Originally published as:

Bernard, H., Brockmann, S.O., Kleinkauf, N., Klinc, C., Wagner-Wiening, C., Stark, K., Jansen, A.
High seroprevalence of Coxiella burnetii antibodies in veterinarians associated with Cattle Obstetrics, Bavaria, 2009
(2012) Vector-Borne and Zoonotic Diseases, 12 (7), pp. 552-557.

DOI: 10.1089/vbz.2011.0879

High seroprevalence of *Coxiella burnetii* antibodies in veterinarians associated with cattle obstetrics, Bavaria, 2009

Helen Bernard, MD
Robert Koch Institute, Department for Infectious Disease Epidemiology
E-mail: bernardh@rki.de

Stefan O. Brockmann, MD
Robert Koch Institute, Berlin, Germany; Postgraduate Training for Applied Epidemiology, Berlin, Germany; Baden-Wuerttemberg State Health Authority, Stuttgart, Germany. Current affiliation: Local Health Authority, Reutlingen, Germany
Email: stefan_brockmann@kreis-reutlingen.de

Niels Kleinkauf, MD
Robert Koch Institute, Berlin, Germany; Postgraduate Training for Applied Epidemiology, Berlin, Germany. Current affiliation: European Centre for Disease Prevention and Control, Stockholm, Sweden
Email: niels.kleinkauf@ecdc.europa.eu

Christina Klinc, MD MPH
Bavarian Health and Food Safety Authority, Oberschleissheim, Germany
Email: christina.klinc@lgl.bayern.de

Christiane Wagner-Wiening, DSc
Baden-Wuerttemberg State Health Authority, Stuttgart, Germany
Email: christiane.wagner-wiening@rps.bwl.de

Klaus Stark, MD MSc (Epi) DTMH PhD
Robert Koch Institute, Berlin, Germany
Email: starkk@rki.de

Andreas Jansen, MD
Robert Koch Institute, Berlin, Germany. Current affiliation: European Centre for Disease Prevention and Control, Stockholm, Sweden
Email: andreas.jansen@ecdc.europa.eu

Keywords: *Coxiella burnetii*; Q Fever; Veterinarians; Seroepidemiologic Studies; Cross-Sectional Studies; Cattle

Abstract

Q fever is a zoonosis caused by *Coxiella burnetii*. Infection can result in severe disease, however, little is known about the risk of infection in veterinarians.

In a cross-sectional study among German veterinarians, participants provided sera and completed an exposure questionnaire. We investigated predictors for seropositivity using multivariable logistic regression modelling.

The 424 participants' median age was 40 (18-74) years, 276 (65%) were female. Sera of 162 (38%) were positive for *Coxiella burnetii* phase II IgG antibodies (ELISA and IFAT). Predictors for seropositivity were occupational exposure to cattle (aOR 2.83; 95%CI 1.64-4.87), occupational exposure to sheep (2.09; 1.22-3.58), male sex (1.9; 1.15-3.13), and increasing age (30-39 year-olds: 4.91, 2.00-12.04; 40-49 year-olds: 5.32, 2.12-13.33; >50 year-olds: 6.70, 2.60-17.25; compared with <30 year-olds). When investigating occupational exposure to cattle and sheep in detail in a separate model, the seroprevalence increased with increasing numbers of cattle obstetrics performed per month and with increasing numbers of individual cattle treated per week.

The high antibody prevalence implies a high lifetime-risk of Q fever in veterinarians. Cattle veterinarians, especially those frequently performing obstetrics, should be counselled early in their career on the clinical picture of Q fever and on specific risks.

Introduction

Q fever is a bacterial zoonosis with worldwide distribution caused by the intracellular bacterium *Coxiella* (*C.*) *burnetii*. In humans, the clinical picture ranges from asymptomatic infection (60%) to severe acute disease including pneumonia, hepatitis, carditis, and meningoencephalitis (Hartzell et al. 2008, Maurin et al. 1999, Parker et al. 2006, Raoult et al. 2005). In 1-2% of acute symptomatic cases, chronic Q fever may develop as a serious complication (Fenollar et al. 2001, Raoult et al. 2000, Tissot-Dupont et al. 2007). Particularly persons with pre-existing heart valve disease, prosthetic valves or vascular grafts are at risk to develop chronic disease which in 60-70% of patients manifests as culture-negative endocarditis with a case fatality up to 50% (Brouqui et al. 1993, Fenollar et al. 2001, Fournier et al. 2010, Limonard et al. 2010, Million et al. 2010, Raoult et al. 2000).

Transmission mainly occurs through inhalation of aerosolized contaminated materials. Small ruminants and cattle livestock are the most common reservoir animals for *C. burnetii* in Europe. Infected animals shed the organism in milk, faeces, urine, and birth by-products. Especially the latter contain large numbers of bacteria which may become aerosolized after drying and remain virulent in the environment for months (Hartzell et al. 2008, Maurin et al. 1999, Parker et al. 2006). A recent Q fever outbreak in The Netherlands linked to dairy goat farms demonstrated the difficulties of controlling the disease in reservoir animals and the potential for large human outbreaks including fatalities associated with animal farming (Roest et al. 2010, Schimmer et al. 2010, van der Hoek et al. 2010).

In Germany, Q fever is endemic in the Southern federal states of Hesse, Bavaria and Baden-Wuerttemberg, and outbreaks have occurred repeatedly in the past (Gilsdorf et al. 2008, Hellenbrand et al. 2001, Lyytikainen et al. 1997, Lyytikainen et al. 1998, Porten et al. 2006, Robert Koch-Institut 2008). Most of them were associated with exposure to sheep, whereas goat farming does not play a major role in Germany.

Although veterinarians are assumed to be at risk for Q fever due to their frequent exposure to animals, large scale studies and systematic risk factor analyses are absent in Europe. In two small descriptive studies from Denmark and Slovakia, 36% and 15% of tested veterinarians were seropositive for *C. burnetii* (Bosnjak et al. 2010, Dorko et al. 2008), emphasizing the need for more in-depth analyses.

We determined the serological status of veterinarians against *C. burnetii* and investigated factors associated with seropositivity to improve recommendations for early diagnosis of acute and chronic Q fever and prevention of chronic infections in this sub-population.

Materials and Methods

Data collection

We conducted a seroepidemiological and occupational risk survey among attendants of the Bavarian Veterinarians Conference held in May 2009. Approximately 1,400 persons were expected to attend the conference. Attendants were mostly from the federal state of Bavaria (87%) and, to a lesser extent, from neighbouring Baden-Wuerttemberg (4%). They were eligible for participation in the cross-sectional study if they were ≥18 years old and provided written informed consent. From each participant we collected a blood sample in a 10 mL serum separator tube and information on demographics, current field of occupational activity, exposures during the 12 months preceding the study, and use of personal protective equipment during work using a self-administered standardized questionnaire. Participants whose serological results indicated recent or chronic infection with *C. burnetii* (see Laboratory procedures), were asked to provide a follow-up serum sample taken by a general practitioner.

Laboratory procedures

Tubes were centrifuged on site and stored at -20°C until testing. Serum samples were screened for *C. burnetii* phase II IgG antibodies by an enzyme-linked immuno-sorbent

assay (ELISA, Virion/Serion). If screened positive (>30 U/ml) or borderline (20-30 U/ml), we performed a phase II IgM ELISA. Positive samples were confirmed and quantified by an immunofluorescence test (IFAT, BIOS/Focus, Cypress, CA) for phase I and phase II IgG (Wagner-Wiening et al. 2006). Samples with simultaneously high (≥1:512) phase II and phase I IgG antibody titres were considered to potentially have beginning or already existing chronic infection and were tested for *C. burnetii* by PCR assay (Fenollar et al. 2007).

Data analysis

We compared seroprevalence in exposed and unexposed using the Chi-square test and calculated 95% confidence intervals for the prevalence ratio which we used as risk measure. All variables associated with seropositivity in univariable analyses (two-sided P values <0.2) were included in the initial multivariable logistic regression model and were then excluded in a stepwise backward selection procedure. Due to missing values for some of the covariates we applied the exclusion criterion of P>0.1 and subsequently of P>0.05. The final model (Model 1) was re-run including all participants with non-missing values on the final covariates. Based on these results we ran an additional analysis replacing the animal exposure variables in the final model with the following sub-variables for each animal group: monthly number of obstetrics performed, weekly number of individual animals treated, and weekly number of animal herds treated (Model 2). Again we applied the same model selection procedure as above. Age-group and sex were forced-in covariates in all models. We used Epidata (Odense, Denmark) for data entry and Stata (College Station, Texas, USA) for all analyses.

The study was approved by the ethics committee of the Charité, University Medicine, Berlin, Germany, on 30 April 2009 (proposal EA2/041/09).

Results

Descriptive epidemiology

In total, 424 of 1,400 expected conference attendants (30%) participated in the study, 276 (65%) were female, 367 (87%) were from the federal state of Bavaria. Information on number and characteristics of non-responders was not available. Male participants were older than female participants (median age 48 vs. 37 years, $p<0.0001$, Wilcoxon rank-sum test).

A total of 207 participants (49%) reported occupational exposure to cattle, 147 (35%) to sheep, 127 (30%) to birds (114 (27%) of these only to pet birds), 116 (27%) to horses, 110 (26%) to pigs, 83 (20%) to goats and 276 (65%) to small animals (53 (13%) of these to small animals only). The matrix of reported exposure to cattle, sheep and goats is shown in **Table 1**.

Of the participants with occupational exposure to cattle, sheep or goats, 70%, 58% and 46% reported to perform obstetric activity on these animals, respectively.

Serological results

Sera of 162 (38%) participants had positive or borderline phase II IgG antibody titre results, including 18 (4%) participants with simultaneously elevated phase II IgG and IgM antibody concentrations indicating recent infection with *C. burnetii*. Phase II IgG antibody concentrations ranged from 20 to >500 U/ml (ELISA) and from ≥1:16 to ≥1:2048 (IFAT), phase I IgG from ≥1:16 to ≥1:1024 (IFAT). In 17 (4%) participants, chronic Q fever could not be excluded initially. PCR tests were negative in all 17. Of these, 16 provided a follow-up serum 4 to 8 months after the initial sampling, 3 of which showed significantly decreasing antibody titres (twofold phase II and/or phase I IgG antibody endpoint decrease) indicating serological recovery. In the other 13 participants titres remained unchanged.

Risk factor analyses

In the univariable analyses we identified various exposures significantly associated with seropositivity (**Table 2**). Of the 20 variables included in the first multivariable logistic

regression model, the following were independently associated with seropositivity (Model 1, **Table 3**): occupational exposure to cattle, occupational exposure to sheep, male sex, and increasing age. Looking at occupational exposure to cattle and sheep in more detail in the second logistic regression model (Model 2, **Table 3**), the adjusted odds ratio increased with increasing numbers of cattle obstetrics performed per month and with increasing numbers of individual cattle treated per week.

Discussion

In this cross-sectional study among German veterinarians we found an unexpectedly high *C. burnetii* antibody prevalence implying a high lifetime risk of Q fever for this occupational group. The seroprevalence we found is considerably higher than the 0-18% derived from a small study among the general population in Baden-Wuerttemberg, the federal state neighboring Bavaria (Brockmann et al., in preparation). It is also higher than the 13-22% found in studies among veterinarians in the United States, Australia, Japan and Slovakia (Abe et al. 2001, Casolin1999, Dorko et al. 2008, Whitney et al. 2009) but comparable to the 36% found in Denmark (Bosnjak et al. 2010). Whether the high seroprevalence correlates with a high disease burden cannot be explained by our study.
In our analyses, the variables for occupational exposure to cattle were the best predictors for seropositivity, followed by occupational exposure to sheep which was also associated with seropositivity in a recent US study (Whitney et al. 2009). To our knowledge this is the first time that an association between cattle obstetrics and *C. burnetii* seropositivity has been established through an analytical study. Our cross-sectional study design does not allow us to determine whether the exposures preceded the outcome and thus to evaluate causality. However, the strength of the association, the positive dose-response relationship, the biological plausibility and the analogy with birth products of small ruminants being a

source of infection with *C. burnetii* for humans argues for a causal relationship between performing cattle obstetrics and seropositivity.

In order to limit recall bias we only acquired information on exposures during the 12 months preceding the study. Exposures prior to this time period, e.g. to sheep or goats, may have confounded the association between exposure to cattle and seropositivity. However, from our data we have no evidence that this was the case in our study population.

The impact of an animal species on the transmission of Q fever to humans presumably depends on the main types of exposure to an animal species in a population and the infection rate of these animals. Whereas in The Netherlands extensive goat farming has contributed to one of the biggest Q fever outbreaks in history, in Germany cattle farming is the predominant type of animal farming. The number of cattle on farms was 12.6 millions in 2010, compared to 2.2 million sheep and 124,200 goats (Federal Statistical Office 2010). A recent survey among cattle in Bavaria found a seroprevalence of 15% and a herd prevalence of 72% of *C. burnetii* antibodies (Böttcher et al. 2011) indicating a wide spread of infection among animals offering a wide source of exposure for veterinarians.

Our study population was a convenience sample of veterinarians and may not be entirely representative of veterinarians in Bavaria or in Germany. Although veterinarians in Germany are represented in terms of distribution of age, sex, and types of animal practices according to official statistics (Federal Association of Veterinarians 2010), differences in infection rates of the different animal species between regions may lead to differences in seroprevalence.

C. burnetii is considered a class 3 biological agent, and regulations exist regarding protective measures for activities involving biological agents in agriculture (Federal Institute for Occupational Safety and Health 2004). Accordingly, Q fever is recognized as an occupational disease in Germany (Federal Act on Occupational Diseases 2009), however, to our knowledge the topic of occupational health and safety is not included in

the curriculum of veterinary faculties in Germany. In addition to increased efforts on informing veterinarians and veterinarian apprentices about Q fever and potential sources of infection, education on the use of personal protective equipment and a safe vaccination would be desirable. A whole-cell vaccine licensed in Australia for the use in risk groups shows >80% efficacy against clinical disease but increased reactogenity in previously seropositive subjects (Chiu et al. 2007, Zhang et al. 2004). This vaccine is not licensed in Europe to date, but licensure for specific risk groups could be considered.

Conclusions

We recommend that awareness should be raised among veterinarians at an early point in their career about the clinical picture of Q fever and about cattle as potential sources of infection with *C. burnetii*, in addition to small ruminants which are often in the focus of public attention regarding Q fever. Education on occupational health and safety should be an obligatory component of the curriculum of veterinary faculties in Germany.

Acknowledgments

The authors wish to thank Pia Geppert for making this study possible on site, Lucie N'koy and Philipp Richter for entering the data, Michael Höhle for statistical support, and Christina Frank, Judith Koch and Dirk Werber for their critical review of the questionnaire.

No external funding was received for this study.

No competing financial interests exist.

References

Federal Act on Occupational Diseases. 11-6-2009. Available from: http://www.gesetze-im-internet.de/bkv/BJNR262300997.html.

Abe T, Yamaki K, Hayakawa T, Fukuda H et al. A seroepidemiological study of the risks of Q fever infection in Japanese veterinarians. Eur J Epidemiol 2001;17:1029-1032.

Bosnjak E, Hvass AM, Villumsen S, Nielsen H. Emerging evidence for Q fever in humans in Denmark: role of contact with dairy cattle. Clin Microbiol Infect 2010;16:1285-1288.

Böttcher J, Vossen A, Janowetz B, Alex M et al. Insights into the dynamics of endemic Coxiella burnetii infection in cattle by application of phase-specific ELISAs in an infected dairy herd. Vet Microbiol 2011;151:291-300.

Brouqui P, Dupont HT, Drancourt M, Berland Y et al. Chronic Q fever. Ninety-two cases from France, including 27 cases without endocarditis. Arch Intern Med 1993;153:642-648.

Casolin A. Q fever in New South Wales Department of Agriculture workers. J Occup Environ Med 1999;41:273-278.

Chiu CK, Durrheim DN. A review of the efficacy of human Q fever vaccine registered in Australia. NSW Public Health Bull 2007;18:133-136.

Dorko E, Kalinova Z, Weissova T, Pilipcinec E. Seroprevalence of antibodies to Coxiella burnetii among employees of the Veterinary University in Kosice, eastern Slovakia. Ann Agric Environ Med 2008;15:119-124.

Federal Association of Veterinarians. Statistics 2009: Veterinarians in the Federal Republic of Germany [in German]. 2010. Available from: http://www.bundestieraerztekammer.de/datei.htm?filename=dtb_04_s_500-505_statistik.pdf&themen_id=4980.

Federal Institute for Occupational Safety and Health. Biological Agents Ordinance. 23-12-2004. Available from: http://www.baua.de/de/Themen-von-A-Z/Biologische-

Arbeitsstoffe/Rechtstexte/pdf/biological-agents-ordinance pdf?__blob=publicationFile&v=3.

Federal Statistical Office. Structures of agricultural enterprises [in German]. 2010. Available from: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Statistiken/LandForstwirtschaft/StrukturenLandwirtschaftlicherBetriebe/Aktuell,templateId=renderPrint psml.

Fenollar F, Fournier PE, Carrieri MP, Habib G et al. Risks factors and prevention of Q fever endocarditis. Clin Infect Dis 2001;33:312-316.

Fenollar F, Raoult D. Molecular diagnosis of bloodstream infections caused by non-cultivable bacteria. Int J Antimicrob Agents 2007;30 Suppl 1:S7-15.

Fournier PE, Thuny F, Richet H, Lepidi H et al. Comprehensive diagnostic strategy for blood culture-negative endocarditis: a prospective study of 819 new cases. Clin Infect Dis 2010;51:131-140.

Gilsdorf A, Kroh C, Grimm S, Jensen E et al. Large Q fever outbreak due to sheep farming near residential areas, Germany, 2005. Epidemiol Infect 2008;136:1084-1087.

Hartzell JD, Wood-Morris RN, Martinez LJ, Trotta RF. Q fever: epidemiology, diagnosis, and treatment. Mayo Clin Proc 2008;83:574-579.

Hellenbrand W, Breuer T, Petersen L. Changing epidemiology of Q fever in Germany, 1947-1999. Emerg Infect Dis 2001;7:789-796.

Limonard GJ, Nabuurs-Franssen MH, Weers-Pothoff G, Wijkmans C et al. One-year follow-up of patients of the ongoing Dutch Q fever outbreak: clinical, serological and echocardiographic findings. Infection 2010;38:471-477.

Lyytikainen O, Ziese T, Schwartlander B, Matzdorff P et al. Outbreak of Q fever in Lohra-Rollshausen, Germany, spring 1996. Euro Surveill 1997;2:9-11.

Lyytikainen O, Ziese T, Schwartlander B, Matzdorff P et al. An outbreak of sheep-associated Q fever in a rural community in Germany. Eur J Epidemiol 1998;14:193-199.

Maurin M, Raoult D. Q fever. Clin Microbiol Rev 1999;12:518-553.

Million M, Thuny F, Richet H, Raoult D. Long-term outcome of Q fever endocarditis: a 26-year personal survey. Lancet Infect Dis 2010;10:527-535.

Parker NR, Barralet JH, Bell AM. Q fever. Lancet 2006;367:679-688.

Porten K, Rissland J, Tigges A, Broll S et al. A super-spreading ewe infects hundreds with Q fever at a farmers' market in Germany. BMC Infect Dis 2006;6:147.

Raoult D, Marrie T, Mege J. Natural history and pathophysiology of Q fever. Lancet Infect Dis 2005;5:219-226.

Raoult D, Tissot-Dupont H, Foucault C, Gouvernet J et al. Q fever 1985-1998. Clinical and epidemiologic features of 1,383 infections. Medicine (Baltimore) 2000;79:109-123.

Robert Koch-Institut. Q fever: Increased occurrence in spring 2008 [in German]. Epid Bulletin 2008;199-203.

Roest HIJ, Tilburg JJHC, van der Hoek W, Vellema P et al. The Q fever epidemic in The Netherlands: history, onset, response and reflection. Epidemiol Infect 2010;Epub, ahead of print:1-12.

Schimmer B, ter SR, Wegdam M, Zuchner L et al. The use of a geographic information system to identify a dairy goat farm as the most likely source of an urban Q-fever outbreak. BMC Infect Dis 2010;10:69.

Tissot-Dupont H, Vaillant V, Rey S, Raoult D. Role of sex, age, previous valve lesion, and pregnancy in the clinical expression and outcome of Q fever after a large outbreak. Clin Infect Dis 2007;44:232-237.

van der Hoek W, Dijkstra F, Schimmer B, Schneeberger PM et al. Q fever in the Netherlands: an update on the epidemiology and control measures. Euro Surveill 2010;15:19520.

Wagner-Wiening C, Brockmann S, Kimmig P. Serological diagnosis and follow-up of asymptomatic and acute Q fever infections. Int J Med Microbiol 2006;296 Suppl 40:294-296.

Whitney EA, Massung RF, Candee AJ, Ailes EC et al. Seroepidemiologic and occupational risk survey for Coxiella burnetii antibodies among US veterinarians. Clin Infect Dis 2009;48:550-557.

Zhang G, Samuel JE. Vaccines against Coxiella infection. Expert Rev Vaccines 2004;3:577-584.

Corresponding author:

Helen Bernard
Robert Koch Institute
Department for Infectious Disease Epidemiology
DGZ-Ring 1
13086 Berlin
Germany
E-mail: bernardh@rki.de

Table 1: Distribution of occupational exposure to cattle, sheep, and goats, among study participants. Cross-sectional study among veterinarians, Bavaria, 2009.

		Cattle NO			Cattle YES		
		Goats			Goats		
		NO	YES	Total	NO	YES	Total
Sheep	NO	200	1	201	72	4	76
	YES	10	6	16	59	72	131
	Total	210	7	217	131	76	207

Table 2: Results of the univariable risk factor analysis. Cross-sectional study among veterinarians, Bavaria, 2009. PR= prevalence ratio, CI=confidence interval, significant results (P<.05) bold, *=variable included in initial multivariable model.

	Exposed			Unexposed					
Exposure variable	No. total with information	No. seropositive	Sero-prevalence (%)	No. total with information	No. seropositive	Sero-prevalence (%)	PR	95%CI	P
Animal exposures									
Any exposure to cattle	218	116	53	206	46	22	2,38	1.79-3.16	**0,000**
- Occupational	207	115	56	217	47	22	2,57	1.94-3.40	**0.000***
-- Cattle obstetrics	145	94	65	279	68	24	2,66	2.09-3.38	**0,000**
-- Treating individual cattle	184	109	59	235	52	22	2,68	2.05-3.50	**0,000**
-- Treating cattle herds	178	104	58	239	57	24	2,45	1.89-3.17	**0,000**
- Non-occupational	38	11	29	383	151	39	0,73	0.44-1.23	0,205
Any exposure to sheep	153	89	58	271	73	27	2,16	1.70-2.74	**0,000**
- Occupational	147	89	61	277	73	26	2,3	1.81-2.91	**0.000***
-- Sheep obstetrics	85	61	72	339	101	30	2,41	1.95-2.97	**0,000**
-- Treating individual sheep	109	69	63	310	92	30	2,13	1.71-2.67	**0,000**
-- Treating sheep flocks	92	54	59	325	107	33	1,78	1.41-2.25	**0,000**
- Non-occupational	23	7	30	398	155	39	0,78	0.42-1.47	0,415
Any exposure to goats	90	53	59	334	109	33	1,80	1.43-2.27	**0,000**
- Occupational	83	52	63	341	110	32	1,94	1.55-2.44	**0.000***
-- Goat obstetrics	38	28	74	386	134	35	2,12	1.68-2.68	**0,000**
-- Treating individual goats	5	1	20	419	161	38	0,52	0.09-3.02	0,399
-- Treating goat flocks	58	33	57	359	128	36	1,60	1.23-2.08	**0,002**
- Non-occupational	14	5	36	407	157	39	0,93	0.45-1.89	0,829
Any exposure to pigs	121	66	55	303	96	32	1,72	1.37-2.17	**0,000**
- Occupational	110	62	56	314	100	32	1,77	1.41-2.23	**0.000***
-- Pig obstetrics	58	31	53	366	131	36	1,49	1.13-1.97	**0,010**
-- Treating individual pigs	20	7	35	404	155	38	0,91	0.50-1.68	0,762
-- Treating pig herds	101	57	56	316	104	33	1,71	1.36-2.16	**0,000**
- Non-occupational	18	6	33	403	156	39	0,86	0.44-1.67	0,646
Any exposure to horses	191	79	41	233	83	36	1,16	0.91-1.48	0,226
- Occupational	116	59	51	308	103	33	1,52	1.20-1.93	**0.001***
-- Horse obstetrics	38	22	58	386	140	36	1,60	1.18-2.16	**0,009**
-- Treating individual horses	109	57	52	310	104	34	1,56	1.23-1.98	**0,001**
-- Treating horse herds	16	7	44	408	155	38	1,15	0.65-2.03	0,642
- Non-occupational	164	51	31,1	257	111	43,19	0,72	0.55-0.94	**0.013***
Any exposure to birds	152	51	34	272	111	41	0,82	0.63-1.07	0,140
- Occupational	127	44	35	297	118	40	0,87	0.66-1.15	0,324
-- Treating individual birds	118	41	35	300	120	40	0,87	0.65-1.15	0,320
-- Treating poultry flocks	13	5	38	411	157	38	1,01	0.50-2.02	0,985
- Non-occupational	47	12	26	374	150	40	0,64	0.38-1.05	0.053*
Any exposure to dogs	361	133	37	63	29	46	0,80	0.59-1.08	0,166
- Occupational	259	93	36	160	68	43	0,84	0.66-1.08	0.178*
- Non-occupational	276	100	36	145	62	43	0,85	0.66-1.08	0.191*
Any exposure to cats	343	129	38	81	33	41	0,92	0.69-1.24	0,602
- Occupational	254	95	37	165	66	40	0,94	0.73-1.20	0,593
- Non-occupational	270	99	37	151	63	42	0,88	0.69-1.12	0,307
Any exposure to small animals	205	65	32	219	97	44	0,72	0.56-0.92	**0,008**
- Occupational	168	49	29	251	112	45	0,65	0.50-0.86	**0.001***
- Non-occupational	65	21	32	356	141	40	0,82	0.56-1.19	0,266
Exposure to Q fever infected animal	24	18	75	346	127	37	2,04	1.56-2.67	**0.000***
Animal bite	312	118	38	103	42	41	0,93	0.71-1.22	0,593
Needlestick injury during work	290	126	43	122	32	26	1,66	1.20-2.29	**0.001***
Male sex	146	81	55	276	81	29	1,89	1.50-2.39	**0.000***
Age group [years]									
<30	64	7	11				Ref.		*
30-39	138	54	39	64	7	11	3,58	1.73-7.42	**0,000**
40-49	118	48	41	64	7	11	3,72	1.79-7.74	**0,000**
≥50	102	53	52	64	7	11	4,75	2.30-9.80	**0,000**
Use of personal protective equipment									
Hand disinfection after									
- exposure to potentially infectious agents	312	119	38	71	36	51	0,75	0.57-0.98	0.052*
- general exposure to patients	139	50	36	239	102	43	0,84	0.65-1.10	0,200
Washing hands after									
- exposure to potentially infectious agents	384	150	39	4	3	75	0,52	0.29-0.93	0.143*
- general exposure to patients	354	143	40	31	10	32	1,25	0.74-2.12	0,375
Wearing gloves during general exposure to patients	73	35	48	315	118	37	1,28	0.97-1.69	0.099*
Wearing face mask during general exposure to patients	4	2	50	381	150	39	1,27	0.47-3.41	0,665
Dietary exposures									
Wild boar liver	25	9	36	379	146	39	0,93	0.55-1.60	0,802
Wild boar meat	152	62	41	237	87	37	1,11	0.86-1.43	0,419
Pig liver	100	41	41	306	115	38	1,09	0.83-1.44	0,542
Pork	143	60	42	267	98	37	1,14	0.89-1.47	0,298
Venison	193	84	44	189	65	34	1,27	0.98-1.63	0.067*
Raw milk	180	62	34	229	98	43	0,80	0.63-1.03	0.086*
Offals	125	55	44	259	91	35	1,25	0.97-1.62	0.094*
Leisure time activities									
Hunting	28	13	46	381	142	37	1,25	0.82-1.89	0,335
Water sports	342	129	38	82	33	40	0,94	0.70-1.26	0,673
Playing golf	9	4	44	400	151	38	1,18	0.56-2.47	0,682
Gardening	243	92	38	166	63	38	1,00	0.77-1.28	0,985
Walking in the woods	341	128	38	68	27	40	0,95	0.68-1.31	0,736
Camping	86	33	38	323	122	38	1,02	0.75-1.37	0,919

Table: Results of the univariable risk factor analysis. Cross-sectional study among veterinarians, Bavaria, 2009. PR= prevalence ratio, CI=confidence interval, significant results (P<.05) bold, *=variable included in initial multivariable model.

Table 3: Results of the final logistic regression models of the multivariable risk factor analysis. In model 2 the variables for occupational exposure to cattle and sheep were replaced with the following three sub-variables, respectively: weekly number of individual cattle/sheep treated, monthly number of cattle/sheep obstetrics procedures performed, and weekly number of cattle herds/sheep flocks treated. n/i=variable removed from multivariable model during model selection process and therefore not included in the final model, aOR=adjusted odds ratio, CI=confidence interval.

	Model 1 (n=421)			Model 2 (n=400)		
Exposure variable	aOR	95%CI	P	aOR	95%CI	P
Occupational exposure to cattle	2.83	1.64-4.87	<0.001			
- Weekly number of individual cattle treated				1.01	1.00-1.02	0.005
- Monthly number of cattle obstetrics performed				1.13	1.04-1.22	0.003
- Weekly number of cattle herds treated					n/i	
Occupational exposure to sheep	2.09	1.22-3.58	0.007			
- Weekly number of individual sheep treated					n/i	
- Monthly number of sheep obstetrics performed					n/i	
- Weekly number of sheep flocks treated					n/i	
Male sex	1.90	1.15-3.13	0.012	1.71	1.01-2.89	0.044
Age group [years]						
<30	Ref.					
30-39	4.91	2.00-12.04	0.001	4.59	1.83-11.51	0.001
40-49	5.32	2.12-13.33	<0.001	4.98	1.95-12.71	0.001
≥50	6.70	2.60-17.25	<0.001	4.64	1.76-12.25	0.002