Zoonotic illness – determining risks and measuring effects: association between current animal exposure and a history of illness in a well characterised rural population in the UK

D Rh Thomas, R L Salmon, S M Kench, D Meadows, T J Coleman, P Morgan-Capner, K L Morgan

Abstract

Study objectives – To recruit a representative sample of farmworkers, accurately quantify the range and extent of their animal exposures, and measure the associated risks of illness.

Design – Inception cohort.

Setting – The study was undertaken among farmworkers living in five local authority areas in the catchment of Hereford and Preston Public Health Laboratories, England.

Participants – A quota sample of 404 people on 255 agricultural holdings took part. The holdings were selected at random from the Ministry of Agriculture, Fisheries and Food register. Altogether 58% of eligible subjects approached agreed to participate.

Measurements and main results – The sample had the same sex distribution as the 1991 census for those giving their occupation as agriculture. The mean age was significantly ($p < 0.01$) higher (44.6 years *v* 42.2 years) than that of those giving their occupation as agriculture, forestry or fishing in the census, although the modal range (45–59 years) was the same. At enrolment interviews, subjects individually reported contact with up to nine animal species (mode 4) out of 26 reported in all. Based on the numbers contacted and the frequency and intimacy of contact, scores on a ranked ordinal scale from 0–5 were constructed for each species and frequencies for each score were plotted. Subjects also reported past operations and serious illness. A history of pneumonia was significantly ($p < 0.05$) associated with a pigeon loft on the farm (relative risk (RR) 7.3) and attending farrowing pigs (RR 6.6), and one of leptospirosis with a rat problem on the farm (RR 28.1). Cattle contact was associated with a significantly lower likelihood (protective) of glandular fever (RR 0.19) and rheumatic or scarlet fever (RR 0.12). These effects were significantly related to rankings of the extent of exposure.

Conclusions – It is possible to recruit a representative sample of farmworkers and measure their animal exposures in great detail. Among these exposures, associations with plausible risk factors for

pneumonia and leptospirosis and apparently protective factors for glandular fever, scarlet fever, and rheumatic fever have been demonstrated, which further show a relationship between the extent of exposure and response. These findings can be tested further by examining the relationship of exposures to serological evidence of illness or by further prospective follow up of this and similarly well characterised cohorts, or both.

(*J Epidemiol Community Health* 1994;48:151–155)

It may seem obvious that to investigate any associations between human disease and exposure to animals it is essential to define clearly and measure exposure.¹ Nevertheless, while cross sectional seroprevalence studies have been performed for many zoonoses, it has usually not proved possible to do this. Thus, studies have been carried out on banked serum collected for other purposes^{2–4} or serum has been obtained from selected populations, but exposure data have not been collected.^{5,6} Likewise, in more detailed studies of zoonoses in which animal exposure has been recorded, in order to interpret serological data, the definitions used have often been loose (for example, “residence in a household keeping a dog”).⁷ Information on the rate, type, and seasonal variation in animal contact or on the health of the animal has not been provided.

To study zoonoses in farmworkers and their families and, ultimately, to interpret serological data on a wide range of zoonotic illnesses, we have recruited a well characterised, representative cohort in which data on: (i) human health; (ii) species range of animal exposure; (iii) extent of animal exposure; and (iv) animal health have been obtained. We report the methods used to estimate animal exposures in the study population and the relative risk of those exposures being associated with a clinical history of diseases which may be zoonotic in origin.

Methods

RECRUITMENT

A “farmer” was defined as someone occupationally concerned with the tending of live animals or plants for at least one day a week. A

Public Health
Laboratory Service,
Communicable
Disease Surveillance
Centre (Welsh Unit),
Wedal Road, Cardiff
CF4 3QX
D Rh Thomas
R L Salmon

Public Health
Laboratory, County
Hospital, Hereford
HR1 2ER
S M Kench
T J Coleman

Public Health
Laboratory, Royal
Preston Hospital,
Preston PR2 4HG
D Meadows
P Morgan-Capner

Department of
Veterinary Medicine,
University of Bristol,
Langford, Avon
BS18 7DU
K L Morgan

Correspondence to:
Dr R L Salmon.

Accepted for publication
October 1993

predetermined quota, governed by the capacity of the laboratories, was recruited using a two stage sampling procedure. Firstly, a random sample was drawn from Ministry of Agriculture, Fisheries and Food (MAFF) June Agricultural Census lists of agricultural holdings for the local government districts of Hereford City, South Hereford, Leominster, Preston, and Lancaster. Holdings were telephoned up to three times and a farmer in each holding that replied was asked to participate. Secondly, that farmer (sample 1) nominated a further adult (over 16 years) who was a member of the household or enterprise (sample 2) but who did not necessarily fulfil the study definition of a farmer.

ENROLMENT

A questionnaire administered by the research assistants asked all subjects about their medical history, the range and extent of animal contact, and the veterinary history of those animals. The section on medical history contained items on immunisation history, past operations, past episodes of "serious illness" (defined as treatment required long term or resulting in the loss of a month, at one time, of normal activity). A sample of venous blood (10 ml) was taken from all subjects at enrolment and again at 12 months.

VALIDATION

Sample representativeness

The sex distribution of the cohort was compared with tabulations from the 1991 Office of Population Censuses and Surveys (OPCS) census data based on 694 persons (a 10% sample) aged 16 or over in the study area giving their occupation as agriculture. The age distribution of the cohort was compared with that of 726 persons (10% sample) classed by the 1991 census as working in agriculture, forestry, or fishing.

Self reported medical history

A 20% subsample was drawn for both study locations. The research worker completed a second parallel questionnaire, blind, from the records of the subject's general practitioner (GP).

ANALYSIS

The sex distribution of the study sample was compared with that of the census sample by the Mantel-Haenszel version of the χ^2 test using EpiInfo version 5⁸ software and the age was compared by Student's *t* test. Agreement between the questionnaire data and GP records was measured with the kappa statistic.⁹

The extent of exposure (frequency and type of animal contact) was quantified on a six point ranked ordinal scale (table 1). Contact was divided into handling (direct contact such as shearing, milking, vaccinating, or stroking) and non-handling (feeding, cage cleaning, "mucking out"). Where contact was seasonal,

Table 1 Scoring the extent of animal exposure in farmworkers and their families

Score	Contact	Contact d/y	
		Handling	Non-handling
0	None	0	0
1	Occasional non-handling	0	1-200
2	Frequent non-handling	< 12	-
3	Occasional handling	12-50	-
4	Monthly handling	51-200	-
5	Weekly handling	> 200	-
	Handling most days		

scores were adjusted by estimating contact days/year. Frequency distributions of ranked scores for animal contact were constructed for each animal species (or husbandry type). Contact with agricultural inputs or products was similarly ranked. The range and extent of exposure to animals and agricultural inputs for subjects who reported a history of different serious illnesses *versus* those subjects who did not report illness was compared using the Mantel-Haenszel version of the χ^2 test and the Mann-Whitney two sample test.⁸ The illnesses examined were those most frequently reported which are infective in origin. Rheumatic fever and scarlet fever were combined a priori as clinical syndromes resulting from Lancefield group A streptococcal infection. Exposures examined were sheep, dairy and beef cattle, pigs, broiler and laying chickens, dogs, cats, pigeon lofts, unpasteurised milk, untreated water, hay, straw, and silage.

Results

At the first stage, out of 438 eligible individuals from 637 holdings (373 in Hereford; 264 in Preston), 255 (58%) from 255 holdings (135 in Hereford; 120 in Preston) agreed to take part in the study. Of the 382 holdings which did not provide a subject, an estimated 50 did not answer the phone, 149 did not have anyone fulfilling the definition of a farmer (individuals having deceased, retired, or being now otherwise employed), and 183 were eligible but refused to participate. Reasons for declining to take part in the study included "too busy", "worried about providing a blood sample", "intending to retire from farming in the near future", and "against research because it restricts farming practice". The 255 eligible subjects nominated a further 149 subjects (67 in Hereford; 82 in Preston) giving a cohort of 404 individuals, 202 at each site.

These 404 subjects comprised 299 men and 105 women with no significant difference in the sex distribution between sites or with the 1991 census. The mean (SD) age of the study population was 44.6 (12.4) years with a range of 16 to 75 years and did not differ significantly between the two study sites. The study sample was significantly ($p < 0.01$) older than the 1991 census sample, the mean of which, assuming a similar range to the study sample, was 42.2 (16.1) years. Similarly, the median age in the study sample was in the range 45-59 years compared with 30-44 years in the census sample. The modal age ranges of the study and the census samples did not differ.

HUMAN HEALTH

A past operation was reported by 234 subjects and 121 reported a "serious" illness. The clinical syndromes reported most frequently that might possibly represent zoonoses were pneumonia (14 subjects), glandular fever (11), jaundice (9), and scarlet fever or rheumatic fever (8). Specific zoonoses reported were leptospirosis (4), cowpox (1), brucellosis (3), chlamydiosis (2), ringworm (1).

For a number of discrete and relatively recent medical events, for example hernia repair or heart disease, there was a good association ($\kappa > 0.6$)⁹ between the self reported and GP recorded medical history (table 2). For less recent events (for example, childhood immunisation), records were often absent from the GP records. For less discrete medical episodes there was little resemblance between the self reported and GP recorded medical history.

RANGE OF ANIMALS

Holdings in Preston were predominantly dairy (65%), whereas in Hereford livestock rearing (36%) or mixed farming (39%) predominated. Exposure to 26 domestic, feral, or wild animal species was reported in all. Subjects reported contact with a maximum of nine different species (mode four) most frequently dogs (375 of 404), cattle (361), sheep (338), and cats (256). Other farm animal contacts were chickens (116), pigs (44), ducks (28), geese (18), goats (22), turkeys (12), and bantams (5). Exposure to guinea fowl, pheasant, peacocks, and trout was reported by less than five subjects. A small number of subjects reported exposure to companion animals other than dogs and cats – horses (92), rabbits (9), ferrets, pet mice, guinea pigs, goshawks, cockatiels, tortoises (all < 5). A rat problem on the farm in the past two years was identified by 39 subjects, and 73 stated that they handled dead rats. Other wild animal contacts reported were mice and bats (both < 5). Nine people had a pigeon loft on the farm.

EXTENT OF EXPOSURE

Numbers contacted

Sheep flocks which study subjects came into contact with ranged in size from 1 to 4000 head (mode 1–100). Six individuals reported occupations such as working in an auction or market or in livestock haulage resulting in contact with many flocks of varying size. The modal herd size for dairy cattle was 51–100 head (range 1–270) and for beef cattle 1–100 head (range 1–1000). Thirty four individuals reported contact with just one cow. Herds of pigs varied from 1 to 1400 animals (mode 1–10). Goats were usually kept singly (herd size range 1–12) as were horses (range 1–15) and cats (range 1–20) but people most commonly reported the presence of two dogs (range 1–160). No estimate was obtained for the numbers of rats contacted. Broiler chicken flocks ranged from 12 to 110 000 (mode 60 000) and flocks of laying chicken from 1 to 5500 (mode 12).

Frequency and intimacy of contact

Distributions of contact scores with sheep, dairy and beef cattle, pigs, broiler and laying chickens, dogs, and cats are given in the figure. Animals were nursed in the home by 353 individuals – 172 nursed lambs, two calves, and two piglets. Altogether 303 of 338 people who reported sheep contact helped during lambing. Of 361 who reported exposure to cattle, 264 reported exposure at calving, and 16 of 44 who had had contact with pigs reported exposure at farrowing. A total of 232 individuals (159 of 161 dairy farmers) reported drinking unpasteurised cows' milk and nine raw goats' milk (one of whom reported no contact with goats).

ANIMAL HEALTH

Altogether 211 of 255 farms had consulted a veterinary surgeon in the previous two years. Leptospirosis was the commonest zoonosis reported as a veterinary problem (32 of 255 farms), followed by orf and enzootic abortion in ewes.

OTHER EXPOSURES

Untreated water from a source on the farm (well, spring, or private supply) had been drunk by 150 subjects.

EXPOSURE AND SELF REPORTED ILLNESS (TABLE 3)

A raised risk of a history of pneumonia was observed in those with a pigeon loft or among subjects who attended farrowing pigs. A high risk of a history of leptospirosis was obtained in those who acknowledged a rat problem on their farm. Other exposures, notably cattle, were apparently protective against glandular fever and (including drinking unpasteurised milk) against rheumatic fever and scarlet fever. Contact with sheep was inversely associated with a history of leptospirosis.

Table 2 Validation of self reported medical history with general practitioner (GP) patient records for a 20% sample of the study group (n=80)

Factor	Self report + GP+	Self report + GP-	Self report - GP+	Self report - GP-	Kappa*
Immunisation:					
Diphtheria	11	54	0	15	0.07
Pertussis	7	21	1	51	0.28
Tetanus	56	10	2	12	0.58
Polio	22	45	2	11	0.07
Measles	2	6	5	67	0.19
BCG	15	32	1	32	0.25
Operations:					
All operations	21	21	11	27	0.21
Hernia repair	8	0	0	72	1.00
Appendectomy	9	7	0	64	0.67
Serious illness:†					
All illness	5	18	16	41	-0.06
Pneumonia	1	4	3	72	0.18
bronchitis/asthma					
Psittacosis	1	0	0	79	1.00
Depression/anxiety	0	0	3	77	0.00
Heart disease‡	2	1	1	76	0.65
Glandular fever	2	0	1	77	0.79

+ = positive; - = negative.

* Kappa values are given as a measure of inter-rater agreement; 1 = maximum agreement, 0 = no agreement better than chance, negative values = worse than chance.⁹

† Past illness was coded as "serious" if it resulted in the loss of a month, at one time, of normal activity or if treatment was required long term.

‡ Angina, myocardial infarction, high blood pressure, "high" cholesterol concentration.

Distributions of animal contact scores for those individuals who reported the presence of that animal species (or animal husbandry type) on the farm of work residence.

Discussion

The true extent of zoonotic illness in agricultural communities is not known. Equally unknown are the risk factors for acquiring such illness in the farm environment. Indeed as Edward Jenner realised 200 years ago when, as a country GP, he was impressed that milkmaids who had suffered from cowpox did not subsequently contract smallpox, some animal contact may protect against disease.¹⁰ This

study is an attempt to measure the extent and quantify the risk of zoonoses within a well characterised and representative exposed population. It does not tell us anything about the risk of living in a farming population relative to a non-farming (urban) population.

The cohort successfully recruited to this longitudinal study is, despite a low participation rate of 58%, broadly representative of people employed in agriculture in the study areas. Further, where it does differ, how it differs is known and the reasons can be addressed. Thus, the higher mean age of the study sample (45 years *versus* 42 years) but similar modal age suggest an under representation of younger farmworkers. This may be accounted for by the sampling procedure which led to the recruitment of principal farmers who frequently nominated their spouses as the second subject. Equally, the only routinely available referent census sample included forestry and fisheries workers, who may well be younger than workers in agriculture. Certainly differences in the distribution of types of farm between the two sites reflect the 1991 MAFF June census results,¹¹ and the risks to which the group is exposed in terms of animals is also typical. The size of the animal groups (particularly of sheep and cattle), the study subjects were exposed to reflects the national flock herd size distribution.¹¹ Distributions of the ranked scores for animal contact followed patterns which appear intuitively reasonable. Thus, exposure to sheep peaked at score 4, representing frequent, but seasonal, handling contact which would correspond with usual husbandry practices such as lambing, shearing, and dipping. Exposure to dairy cattle, which peaked at score 5, reflects daily milking.

The associations between self reported illness and animal contact shown here merit careful consideration, therefore, and would be worth testing prospectively as well as by characterising illness serologically, which is being done. This is notwithstanding certain factors. Firstly, that the number of comparisons made means that some associations may emerge merely by chance. Secondly, in certain circumstances, self reported illness correlated poorly with illness recorded in GP records. This reflects previous findings¹² that GP patient

Table 3 Animal exposures in 404 farm dwellers associated significantly* with a history of serious illness

Exposure	Attack rate	Relative risk (95% CI)	Level of exposure (ranked)		p†
			Ill median:mode (range)	Well median:mode (range)	
Pneumonia (n=14):					
Pigeon loft	2.9	7.31 (1.91-28.03)	—	—	—
Attending birth of piglets	3.16	6.61 (2.04-21.41)	0.0 (0-3)	0.0 (0-3)	< 0.00005
Glandular fever (n=11):					
Dairy cattle	2.217	0.19 (0.04-0.88)	0.0 (0-5)	0.2 (0-5)	< 0.05
Rheumatic fever or scarlet fever (n=8):					
Dairy cattle	1.217	0.12 (0.02-0.99)	0.0 (0-2)	2.0 (0-5)	< 0.05
Milking of cattle	0.190	0	0.0 (0-0)	0.0 (0-5)	< 0.05
Drinking raw milk	1.232	0.11 (0.01-0.85)	—	—	—
Leptospirosis (n=4):					
Sheep	1.338	0.07 (0.01-0.62)	0.0 (0-2)	4.4 (0-5)	< 0.005
Attending birth of lambs	1.305	0.11 (0.1-1.03)	0.0 (0-0)	2.2 (0-3)	< 0.01
Rat problem on farm	3.39	28.08 (2.99-263.47)	—	—	—

* $p < 0.05$, two tailed, for categorical comparison (ill exposed *v* ill unexposed).

† Mann-Whitney two sample test.

records are not a good tool for validating self reported medical history but have to be used because they are one of the only sources of population morbidity data. Thirdly, diagnosis, for example of rheumatic fever or scarlet fever, may be subject to error. Nevertheless the illnesses reported on have distinctive features, clinically, and are worth examining, initially, in their own right as self reported clinical diagnoses.

Thus, looking at illness and animal exposure, the finding that contact with dairy cattle was associated with a reduced likelihood of a history of streptococcal disease or glandular fever is striking with its overtones of Jenner. Nevertheless, if this is a true protective effect then the biological mechanism is obscure, although it is tempting to speculate that immunity is acquired actively to one or both diseases by exposure to enzootic organisms at titres below those that cause overt clinical disease. The finding of a protective effect further assumes that current exposure to animals is similar to exposure over the subjects' lifetime. This is not implausible, given that inward migration into farming communities in more recent times is unusual and given that a relationship between level of exposure and effect was observed.

The associations that show a high likelihood of illness are equally plausible. Clearly the association of leptospirosis and a rat problem on the farm falls into this category as does the association of pneumonia with pigeon lofts and farrowing (both possible sources of *Chlamydia*¹³).

This work has produced a well characterised

and representative study sample in which animal exposures have been measured in great detail. It has given a number of insights into the extent of zoonotic illnesses and lifetime risks for acquiring them in agricultural populations. This will provide an important foundation for identifying workable, scientifically based intervention strategies to prevent such illnesses.

We thank Dr D Gompertz. This study was funded by the Health and Safety Executive.

- 1 Scarlett Kranz JM. Defining and measuring exposure in epidemiologic studies of potential zoonoses. *J Am Vet Med Assoc* 1983;**183**:1454-8.
- 2 Childs JE, Schwartz BS, Ksiazek TG, Graham RR, LeDuc JW, Glass GE. Risk factors associated with antibodies to leptospires in inner-city residents of Baltimore: a protective role for cats. *Am J Public Health* 1992;**82**:597-9.
- 3 Walker J, Nokes DJ, Jennings R. Longitudinal study of toxoplasma seroprevalence in South Yorkshire. *Epidemiol Infect* 1992;**108**:99-106.
- 4 Tanner CE, Staudt M, Adamowski R, Lussier M, Bertrand S, Prichard RK. Seroepidemiological study for five different zoonotic parasites in northern Quebec. *Can J Public Health* 1987;**78**:262-6.
- 5 Bonifacio R, Malgor R, Barbeito R, Balleste R, Rodriguez MJ, Botto C, Klug F. Seroprevalence of *Echinococcus granulosus* infection in a Uruguayan rural human population. *Trans R Soc Trop Med Hyg* 1991;**85**:769-72.
- 6 Stanford CF, Connolly JH, Ellis WA, et al. Zoonotic infections in Northern Ireland farmers. *Epidemiol Infect* 1990;**105**:565-70.
- 7 Cooper CW. Risk factors in transmission of brucellosis from animals to humans in Saudi Arabia. *Trans R Soc Trop Med Hyg* 1992;**86**:206-9.
- 8 Dean AD, Dean JA, Burton AH, Dicker RC. *Epi Info, Version 5: a word processing, database, and statistics program for epidemiology on micro-computers*. Stone Mountain, Georgia: USD Incorporated, 1990.
- 9 Altman DG. *Practical statistics for medical research*. London: Chapman and Hall, 1991.
- 10 Gale AH. *Epidemic diseases*. London: Penguin Books, 1959.
- 11 MAFF. *Agricultural Statistics UK 1989*. London: HMSO, 1991.
- 12 Rawson NSB, Alderslade R, Miller DL. Discrepancies in immunization records. *Community Medicine* 1980;**2**:202-8.
- 13 Harris JW. Chlamydial antibodies in pigs in Scotland. *Vet Rec* 1976;**98**:505-6.