ORIGINAL RESEARCH

Q Fever awareness and risk profiles among agricultural show attendees

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Abstract

Objective: To assess awareness and risk of Q fever among agricultural show attendees.

Setting: University of New England's Farm of the Future Pavilion, 2019, Sydney Royal Agricultural Show.

Participants: Participants were ≥18 years, fluent in English, Australian residents, and gave their informed consent.

Main Outcome Measures: Participants reported whether they had ever heard of Q fever and then completed the 'Q Tool' (www.qfevertool.com), which was used to assess participants' demographics and risk profiles. Cross-tabulations and logistic regression analyses were used to examine the relationship between these factors.

Results: A total of 344 participants were recruited who, in general, lived in major NSW cities and were aged 40–59 years. 62% were aware of Q fever. Living in regional/remote areas and regular contact with livestock, farms, abattoirs and/or feedlots increased the likelihood of Q fever awareness. Direct or indirect contact with feral animals was not associated with Q fever awareness after controlling for the latter risk factors. 40% of participants had a high, 21% a medium, and 30% a low risk of exposure. Slightly less than 10% reported a likely existing immunity or vaccination against Q fever. Among those who were not immune, living in a regional or remote area and Q fever awareness were independently associated with increased likelihood of exposure.

Conclusions: Awareness of Q fever was relatively high. Although 61% of participants had a moderate to high risk of exposure to Q fever, they had not been vaccinated. This highlights the need to explore barriers to vaccination including accessibility of providers and associated cost.

KEYWORDS

agriculture, *Coxiella burnetii*, immunisation, livestock reservoir, zoonoses

1 | INTRODUCTION

On average, 2 in every 100 000 Australians are diagnosed with Q fever each year, with the majority of notifiable cases located in New South Wales and Queensland.[1,2] The actual prevalence of Q fever is, however, likely to be greater than this estimate as many cases are undiagnosed.[3–6] Infection typically occurs after the inhalation of dust or aerosols that have been contaminated with *Coxiella burnetii*: a bacterium found in animal secretions including birth products, faeces and urine. The majority of those exposed to the bacteria do not develop clinically significant symptoms. Those who do, can experience mild to severe influenza-like symptoms through to the need for hospitalisation due to complications including acute respiratory illness and liver failure.[7] Most people who experience an acute episode of Q fever make a full recovery and become resistant to reinfection. However, 10–15% develop a chronic post-Q fever fatigue syndrome, sometimes years after exposure, which can cause a range of problems including endocarditis.[8] Identifying people at risk of Q fever and increasing community awareness about prevention has the potential to reduce the number of incident cases and its acute and longer-term negative health outcomes.

Q fever is the most common zoonosis in Australia.[9] A vaccine is available that is effective, approved for people aged 15 years and above and recommended for those at risk of exposure.[10–12] Known risk factors include being male, aged between 40 and 59 years, residing in New South Wales or Queensland,[2,13] and having contact with livestock, with people present at birthing or slaughtering cattle, sheep or goats at particular risk of exposure.[2,13–17] Moreover, in a recent NSW seroprevalence study, Gidding, Faddy[3] found that living in a rural area and having rare or no contact with livestock was an independent risk factor for Q fever. Based on these findings, the authors concluded that vaccination should be considered for all rural residents.

Despite the development of the Q fever vaccine, vaccination rates are suboptimal in Australia.[3] Several barriers exist including limited community awareness of Q fever and of the vaccine itself, and attitudinal and structural barriers to obtaining a vaccination. For instance, among those with a high-risk occupation (e.g. farmers and abattoir workers) for whom vaccination is recommended, 69% had heard of Q fever, 40% knew about the vaccine, and only 10% had been vaccinated.[3] Reasons for not getting vaccinated include the lack of perceived risk; access to and cost of the vaccine; and 'not getting around to it'.[18] Given that these are the base rates among those with high-risk occupations and that there is an increased community-level risk of exposure for rural Australians, there is a need for additional strategies to increase public awareness and vaccination rates.

What is already known on this subject:

- A proportion of people who are exposed to the bacterium *Coxiella burnetii* develop acute and long-term health problems due to Q fever
- An effective vaccine is available
- High-risk populations can be protected if they are aware of, and have ready access to the vaccine

What this paper adds:

- 62% of agricultural show respondents were aware of Q fever, with many at moderate to high risk of exposure
- Despite this awareness, slightly less than 10% had been vaccinated or had likely immunity to Q fever based on the results of previous serological tests
- Additional research and public health strategies are required to reduce barriers to preventing incident cases of Q fever. Doing so would have both health and economic benefits

Recognising the public health significance of Q fever and the potential for prevention through vaccination, the Hunter New England Population Health Unit (HNEPH) designed a freely available, brief tool (www.qfevertool.com) that assesses the known risks of this zoonosis. Using the HNEPH's 'Q Tool', we aimed to examine the prevalence and predictors of community awareness of Q fever, and the risk profiles of agricultural show attendees.

2 | METHODS

2.1 | Setting and procedure

This study was conducted as part of the University of New England's (UNE) Farm of the Future Pavilion ('the Pavilion') at the Royal Agricultural Show, Sydney, NSW between the 12th and 18th April 2019. The Pavilion showcased research and technology set to sustain farming into the future. A high proportion of attendees of the Royal Agricultural Show are accompanied by their pre-school (33%) and primary school aged (21%) children.[19] As a result, the Pavilion was designed to engage children as well as their parents and included a mix of child-focused interactive exhibits balanced with information-driven posterboards and opportunities for attendees to discuss exhibit content with representatives from UNE and its collaborating organisations (N = 79

representatives staffed the exhibit over the 12 days of the entire show).

Within the Pavilion, two iPads were attached to fixed stands and were pre-programmed with the study assessment measures. People who approached the exhibit were invited by members of the research team (FQ, MH and KN) to participate in the study. Those who were interested and assessed as being eligible completed the online survey. People were eligible for inclusion if they were: (i) aged 18 years or above; (ii) fluent in English; and (iii) Australian residents.

2.2 | Measures

All data were collected electronically. Participants initially reported whether or not they had heard of Q fever and then completed the Q Tool (www.qfevertool.com). This 9-item screening tool is available online to the public on the HNEPH website and assesses demographic and known risk factors of Q fever (e.g. gender, age, state of residence, postcode, contact with livestock, feral animals, farms, abattoirs and/or feedlots, and likely immunity based on prior diagnosis or serology). Once completed, participants were provided with their likely risk of Q fever (e.g. low, moderate, high and likely immune). Those at moderate to high risk of infection were provided additional information from the NSW Health Department about Q fever, immunisation and the benefits of discussing vaccination with their general practitioner.

2.3 | Analyses

All analyses were conducted using Stata v17. First, cross-tabulations were used to examine the distribution of Q fever awareness stratified by participant demographics and individual risk factors for Q fever. Participants' rurality (i.e. whether they resided in major cities or not) was inferred from their postcode and the Australian Statistical Geography Standards.[20]

Second, the multicollinearity of independent variables was assessed. This involved calculating the pairwise correlations between independent variables where r's > 0.80 indexed severe multicollinearity. The collin.ado package[21] was also used to calculate tolerance values and variance impact factors (VIFs). Tolerance values less than 0.2 (e.g. VIF > 5) and less than 0.1 (e.g. VIF > 10) indicated potential and serious multicollinearity, respectively.[22,23]

After examining potential sources of multicollinearity, univariable logistic regression analyses were then used to examine the relationship between risk factors (IVs) and Q fever awareness (DV). A stepwise forward logistic regression analysis that retained significant predictors of Q fever was then estimated. An inflated level of significance (e.g. $p < 0.25$) was implemented to minimise type II error rates in predictor selection.[24] Next a stepwise multivariable logistic regression with backward elimination of non-significant variables at $p < 0.05$ was specified. Standardised Pearson residuals (e.g. the standardised difference between observed and fitted values) and Pregibon's leverage values were then calculated to identify outlying observations that could bias regression estimates. As rules of thumb, participants with standardised Pearson residuals > |2| were considered to be outliers and those with leverage values greater than 2 or 3 times the mean leverage value of the sample were considered to bias regression estimates.[23,25]

Finally, the relationship between Q fever awareness and living in a regional area (IV), and overall risk category of Q fever exposure (e.g. low, moderate, high: DV) was examined using univariable and multivariable logistic regression analyses. These analyses did not include the other risk factors that were assessed in the Q Tool as IVs because they form the basis of the risk assessment and doing so would have induced singularity of the matrix. Similarly, these analyses excluded participants with likely immunity because all of those who had been previously diagnosed or vaccinated had necessarily heard about Q fever.

3 | RESULTS

3.1 | Participant characteristics

Approximately 140 000 patrons attended the Pavilion during the data collection period. Given the scale and structure of the Pavilion (e.g. attendees were not ticketed at its entry), it is not possible to report the exact number of attendees or their demographics. Similar to the organisation of most Royal Agricultural Show Pavilions, attendees walked through the Pavilion and approached the exhibits that were of personal interest. Conservatively, we estimate that one attendee approached the exhibit every 5 min, which equates to a total recruitment pool of ~504 over the course of data collection. Of which, a convenience sample of 403 consented to participate (~80% recruitment rate). Forty-two participants experienced technical difficulties, which led to their questionnaire responses not being recorded and 17 reported that they 'did not know' their exposure to one (or more) of the Q fever risk factors. Results presented are therefore based on the 344 participants with complete data. Participants' demographic characteristics are presented in Table 1. In general, most participants were aged between 40 and 59 years and lived in major New South Wales cities. The sample was characterised by an equal sex distribution.

Over the 6 days of recruitment, we aimed to recruit as many participants as possible in order to gauge and increase public awareness of Q fever. As a result, we did not conduct a priori power calculations for this study. However, with a sample size of 344 and the respective distribution of the potential predictors of Q fever awareness, this study had >80% power at $\alpha = 0.05$ to detect significant differences using Wald χ^2 analyses between awareness (DV) for rurality, contact with livestock, feral animals and farms, abattoirs and feedlots (IVs). The relative distribution of sex,

age and state of residence across Q fever awareness groups did not permit group differences to be calculated. Cross-tabulation output is included here to describe the sample and as a way to inform the power of future studies.

3.2 | Awareness of Q fever

Sixty-two per cent of participants had previously heard of Q fever ($n = 212/344$). Analyses of the predictors of Q

TABLE 1 Participant characteristics and predictors of Q fever awareness

| | Total sample (N = 344) | | Heard of Q fever? | | | | Have vs. have not heard of Q fever | | |
| | | | Yes (n = 212) | | No (n = 132) | | | | |
	N	%	n	%	n	%	OR (95 CI)[a]	aOR (95 CI)[b]	aOR (95 CI)[c]
Sex									
Male	172	50.00	108	50.94	64	48.48		–	–
Female	172	50.00	104	49.06	68	51.52	–	–	–
Age									
18–39 years	86	25.00	50	23.58	36	27.27	–	–	–
40–59 years	160	46.51	95	44.81	65	49.24	–	–	–
≥60 years	98	28.49	67	31.60	31	23.48	–	–	–
State									
NSW	316	91.86	191	90.09	125	94.70	–	–	–
Other	28	8.14	21	9.91	7	5.30	–	–	–
Rurality									
Regional areas	151	43.02	129	60.85	19	14.39	**9.24 (5.29–16.16)**	**3.02 (1.55–5.91)**	**3.41 (1.77–6.57)**
Major cities	210	56.98	83	39.15	113	85.61	1.00	1.00	1.00
χ^2 (1), p-value							60.85, $p < 0.001$	10.48, $p < 0.01$	13.50, $p < 0.001$
Regular contact with livestock									
Yes	168	48.84	145	68.40	23	17.42	**10.26 (6.01–17.51)**	**2.52 (1.16–5.46)**	**3.24 (1.56–6.69)**
No	176	51.16	67	31.60	109	82.58	1.00	1.00	1.00
χ^2 (1), p-value							72.76, $p < 0.001$	5.45, $p < 0.05$	10.03, $p < 0.01$
Contact with feral animals									
Direct or indirect contact	130	37.79	114	53.77	16	12.12	**8.43 (4.68–15.19)**	1.82 (0.94–4.24)	–
No	214	62.21	98	46.23	116	87.88	1.00	1.00	–
χ^2 (1), p-value							50.46, $p < 0.001$	3.31, $p = 0.07$	
Regularly visit farms, abattoirs or feedlots?									
Yes	188	54.65	157	74.06	31	23.48	**9.30 (5.61–15.43)**	**2.24 (1.09–4.58)**	**2.43 (1.20–4.92)**
No	156	45.35	55	25.94	101	76.52	1.00	1.00	1.00
χ^2 (1), p-value							74.55, $p < 0.001$	4.87, $p < 0.05$	6.03, $p < 0.05$

[a]Univariable logistic regression of the relationship between Q fever awareness and individual risk factors.

[b]Multivariable forward stepwise logistic regression of the relationship between Q fever awareness and risk factors using a $p < 0.25$ threshold.

[c]Multivariable stepwise logistic regression with stepwise backward deletion of the relationship between Q fever awareness and risk factors using a $p < 0.05$ threshold.

Bold values indicate statistical significance of $p < 0.05$.

fever awareness indicated that multicollinearity was not a concern with pairwise correlations ≤0.74, tolerance values ≥0.38 and VIF ≤2.61. As can be seen in Table 1, a stepwise logistic regression with forward variable selection using a liberal $p < 0.25$ inclusion criterion found significant associations between Q fever awareness and living in regional areas, regular visits to farms, abattoirs and/or feedlots, working with livestock and contact with feral animals ($\chi^2[4] = 84.27$, $p < 0.001$). Non-significant independent variables at a $p < 0.05$ level were then excluded from the model using logistic backward deletion. Doing so, removed contact with feral animals from the prediction model ($\chi^2(3) = 84.21$, $p < 0.001$). An examination of the Pearson residuals found that no participants had standardised values $>|2|$ ($R = |0.99|$), and the sample had an average (SD) Pregibon's leverage value of 0.71 (0.17) with all participants having values less than twice this average (e.g. $R(0.12–0.87)$; IQR = 0.69 (0.66–0.87)). These metrics indicate that based on the final model, no participants were outliers or disproportionately biasing the regression estimates.

3.3 | Risk of Q fever and immunity rate

Forty per cent of participants were identified as being at high risk of exposure ($n = 136/344$), followed by 21% a medium ($n = 72/344$) and 30% at low risk ($n = 102/344$). Among those at moderate to high risk of exposure, 68.75% had heard about Q fever previously ($n = 143/208$). Despite approximately half of the respondents reporting regular contact with livestock and/or regular visits to farms, abattoirs and/or feedlots, slightly less than 10% of participants had been vaccinated or had likely developed an immunity to Q fever based on a previous diagnosis or serology test ($n = 34/344$). Among those who had a low to high risk of being exposed to Q fever (e.g. those who had not been vaccinated and were not likely to be immune to Q fever based on previous diagnosis or serology), univariable analyses found that living in a regional area ($\chi^2[2] = 73.97$, $p < 0.001$) and having prior knowledge of Q fever ($\chi^2[2] = 58.56$, $p < 0.001$) were associated with increased risk of exposure to Q fever. Both factors continued to predict participants' category of risk in multivariable analyses ($\chi^2[4] = 83.95$, $p < 0.001$).

4 | DISCUSSION

This study examined awareness and risk profiles of Q fever among a relatively large group of attendees of UNE's Farm of the Future Pavilion at the 2019 Royal Agricultural Show, Sydney. We found that while the majority of participants had previously heard about Q fever and had an elevated risk of exposure, slightly less than 10% had been vaccinated or had likely developed an immunity to Q fever based on a previous diagnosis or serology. Together, these data indicate the need to increase health literacy and vaccination rates to reduce incident cases of Q fever.

4.1 | Awareness, risk and immunity

We found that 62% of participants had previously heard about Q fever, and that living in regional areas, having regular contact with livestock, farms, abattoirs and feedlots increased awareness. In comparison, previous reports show that those employed in high-risk occupations are more aware of the disease than the current sample (e.g. 69% aware[3]:). The extent to which these rates differ may reflect the demography of our sample. Given that 55% of the sample had regularly visited farms/abattoirs or feedlots, 49% had had regular contact with livestock and 44% lived in regional areas, it is likely that many participants were (or had previously been) employed in occupations at high-risk of exposure to Q fever. Indeed, 61% of the sample were at a moderate to high risk of exposure but 31% of this group participants had not heard of Q fever before. These findings therefore replicate those reported by Gidding, Faddy.[3] Together these data suggest that in general, there are gaps in community awareness about Q fever but importantly, there are opportunities for improving knowledge among those most at risk of exposure. As a result, campaigns designed to increase health literacy around Q fever and its prevention via a One Health model of managing the human, animal and environmental contributors to transmission[26] could improve health outcomes.

Several factors are worth reflecting on if vaccine coverage is to increase. There are both attitudinal and structural barriers to accessing Q-Vax. People can underestimate their risk of exposure and the seriousness of Q fever-related health outcomes[18] and therefore not prioritise the need for vaccination. Moreover, not all general practitioners/pharmacists are able to vaccinate their patients even if asked to do so nor is the vaccination process subsidised.[10] Having the likely combined result, that the cost of the vaccine can be prohibitive for some, and that the limited availability of trained local clinicians in some health districts, and the time needed to complete the 2-stage vaccination screening process are reducing vaccine coverage.[1,17,27,28] Indeed, recent data suggest that subsidising the vaccine could increase vaccination rates.[29] The public health benefits of reducing these barriers, as well as the direct and indirect economic costs (e.g. compensation claims, medical costs

and lost productivity) of doing so, justify additional study and investment in preventing incident cases.[17,30,31] For instance, examinations of the return-on-investment—with regard to health and economic outcomes—of (i) reviewing the National Q Fever Management Program; (ii) industry rather than individual-led vaccination programs; and (iii) increased use of community-based vaccination clinics could all significantly impact public planning strategies.

4.2 | Limitations and areas for future study

While we examined the awareness of Q fever and risk profiles among a relatively large sample of show attendees over a short study period, the results of this study are not without limitation. First, results are based on a convenience sample of those attending an agricultural show, rather than a representative sample of the general population. It is therefore unclear whether results generalise to the broader community.

Second, the study relied on a self-report measure rather than serology tests. Results should therefore be considered only indicative of participants' risk profiles/immunity status. Nonetheless, this study does demonstrate the feasibility of a stepped model of assessment whereby brief, self-report risk assessments such as the Q Tool provide an important albeit initial triaging step in determining Q fever risk, the results of which can be used to make subsequent recommendations for Q fever screening and vaccination, where appropriate.

Finally, the brevity of the assessment battery was necessitated by the study setting and the need to recruit participants from passing foot-traffic. As a result, investigators were unable to collect data about participants' personal experiences of Q fever. There is a limited number of qualitative studies regarding the personal and economic costs of Q fever, with most of the Q fever literature focusing on its epidemiology. Additional studies into the psychosocial impacts of Q fever would complement the available economic and epidemiological modelling of the disease, and could be used to tailor public health messages to specific at-risk populations.

5 | CONCLUSIONS

Almost two thirds of participants selected from attendees of an agriculture show who participated in this study had heard of Q fever, with a substantial number being at moderate to high risk of exposure. While the risk factors for Q fever are known and are particularly pertinent for regional and rural Australians, the vaccination and likely exposure rates reported herein clearly indicate the need for additional public health strategies to reduce barriers to vaccination and incident cases.

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