9].

Consumption of unpasteurised milk or untreated water may also put farmers and their families at risk of contracting zoonotic infection. Unpasteurised (raw) milk can carry harmful bacteria such as *Campylobacter*, *Listeria*, *Brucella*, *Mycobacterium bovis*, *Salmonella*, or *Verotoxigenic Escherichia coli* (VTEC) [10]. The significant infection risks associated with the consumption of raw milk or raw milk derived products are well documented internationally [11–13]. The Central Statistics Office (CSO) reported that, in 2011, 48% of Irish agricultural households get water from a private source [14]. This contrasts with private well ownership in Ireland generally, which was 11% in 2011 [15]. Well water can be vulnerable to contamination, particularly if the well is not properly constructed or protected [16]. Human cases of Cryptosporidiosis and VTEC are legally notifiable in Ireland [17]. Nationally, cases with private wells are consistently, statistically significantly, overrepresented among cases of both Cryptosporidiosis and VTEC [18]. In 2014, 25% and 32% of human cases of

Cryptosporidiosis and VTEC cases, respectively, reported consuming water from a private well source [19]. The Environmental Protection Agency (EPA) has reported that 25% of groundwater supplies in Ireland are contaminated with faecal coliforms [20].

The South East Regional Zoonoses Committee (SERZC) is a multi-agency group comprising human and animal-health professionals from the South East of Ireland. Members include doctors, scientists, environmental health officers and veterinarians. The SERZC undertakes health education and promotion activities throughout the year. One group which is an important target audience for the committee is farmers.

The six Regional Veterinary Laboratories (RVLs), sited across the country, provide a national, subsidised clinical pathology, and post-mortem diagnostic service to farmers, through referral by their private veterinary practitioners. Farmers attending the RVLs to submit material do so to diagnose animal health problems on their farm. A subgroup of the SERZC decided to conduct a survey of these farmers, with the following objectives: to determine farmers' knowledge of zoonoses, and of the risk of infection posed to humans by some common animal exposures; to determine whether (and how often) farmers carry out simple infection prevention activities on their farms; and to find out where farmers get information on diseases, to inform future health promotion activities. To our knowledge it is the first survey of its kind in Europe.

METHODS

An anonymous survey of people who presented at the six Irish RVLs, located in Athlone, Cork, Dublin, Kilkenny, Limerick and Sligo was undertaken between February and June 2015. The director of each RVL was briefed on the questionnaire by an author and they explained the meaning of each question to their staff. Administrative staff at each RVL aimed to request consecutive persons, who presented to submit material for examination at the RVLs, to complete the survey questionnaire. Each potential respondent was asked if they had previously completed the questionnaire, and if so it was not re-offered to them. Administrative or professional staff at each laboratory were available to those completing the survey, to answer queries about the meaning of the survey questions. They did not assist in answering questions.

The self-administered pen-and-paper questionnaires, consisting of 22 closed, partially closed and

Table 1. *Aspects of farmers' knowledge of the risk of zoonotic infection and their transmission prevention practices addressed by the Farmer Survey questionnaire listed by topic and question type*

Aspect	Detail ^a
1. Farmer characteristics	Gender (c); age (o); type of farm (pc); regional veterinary laboratory attended (c)
2. Knowledge of infection	What is a zoonosis (c); can a farmer or a family member get an infection from scouring animals, aborting animals, sick poultry, pets, healthy animals (c); can a child get gastroenteritis from being around animals (c); is it safe for a pregnant woman to attend birthing animals (c)
3. Farm hygiene	Are hands washed before eating or smoking (c); when are hands washed during the working day (c); when is personal protective clothing worn (c); when are disposable gloves worn (pc)
4. Drinking water supply to the home	What type of water supply services the family home (c); how often is private well water microbiologically tested (c)
5. Consumption of unpasteurised milk	Frequency of consumption of unpasteurised milk (c)
6. Information sources for farm diseases	Where do farmers source information on farm diseases (c)

^a c, closed-ended; o, open-ended; pc, partially closed-ended question.

open questions, were devised by veterinary, medical and scientific members of the SERZC. The questions are summarised in Table 1. The questionnaire was pilot-tested on 39 people who attended Kilkenny RVL during the first week of February, 2015. They all completed the survey in <5 min.

This was a cross-sectional survey. Survey responses were entered into an author-designed Excel spreadsheet by an RVL administrator. The data was validated and cleaned in Excel by one of the authors, before being copied to IBM SPSS Statistics (SPSS Inc, Chicago) Version 22, which was used to recode variables and to calculate proportions, odds ratios (ORs) and significance values. Data were collapsed into dichotomous variables as per Tables 3–5 for the calculation of ORs. Associations were determined between variables such as age, specialist farming type, knowledge and behaviour. Gender could not be examined as there were so few female farmers. Respondents did not always answer all the questions; for the questions on knowledge of infection, missing data were considered not being able to answer the question, for all other questions, missing data were excluded and available-case analysis was used.

RESULTS

Study sample and demographics

In total, 1242 persons who presented at the six RVLs between February and June 2015 were requested to complete the survey. There was a response rate of 84%, giving a final sample size of 1044. The age of

the respondents ranged from 12 to 91 years, with a mean age of 46 years (Fig. 1). More than 90% were male (Fig. 1, Table 1). Responses were received from each of the six RVLs in Ireland; however, more responses were received from the laboratories servicing farmers in the Midlands/North (Athlone), South East (Kilkenny), West/South West (Limerick) and West/North West (Sligo) than those servicing the South (Cork) and the East (Dublin) (Table 2). There was a variety of farming types reported. While more than half (57%) practised only one type, many farmers practised more than one type of farming (Table 2).

Knowledge of zoonoses and risk of infection from animals

Respondents' answers to questions probing knowledge of zoonoses and the risk of infection from animals, and comparisons between younger and older farmers and specialist dairy and specialist suckler farmers are shown in Table 3. Two-thirds of respondents were unaware that a zoonosis is a disease a person gets from an animal, while 90% did not know that healthy animals may be a source of infection for themselves or family members. Almost 80% of farmers identified aborting cows, ewes or sows as potential sources of infection and 88% knew that it is not safe for pregnant women to help birthing animals. Younger farmers (<45 years) were more likely than older farmers (45+ years) to know what a zoonosis is, that one can catch an infection from healthy

Table 2. Characteristics of respondents in the Farmer Survey

	Respondents (N)		Number	Percentage	95% CI ^a
Gender	889	Male	815	91.7	89.7–93.3
		Female	74	8.3	6.7–10.3
Age group	982	<45 years	440	44.8	41.7–47.9
		45+ years	542	55.5	52.1–58.3
RVL attended	1044	Athlone	299	28.6	26.0–31.5
		Cork	92	8.8	7.2–10.7
		Dublin	18	1.7	1.1–2.7
		Kilkenny	263	25.2	22.7–27.9
		Limerick	211	20.2	18.0–22.8
		Sligo	161	15.4	13.4–17.7
Farming type ^b	1031	Dairy	438	42.5	39.5–45.5
		Suckler	486	47.1	44.1–50.2
		Beef	339	32.9	30.1–35.8
		Sheep	270	26.2	23.6–29.0
		Pigs	12	1.1	0.7–2.0
		Poultry	27	2.6	1.8–3.8
		Other	43	4.2	3.1–5.6
		Specialist farming type ^c	592	Dairy	266
Suckler	220	37.2		33.3–41.1	
Beef	44	7.4		5.6–9.8	
Sheep	56	9.4		7.4–12.1	
Pigs	2	0.3		0.09–1.2	
Poultry	1	0.2		0.03–0.95	
Drinking water supply to the home ^b	1036	Other	3	0.5	0.002–1.4
		Public	242	23.4	20.9–26.0
		Private Well	611	59.0	56.0–61.9
		Private group water scheme	131	12.6	10.8–14.8
		Public group water scheme	80	7.7	6.2–9.5

^a CI, confidence interval.

^b Categories sum to >100% as some respondents listed more than one category.

^c Practises one type of farming only.

animals, from sick poultry, and from pets. Specialist dairy farmers were more likely than specialist suckler farmers to know what a zoonosis is and, that they or a family member might get an infection from aborting cows/ewes/sows. No significant differences were found between younger and older, nor specialist dairy and specialist suckler farmers in their knowledge of children contracting diarrhoea from being around animals, of the safety of pregnant women helping birthing animals, or of acquiring infections from scouring livestock.

Most respondents accessed information on diseases on the farm from multiple sources. The most common information sources were the veterinary practitioner (913), newspapers (519), Teagasc (the Agriculture and Food Development Authority) (502) and the Department of Agriculture, Food and the Marine (385). Less frequently cited sources were social

media (153), agricultural shows (130), the local co-operative (115) and the general practitioner (57).

Hand-washing, use of personal protective equipment (PPE) on the farm

Farmers' responses to questions on hand washing and their use of PPE are summarised in Table 4, along with comparisons of younger and older and specialist dairy and specialist suckler farmers. Ninety-three per cent of respondents reported washing their hands before eating or smoking while on the farm. Similarly, most reported always washing their hands at the opportunities during the working day about which they were queried. Younger farmers were less likely than older farmers to wash their hands before eating or smoking on the farm, after handling sick animals and, in the morning and evening. However, there was no

Table 3. *Farmers Survey respondents' knowledge of zoonoses and the risk of infection from animals*

Variable	All respondents		Age group of respondents			<i>P</i> value ^c	Specialist ^a farming type of respondents			
	<i>N</i>	Rate % (95% CI ^b)	<45 years <i>n</i> (%)	45+ years <i>n</i> (%)	Odds ratio (95% CI ^b)		Dairy <i>n</i> (%)	Suckler <i>n</i> (%)	Odds ratio (95% CI ^b)	<i>P</i> value ^c
Might you or family member get an infection from aborting cows/ewes/sows?										
Yes	818	78.8 (75.6–80.7)	340 (77.3)	447 (82.5)	0.73 (0.5–1.0)	0.04	217 (80.7)	161 (72.9)	1.6 (1.1–2.4)	0.04
No/not sure/missing	226	21.6 (19.3–24.3)	100 (22.7)	95 (17.5)			52 (19.3)	60 (27.6)		
Might you or family member get an infection from sick poultry										
Yes	516	49.4 (46.4–52.4)	258 (58.6)	238 (43.9)	1.8 (1.1–2.3)	<0.001	130 (48.3)	105 (47.5)	1.0 (0.7–1.5)	0.86
No/not sure/missing	526	50.6 (47.4–53.6)	182 (41.4)	304 (56.1)			139 (51.7)	116 (52.5)		
Might you or family member get an infection from healthy animals										
Yes	110	10.5 (8.8–12.6)	59 (13.4)	46 (8.5)	1.7 (1.1–2.5)	0.01	24 (8.9)	21 (9.5)	0.9 (0.5–1.7)	0.83
No/not sure/missing	934	89.5 (87.5–91.2)	381 (86.6)	496 (91.5)			245 (91.1)	200 (90.5)		
Might you or family member get an infection from pets										
Yes	498	47.7 (44.7–50.7)	248 (56.4)	234 (43.2)	1.7 (1.3–2.2)	<0.001	131 (48.7)	106 (48.0)	1.0 (0.7–1.5)	0.87
No/not sure/missing	546	52.3 (49.3–55.3)	192 (43.6)	308 (56.8)			138 (51.3)	115 (52.0)		
What is a zoonosis?										
A disease a person can pick up from an animal	346	33.1 (30.3–36.1)	194 (44.1)	143 (26.4)	2.2 (1.7–2.9)	<0.001	95 (35.3)	57 (25.8)	1.6 (1.1–2.3)	0.02
Incorrect/don't know/missing	698	66.9 (64.0–70.0)	246 (55.9)	399 (73.6)			174 (64.7)	164 (74.2)		

^a Practises one type of farming only.^b CI, Confidence interval.^c *P* value for Pearson χ^2 .

Table 4. *Farmers Survey respondents' hand washing practices and use of personal protective equipment*

Variable	All respondents		Age group of respondents				Specialist ^a farming type of respondents			
	N	Rate % (95% CI ^b)	<45 years n	45+ years n	Odds ratio (95% CI ^b)	P value ^c	Dairy n	Suckler n	Odds ratio (95% CI ^b)	P value ^c
When on the farm, do you wash your hands before eating/smoking?										
Yes	944	96.0 (94.2–96.8)	401 (93.9)	492 (97.0)	0.47 (0.3–0.9)	0.02	244 (94.9)	202 (95.3)	0.9 (0.4–2.2)	0.86
No	43	4.0 (3.3–5.8)	26 (6.1)	15 (3.0)			13 (5.1)	10 (4.7)		
Do you wash your hands after handling sick animals?										
Always	830	88.9 (86.7–90.7)	338 (83.7)	435 (92.0)	0.45 (0.3–0.7)	<0.001	216 (88.2)	169 (91.3)	0.71 (0.4–1.3)	0.29
Sometimes/never	104	11.1 (9.3–13.3)	66 (16.3)	38 (8.0)			29 (11.8)	16 (8.6)		
Do you wash your hands in the morning and evening?										
Always	689	85.7 (83.1–88.0)	306 (82.0)	351 (88.9)	0.57 (0.4–0.9)	0.007	186 (87.8)	130 (86.1)	1.2 (0.6–2.1)	0.6
Sometimes/never	115	14.3 (12.1–16.9)	67 (18)	44 (11.1)			26 (12.2)	21 (13.9)		
Do you wear gloves when working?										
Yes	–	–	381 (87.0)	471 (87.8)	0.93 (0.6–1.4)	0.74	260 (97.0)	177 (81.6)	7.4 (3.4–16.1)	<0.001
Sometimes/never	–	–	57 (13.0)	66 (12.2)			8 (3.0)	40 (18.4)		
When do you remove your boiler suit/wet gear?										
Every time I enter the home	394	75 (71.6–79.0)	196 (58.5)	184 (46.0)	1.7 (1.2–2.2)	0.001	117 (58.5)	80 (44.0)	1.8 (1.2–2.7)	0.004
Less frequently	128	25 (21.0–28.4)	139 (14.5)	216 (54.0)			83 (41.5)	102 (56.0)		

^a Practises one type of farming only.

^b CI, confidence interval.

^c P value for Pearson χ^2 .

Table 5. Farmer Survey respondents' consumption of unpasteurised milk and testing of private well water

Variable	All respondents		Age group of respondents			Specialist ^a farming type of respondents				
	N	Rate % (95% CI) ^b	<45 years n	45+ years n	Odds ratio (95% CI) ^b	P value ^c	Dairy n	Suckler n	Odds Ratio (95% CI) ^b	P value ^c
If you have a private well at home, how often do you get it tested?										
Once a year	219	36.7 (33.0–40.7)	80 (29.7)	125 (38.8)	0.8 (0.5–1.1)	0.1	102 (50.7)	22 (22.0)	3.7 (2.1–6.3)	<0.001
Less often than once a year	377	63.2 (59.1–67.0)	189 (70.3)	197 (61.2)			99 (49.3)	78 (78.0)		
How often do you drink unpasteurised milk?										
At least once a week	208	20.1 (17.8–22.6)	82 (19.7)	113 (21.0)	0.9 (0.6–1.2)	0.39	98 (36.7)	13 (6.0)	9.1 (5.0–16.9)	<0.001
Less often than once a week	828	79.9 (77.3–82.2)	335 (80.3)	426 (79.0)			169 (63.3)	205 (94.0)		

^a Practises one type of farming only.

^b CI, confidence interval.

^c P value for Pearson χ^2 .

significant difference in washing hands before meals between younger and older farmers. No significant differences were found in hand-washing opportunities taken between; specialist dairy and specialist suckler farmers; those who knew what a zoonosis is and those who did not; and those who knew that children can get vomiting and diarrhoea from being around animals and those who did not.

Farmers were asked about disposable glove usage during the working day (assisting animals giving birth, milking, looking after stock, and for other activities). Many respondents wear disposable gloves for more than one of the listed tasks, while 125 stated that they rarely or never wear disposable gloves. Specialist dairy farmers were more likely than specialist suckler farmers to wear gloves during the working day. No significant differences were found in glove-wearing opportunities between younger and older farmers; those who knew what a zoonosis is and those who did not; and those who knew that children can get vomiting and diarrhoea from being around animals and those who did not.

Three quarters of survey respondents (767) completed the questions on the removal of personal protective clothing. Of these, a third (245) reported that they did not wear a boiler suit/wet gear while working. Of those who did wear a boiler suit/wet gear, almost one-quarter reported not removing the boiler suit/wet gear every time they entered the family home. Younger and specialist dairy (as opposed to specialist suckler) farmers were more likely to do.

Drinking-water source to the home and consumption of unpasteurised milk

Responses to questions on farmers' home drinking-water source and their consumption of unpasteurised milk are summarised in Table 5. Almost three-quarters use a private drinking-water source; a private well or a private group water scheme (a shared private source, that is treated and managed privately) (Table 1). When private well-water users were asked how often they had their well-water tested, 37% reported having it tested annually while 63% reported having it tested less often than once a year. Specialist dairy farmers were more likely than specialist suckler farmers to test their well water annually. No significant differences were found in frequency of well-water testing between younger and older farmers; those who knew what a zoonosis is and those who did not; and those who knew that children can get vomiting and diarrhoea from being around animals and those who did not.

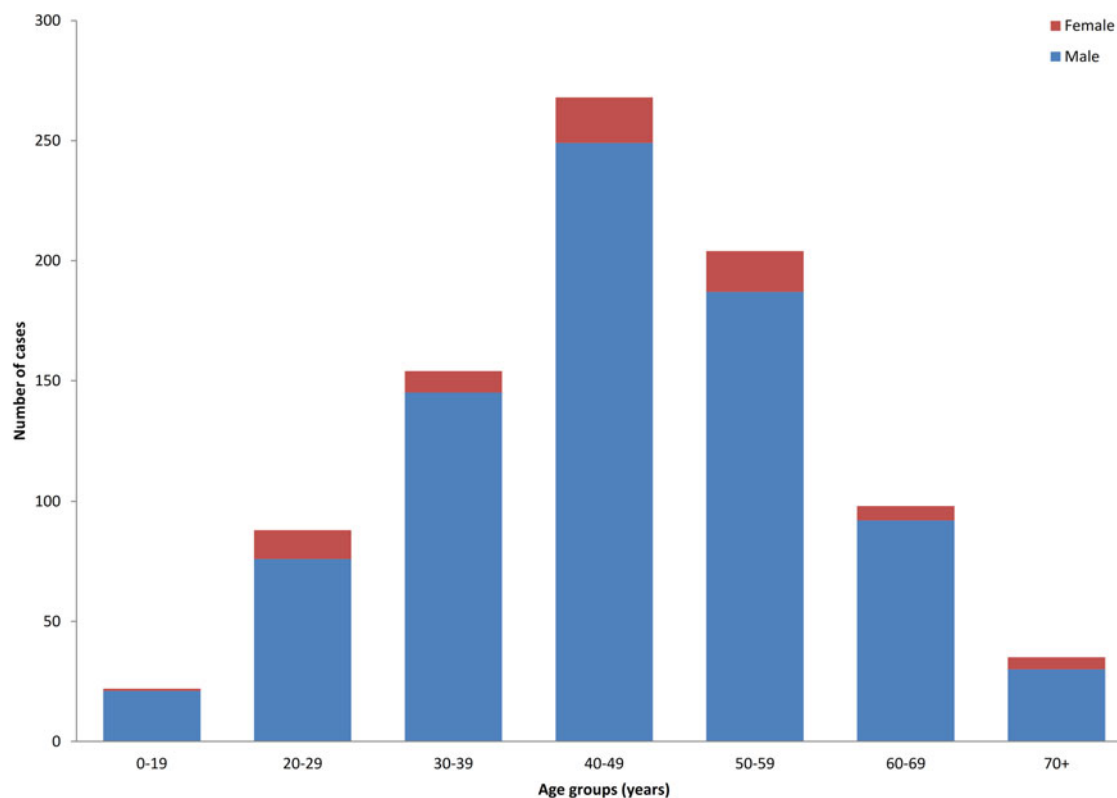


Fig. 1. Gender and age groups of Farmers' Survey respondents, 2015 ($n = 869$).

One-fifth (208) of all farmers and two-fifths (171) of dairy farmers reported drinking unpasteurised milk at least once a week (Fig. 2). Specialist dairy farmers were nine times more likely to report drinking unpasteurised milk at least once a week than specialist suckler farmers were. No significant differences were found in consumption of unpasteurised milk between younger and older farmers; those who knew what a zoonosis is and those who did not; and those who knew that children can get vomiting and diarrhoea from being around animals and those who did not.

DISCUSSION

Despite the well-recognised human disease risks associated with farm animals and the farming environment, a national survey of this type is, to our knowledge, unique. A review of the literature suggests that this subject has attracted little research.

This study shows considerable variation in respondents' knowledge. The farmers were well informed about the risk of infection from aborting and birthing animals, but were less aware that scouring stock, sick poultry and pets were potential infection sources, and that children can contract infectious gastroenteritis

from being around animals. Alarming, only 10% of farmers identified healthy animals as a possible infection source. A small survey of ruminant farm families in the USA [21] found that 70% of farmers did not think, or were unsure that, their knowledge of zoonotic diseases was sufficient to protect themselves or their family members. A Canadian study involving patients attending two urban physician practices found only 24% were aware that infectious diarrhoea could be transmitted from pets to humans [22]. Since awareness of the risk of infection from zoonoses is a prerequisite to infection prevention, it is concerning that farmers' knowledge of the sources of zoonotic infections is limited.

The age groups <45 years and 45+ years were used as an indicator having received vocational agricultural education. These age groups were chosen because in the early 1990s, exemptions from acquisition taxes and eligibility to receive farming grants in Ireland were linked to farmers having a certified vocational qualification in farming called 'The Green Cert' [23]. Therefore, it would be expected that farmers who came of age since the early 1990s, i.e. those under the age of 45 years, would be more likely to have formal farming education than those over 45 years. The

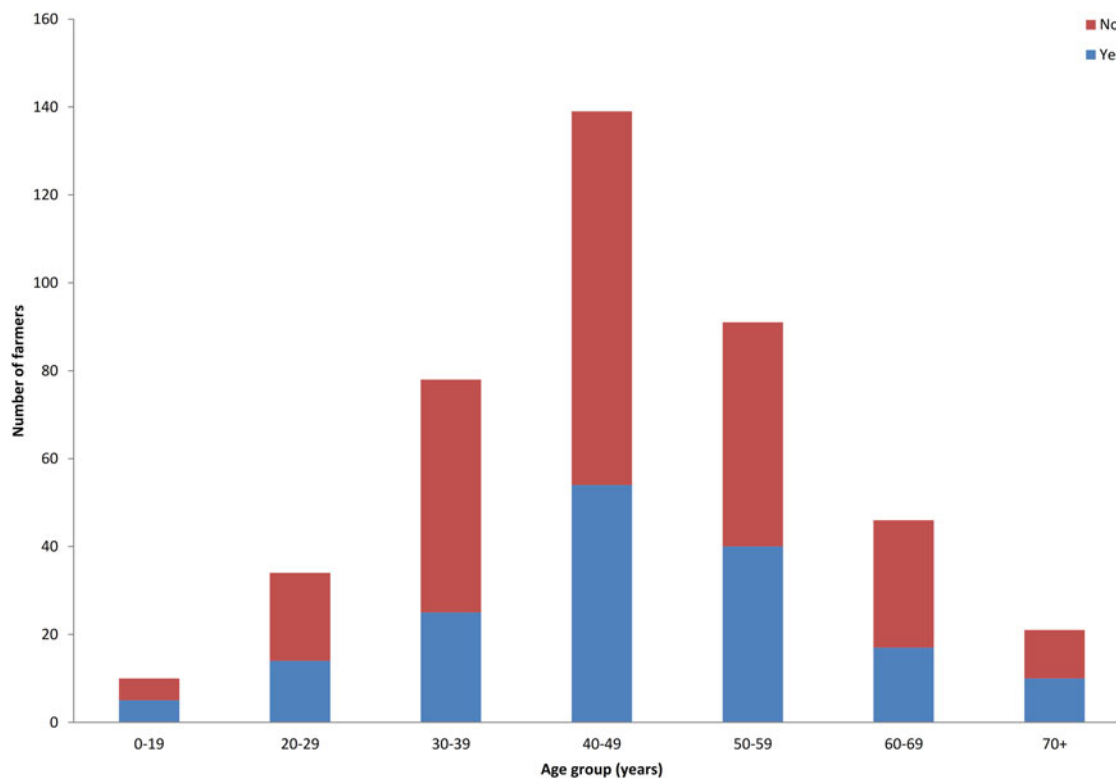


Fig. 2. Age groups of dairy farmers and their consumption of unpasteurised milk ($n = 419$)

category specialist dairy farming was used as an example of a highly regulated farming type where the farmer has a lot of interaction with animals, while the category of specialist suckler farmer was used as an example of a farming type with minimal regulation and where the farmer has little interaction with animals. Knowing that children can get diarrhoea from being around animals and knowing what a zoonosis is were used as two indicators of having an awareness of zoonoses and the risk of infections from animals.

Only one-third of survey respondents could correctly (from three possible options) define a zoonosis as 'a disease that a person can pick up from animals'. A study of a university community in Nigeria [24] found that only 19% those questioned had heard of the term 'zoonoses'. This is a reminder to those providing infection prevention and control advice to farmers to use plain English and to avoid use of medical terms.

Our results indicate that veterinarians are well placed, within the One Health approach, to help in the prevention of zoonoses. This would include providing specific risk-reduction advice about appropriate vaccinations, parasite preventatives and the use of PPE.

Approximately 40% of dairy farmers consume unpasteurised milk once, or more often than once a

week. It is not surprising that dairy farmers are more likely than suckler farmers to do so. In 1998, a prevalence study indicated that 84% of Irish dairy farming families consumed unpasteurised milk [25], while smaller studies since have put the figure at 72% [26] and 20% [27]. While our study may represent a real change in the percentage of dairy farmers consuming raw milk, or the difference may be due to sampling (farmers present with animals to the RVL for diagnosis, and to institute control measures on the farm, and are, therefore, possibly more conscious of health risks on the farm), the results indicate that dairy farmers continue to potentially expose themselves and their families, unnecessarily, to pathogenic organisms in their milk.

In Ireland, studies have shown *Listeria monocytogenes* [28, 29] and VTEC or *vt* gene [27, 30] contamination of the dairy farm environment and raw milk from bovine, caprine and ovine herds/flocks. In Ireland from 2013 to 2015, 2.7% of all cases of VTEC notified on the Irish central repository, Computerised Infectious Disease Reporting (CIDR) System, reported that they consumed unpasteurised milk or cheese [31]. In an outbreak affecting cattle and humans on an Irish dairy farm,

bovine tuberculosis had a significant impact on the health of two young children who drank unpasteurised milk [32].

Hegarty *et al.* [26] cited the main reasons for the continued consumption of raw milk as confidence in its safety, cost, convenience, taste and tradition. They also found that farmers believed that if routine tests of milk for total and somatic cell counts and brucellosis are 'clear', and then the milk is safe to use. The fact that their animals were not showing clinical signs of disease afforded them further confidence in the safety of the milk [26]. In our survey, only 10% of farmers were aware that it is possible to contract disease from apparently healthy animals. It is healthy animals that contribute milk to the bulk tank, from which unpasteurised milk would be taken, giving a false sense of security to the consumers of unpasteurised milk.

Fifty-nine per-cent of farmers said that a private well was their only source (55%), or one of their sources (4%) of drinking water. Water charges were introduced in Ireland in 2014 (since suspended), and this may have had an impact on private well ownership since then. There was a national census in 2016, and a comparative figure to the 48% cited by the CSO for 2011 [14] will be available when these data are published. It is not surprising that a high proportion of farmers have private wells, but does illustrate a risk to which farmers, their families, and visitors to their homes may be exposed if the well is not properly constructed, protected and tested.

It is recommended that private wells, while not regulated (European Communities Drinking Water Regulations 2014 [33]), should comply with the water quality standards [34], which have been set in order to protect human health. Moreover, farmers who are primary producers and food business operators (e.g. dairy farmers) are obliged under European Communities Hygiene of Foodstuffs regulations [23] to use potable water that complies with the drinking-water regulations [33]. Our results indicate that guidance on safe construction and protection of private wells [16, 35] needs to be targeted at the agricultural community. In this survey, almost 20% of those with a private well at home had never had it tested and 45% have their well tested less often than annually. The IGI states that there is a need for standards to regulate the drilling, construction, testing and sealing of water wells [16].

The risk to human health to people working and visiting farms, through exposure to animals and the farm environment, is real [36–38]. The risk can be reduced by taking practical measures to reduce

exposure to zoonotic agents, e.g. proper use of PPE, and taking practical measures to mitigate against infection arising from exposure, e.g. hand washing. A reassuring 93% of respondents reported washing their hands before eating or smoking while on the farm. The impact of hand hygiene in reducing infectious disease risks among the farming community could be increased by convincing people to wash their hands correctly, and at the correct time [38].

A large number of respondents wore gloves when carrying out particular tasks. The benefits of gloves when used and disposed of properly are well documented [8]. Unfortunately, this survey did not establish whether farmers are aware that wearing gloves is not a substitute for hand washing.

Thirty per cent of respondents did not wear a boiler suit/wet gear, and of those who did, one quarter did not remove these potentially contaminated garments when entering the family home. The Food Safety Authority of Ireland recognises this risk and recommends that farm work clothes or footwear are not worn in the home because they can spread *E. coli* [39].

Even though older farmers are less likely to be aware of the science, they are more likely to carry out basic practices (hand-washing) for disease prevention. Younger farmers are more likely to know that they can catch an infection from healthy animals, from sick poultry, and from pets. However, older farmers are more likely to wash their hands before eating or smoking on the farm; after handling sick animals; and in the morning and evening. Specialist dairy farmers are more likely than specialist suckler farmers to know what a zoonosis is and, that they or a family member might get an infection from aborting cows/ewes/sows. Specialist dairy farmers are more likely than specialist suckler farmers to have their well water tested annually and to wear gloves while working (they are primary producers and obliged to adhere to European Communities Hygiene of Foodstuffs regulations [40]).

In terms of behaviour and knowledge, no significant differences were found in hand-washing/glove-wearing opportunities between those who knew what a zoonosis is and those who did not; and those who knew that children can get vomiting and diarrhoea from being around animals and those who did not.

As the respondents are farmers who attended RVLs to investigate ill-health in their animals, the sample may be biased in favour of farmers with more knowledge of zoonoses and infection prevention practices. Therefore, it is possible that our study may over estimate farmers' knowledge of zoonoses and infection

prevention practices. The results illustrate the need for further education, in plain language, to increase the awareness of potential biohazards on farms, and practical measures that can be taken to mitigate the risk of zoonotic infection. The fact that most farmers accessed information on diseases on the farm from multiple sources, suggests that a multi-faceted, One Health approach to health protection in the farming community is merited. Evidence shows that building partnerships with agencies providing services in rural communities and trusted sources of information for the target population (e.g. farmer and country women's organisations, government departments, financial organisations, etc.), to provide information and training are effective ways of engaging with health promotion activities in farming and rural communities [41–43].

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DECLARATION OF INTEREST

None.

DISCLAIMERS

None.

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