



Seroprevalence of *Coxiella burnetii* among abattoir and slaughterhouse workers: A meta-analysis

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ABSTRACT

Q fever caused by the gram negative bacteria, *Coxiella burnetii*, is an occupational hazard for those who live and work in rural settings and those who are in contact with animals, especially abattoir and slaughterhouse workers. Australia is the only country to register a vaccine to prevent Q fever (Q-vax[®], Seqirus, Australia) that is used in high risk populations. Seroprevalence studies conducted to determine the burden of Q fever (*C. burnetii* infection) in different settings have demonstrated high levels of heterogeneity with estimates of the percent positive ranging from 30% to 70%. There is a need for a more systematic evaluation of the findings of these studies in order to provide summary estimates of the seroprevalence in different settings.

We searched for published articles using PubMed, MEDLINE-EMBASE, and Scopus databases using search terms obtained from an initial review of published reports of recent Q fever outbreaks. Data on the seroprevalence of *C. burnetii* infection (Q fever) was extracted from the selected studies and a random effects meta-analysis was performed with stratification by outbreak status, year, country and serological techniques used. Results were visualised with a forest plot with 95% CI and measures of heterogeneity (I^2) for the random effects model.

A total of 19 articles that met the search criteria were included. The reported seroprevalence rate ranged from 4.7% to 91.7% among abattoir and slaughterhouse workers. No inter-group heterogeneity was observed ($p = 0.956$), supporting the pooling of all studies into one pooled measure. The pooled estimate of seropositivity for *C. burnetii* infection in people working in abattoirs and slaughterhouses was 26% (95% CI: 18–35%) regardless of the evidence of an “outbreak”, the time of year or country. Seropositivity for *C. burnetii* was independent of a person's age and years of occupational experience. Within abattoirs and slaughterhouses, slaughtering of cattle, sheep and goats are the most important risk factors associated with seropositivity and for those who showed over symptoms upon infection.

We recommend that vaccination programmes are directed towards people employed in the meat processing industry to mitigate the significant health and economic impacts of Q fever.

1. Background

Q fever (Q stands for query), caused by the highly pathogenic bacteria called *Coxiella burnetii*, is a zoonotic disease [15] and has worldwide distribution [28]. Since its discovery and description in Australia in 1937 [10,13] there have been several Q fever outbreaks reported internationally and the disease is considered endemic in most regions of the world [12,22,28,43]. The Netherlands is the country which experienced the highest ever reported Q fever outbreak [35]. Intensive farming of dairy goats and dairy sheep was the main reason

for the outbreaks that occurred in The Netherlands [34].

Domestic ruminants and pets and in Australia, native marsupials, are the main reservoirs of infection [8,9,37,40]. Transmission to humans occurs mainly through inhalation of contaminated aerosols originating from parturient animals and their birth products [15,29]. Humans are considered accidental and dead-end hosts as there is no evidence of human-to-human transmission [15]. The seroprevalence of *C. burnetii* infection can range from 30% to 70% in people working in high-risk occupations such as farmers, veterinarians and abattoir workers [4].

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Table 1
Characteristics of studies that included abattoir and slaughterhouse workers.

Author (Year)	Outbreak	Country	Setting	Size (n)	Seropositive	Prevalence (%)	Lab method
Gilroy [17]	Yes	Australia	Abattoir	68	29	43	CFT
Abebe [11]	No	Ethiopia	Abattoir	465	30	6.5	CFT
Adesiyun [2]	No	Trinidad	Abattoir	85	4	4.7	ELISA
Khalili [24]	No	Iran	Slaughterhouse	75	51	68	ELISA
Marrie [27]	No	Canada	Slaughterhouse	96	12	12.5	CFT
Esmaeili [14]	No	Iran	Slaughterhouse	190	43	22.5	ELISA
Aflatoonian [3]	No	Iran	Slaughterhouse	64	5	7.8	ELISA
Perez-Trallero [33]	No	Spain	Slaughterhouse	36	33	91.7	IFA
Berktaş [7]	No	Turkey	Slaughterhouse	41	27	65.9	ELISA
Htwe [21]	No	Japan	Abattoir	107	12	11.2	IFA
CDC [44]	Yes	USA	Abattoir	42	19	45.2	CFT
Beech [45]	Yes	Australia	Abattoir	516	50	9.7	CFT
Schnurrenberger [46]	No	USA	Abattoir	2091	104	5	CFT
Schonell [47]	No	UK	Abattoir	96	21	28.1	CFT
Riemann [48]	No	Brazil	Abattoir	144	42	29	AGGLUTINATION
McKelvie [30]	Yes	Australia	Abattoir	139	22	15.8	CFT
CDNANZ [49]	Yes	Australia	Abattoir	100	18	18	CFT
Donaghy [11]	Yes	UK	Abattoir	228	49	21.5	NA
Wilson [42]	Yes	UK	Slaughterhouse	179	75	41.9	IFA
Berktaş [7]	No	Turkey	Butcher house	77	33	42.9	ELISA

Note: CFT = Complement Fixation Test, IFA = Immunofluorescence Assay, and ELISA = Enzyme-Linked Immunosorbent Assay. NA refers to Not Available.

Table 2
PubMed search strategy: Articles search history and strategy for abattoirs and slaughterhouse workers.

Search	Query	Items found
#12	Search (((q fever) OR coxiella burnetii) AND (((((((seroprevalence) OR seroepidemiology) OR serology) OR serological) OR prevalence) OR incidence) OR epidemiology)	2864
#11	Search (((((((seroprevalence) OR seroepidemiology) OR serology) OR serological) OR prevalence) OR incidence) OR epidemiology	2,745,738
#10	Search (q fever) OR coxiella burnetii	5865
#9	Search epidemiology	1,970,371
#8	Search incidence	2,343,722
#7	Search prevalence	2,189,454
#6	Search serological	56,243
#5	Search serology	194,892
#4	Search seroepidemiology	1336
#3	Search seroprevalence	25,616
#2	Search coxiella burnetii	3157
#1	Search q fever	4994

Table 3
MEDLIN-EMBASE search history: Articles search history and strategy for abattoirs and slaughterhouse workers.

No.	Query	Results
#11	'q fever'/exp. OR 'coxiella burnetii'/exp. AND ('seroprevalence'/exp. OR 'seroepidemiology'/exp. OR 'serology'/exp. OR 'prevalence'/exp. OR 'incidence'/exp. OR 'epidemiology'/exp)	2246
#10	'seroprevalence'/exp. OR 'seroepidemiology'/exp. OR 'serology'/exp. OR 'prevalence'/exp. OR 'incidence'/exp. OR 'epidemiology'/exp	2,687,691
#9	'q fever'/exp. OR 'coxiella burnetii'/exp	6631
#8	'epidemiology'/exp	2,514,169
#7	'incidence'/exp	313,776
#6	'prevalence'/exp	520,913
#5	'serology'/exp	202,792
#4	'seroepidemiology'/exp	2906
#3	'seroprevalence'/exp	15,639
#2	'coxiella burnetii'/exp	3640
#1	'q fever'/exp	5152

Prevention of Q fever in Australia is through targeted immunization especially in those working in, or associated with the meat industry using the locally produced Q Vax vaccine (Seqirus, Australia), which has high efficacy in adults [25,26]. Q Vax is reported to provide up to 93% immune protection [32] with long-lived immune responses to *C. burnetii* [23]. However, the incidence of Q fever in people working in the red meat industry remains relatively high. Therefore, the current review provides information on the variability of the prevalence of Q fever exposure and risk factors for exposure in this occupational group.

2. Materials and methods

A search for published articles was conducted using several strategies (see details in Tables 1–3 and supporting files 1–2 and Fig. 2): an online search of PubMed, MEDLINE-EMBASE, and Scopus databases was conducted using the terms Q fever, *Coxiella burnetii*, seroprevalence, sero-epidemiology, serology, incidence, prevalence, abattoir, abattoir workers, slaughterhouse, slaughterhouse workers, and butcher and meat workers. Further key words were then obtained from an initial review of reports of outbreak investigations in various countries.

One reviewer individually screened all study titles identified through database searches. An initial review of abstracts was performed to identify articles for a more detailed full text review. The final articles were selected if they met the following criteria: 1) if the full text or abstract is available, 2) articles that are published in a peer-reviewed or refereed archival journal in English, 3) articles that are based on original data; i.e., not a review article or meta-analysis, 4) articles that contained reported prevalence estimates from statistical analyses, and 5) articles of studies that were conducted on people working in the meat industry (slaughterhouse and abattoir workers, and butchers). Meta-analysis was done for abattoir and slaughterhouse workers with a total of 19 studies which met the inclusion criteria. Details of the studies' characteristics along with the number of studies included in each are summarized in supporting information Table 1.

Articles with extreme reported seroprevalence rates, that is, 0.0% and 100%, have been included in order to minimize the publication bias especially for positive findings. The prevalence of exposure was selected as the outcome variable in each of the various sub-groups. Odds and risk ratios were also extracted as measures of the strength of association between Q fever and exposures to different risk factors. Initial data extraction was done using Microsoft Excel and compiled

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