

SUPPLEMENTARY MATERIAL

Additional Supplementary Material can be found in the online version of this article.

Appendix S1.

Protocol for identifying literature relevant to heat load and sea transport of Australian livestock.

Appendix S2.

Figure S1. PRSIMA flow diagram [1] for inclusion of the 92 publications identified in our literature search.

Figure S2. Year of publication for the 93 publications identified in our literature search. Five-year intervals were used, except for 2015–2018, which was four years.

Table S1. PRISMA checklist.

Table S2. Classification and appraisal of each literature item.

SUPPLEMENTARY MATERIAL

Protocol for identifying literature relevant to heat load and sea transport of Australian livestock.

To minimise the risk of reporting bias due to incomplete retrieval of research, we followed the PRISMA guidelines for systematic reviews [1]. We used an electronic database (Google Scholar), the Murdoch University library catalogue, and our professional networks to identify relevant journal articles, books, unpublished reports, conference proceedings and theses. We conducted searches of literature published in English. We conducted a series of searches in all years for each of the common (sheep, cattle) and the scientific names (*Ovis aries*, *Bos taurus/indicus*) of the species of interest and the terms ‘heat’, ‘heat load’ and ‘heat stress’. We then combined these iteratively with the following search terms: ‘Australia’, ‘live export’ and ‘sea transport’ to ensure that no relevant studies were missed. For unpublished studies, we searched the databases of the funding agency commissioning research into live export in Australia: Meat and Livestock Australia. We also searched the websites of the two most prominent animal welfare advocacy groups involved: RSPCA Australia and Animals Australia. We also searched the bibliographies of the literature obtained and cited some non-Australian studies of relevance that were cited by Australian studies that we found.

We found 93 literature items in total, comprising published and unpublished items (Figure S1). One item [2] was excluded from the study due to the unavailability of a full-text. We displayed literature found by year and publication type. Most literature items found were contemporary, with 79% published since 2000 (Figure S2). We did not extract effect and precision estimates (as is desirable when conducting a systematic review focused on a

specific question) [1] because our review topic was so broad and involved qualitative information. To summarize the findings and appraise the quality of the evidence presented in the literature, we tabulated study characteristics, quality and outcomes (Tables S2). Specifically, each piece of literature was classified by risk of bias as influenced by publication type and study type, and ranked as low (presents original data and peer-reviewed), medium (presents original data but not peer-reviewed *or* does not present original data but is peer-reviewed) or high (does not present original data and is not peer-reviewed).

References

1. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; Group, P. Preferred reporting items for systematic reviews and meta-analyses: The prisma statement. *PLoS Medicine* **2009**, *6*, e1000097.
2. Hedlefs, R. *Factors influencing mortality and wastage of slaughter cattle transported from Queensland to Japan by sea*; Queensland Department of Primary Industries: Brisbane, Australia, 1988.

Figure S1. PRSIMA flow diagram [1] for inclusion of the 93 publications identified in our literature search.

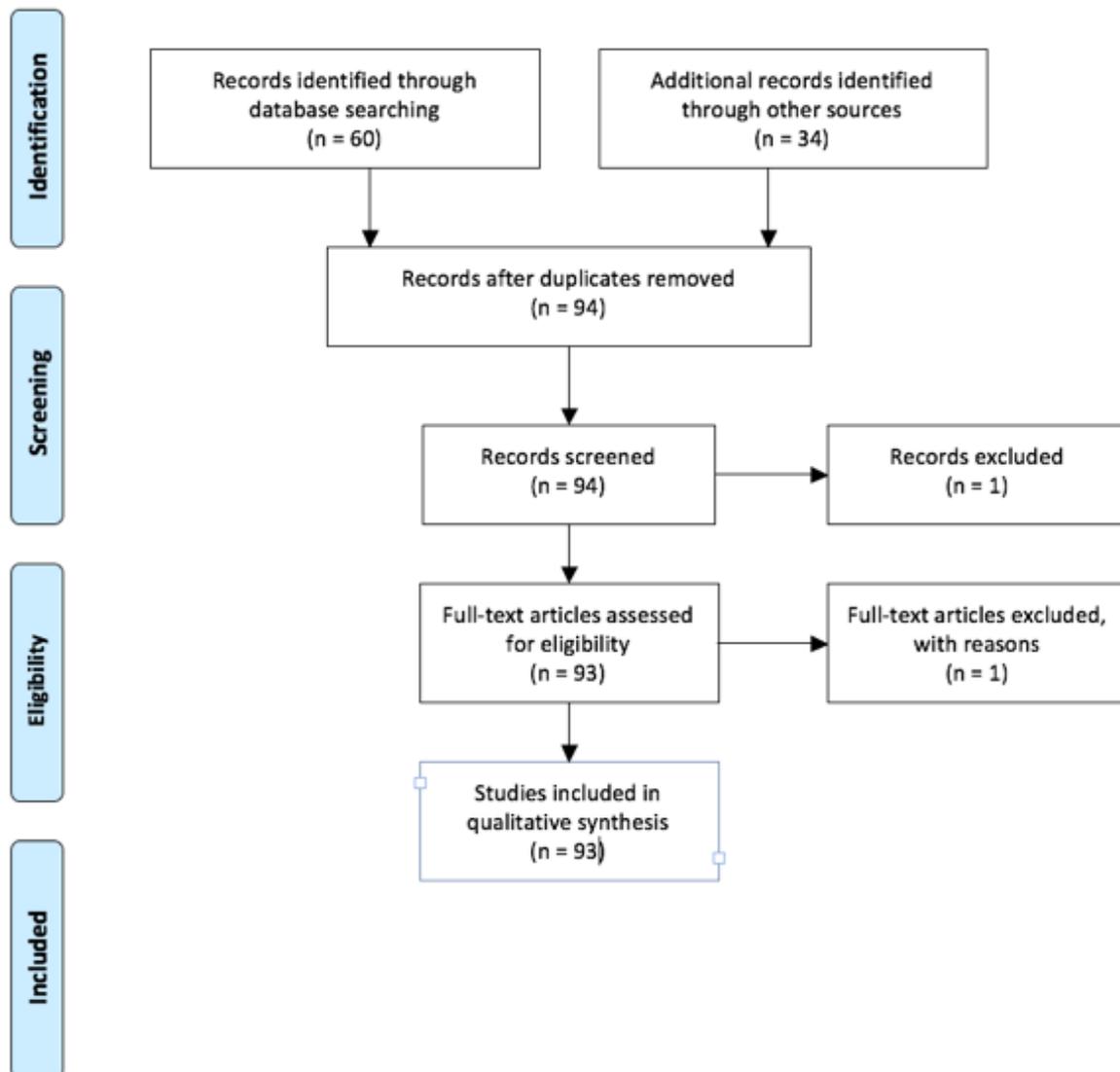
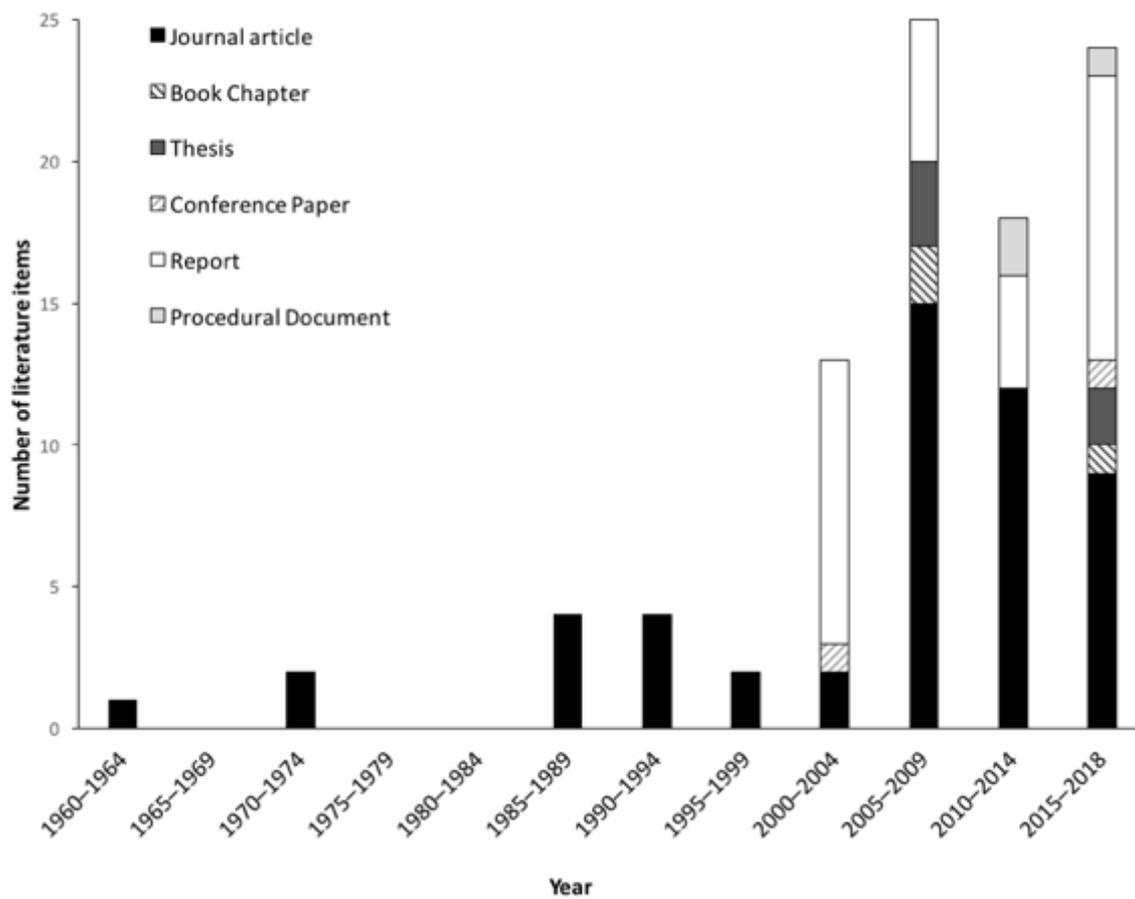


Figure S2. Year of publication for the 93 publications identified in our literature search.

Five-year intervals were used, except for 2015–2018, which was four years.



1 **Table S1.** PRISMA checklist [1].

| Section/topic | # | Checklist item | Reported on page # |
|------------------------------------|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| TITLE | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | 1 |
| ABSTRACT | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 1 |
| INTRODUCTION | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 3 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 3 |
| METHODS | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | Supporting Material |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | Supporting Material |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | Supporting Material |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | Supporting Material |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | Supporting Material |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | Supporting Material |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | Supporting Material |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | Supporting Material |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | NA |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis. | NA |

2 **Table S2.** Classification and appraisal of each literature item.

| Study | Year | Publication type | Livestock species | | Study type | | | | | Original data (Y/N) | Risk of bias |
|-------------------------|-------|------------------------|-------------------|--------|------------|-----------------------------|--------|-----------|---------------------|---------------------|--------------|
| | | | Sheep | Cattle | Experiment | Monitoring and epidemiology | Review | Modelling | Procedural document | | |
| Fisher and Jones | 2008 | Book chapter | ✓ | ✓ | | | ✓ | | | N | High |
| Phillips | 2008 | Book chapter | ✓ | ✓ | | | ✓ | | | N | High |
| Zhang and Phillips | 2018 | Book chapter | ✓ | ✓ | | | ✓ | | | N | High |
| More et al. | 2003 | Conference proceedings | ✓ | ✓ | | ✓ | | | | Y | Moderate |
| Collins et al. | 2016 | Conference proceedings | ✓ | | ✓ | | | | | Y | Moderate |
| Wodzicka | 1960 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Johnson | 1970 | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |
| Maskrey | 1974 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Norris et al. | 1989a | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Norris et al. | 1989b | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Norris et al. | 1989c | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Richards et al. | 1989 | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Higgs et al. | 1991 | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Richards et al. | 1991 | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Higgs et al. | 1993 | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Blackshaw and Blackshaw | 1994 | Peer-reviewed article | | ✓ | | | ✓ | | | N | Moderate |
| Dixon et al. | 1999 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Higgs et al. | 1999 | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |

3 **Table S2 continued.**

4

| Study | Year | Publication type | Livestock species | | Study type | | | | | Original data (Y/N) | Risk of bias |
|------------------------|-------|-----------------------|-------------------|--------|------------|-----------------------------|--------|-----------|---------------------|---------------------|--------------|
| | | | Sheep | Cattle | Experiment | Monitoring and epidemiology | Review | Modelling | Procedural document | | |
| Norris et al. | 2003 | Peer-reviewed article | | ✓ | | ✓ | | | | Y | Low |
| Srikandakumar et al. | 2003 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Bortolussi et al. | 2005 | Peer-reviewed article | | ✓ | | | ✓ | | | N | Moderate |
| Norris | 2005 | Peer-reviewed article | ✓ | ✓ | | | ✓ | | | N | Moderate |
| Petherick | 2005 | Peer-reviewed article | | ✓ | | | ✓ | | | N | Moderate |
| Beatty et al. | 2006 | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |
| Beatty et al. | 2007 | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |
| Petherick | 2007 | Peer-reviewed article | ✓ | ✓ | | | ✓ | | | N | Moderate |
| Adams and Thornber | 2008 | Peer-reviewed article | ✓ | ✓ | | | ✓ | | | N | Moderate |
| Gaughan et al. | 2008 | Peer-reviewed article | | ✓ | | ✓ | | | | Y | Low |
| Beatty et al. | 2008a | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Beatty et al. | 2008b | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |
| Savage et al. | 2008 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Stinson | 2008 | Peer-reviewed article | ✓ | ✓ | | | ✓ | | | N | Moderate |
| Gaughan et al. | 2009 | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |
| Petherick and Phillips | 2009 | Peer-reviewed article | ✓ | ✓ | | | | ✓ | | N | Moderate |
| Gaughan et al. | 2010 | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |

5 **Table S2 continued.**

6

| Study | Year | Publication type | Livestock species | | Study type | | | | | Original data (Y/N) | Risk of bias |
|---------------------|-------|-----------------------|-------------------|--------|------------|-----------------------------|--------|-----------|---------------------|---------------------|--------------|
| | | | Sheep | Cattle | Experiment | Monitoring and epidemiology | Review | Modelling | Procedural document | | |
| Stockman et al. | 2011 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Alhidary et al. | 2012a | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Alhidary et al. | 2012b | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Gaughan et al. | 2013 | Peer-reviewed article | | ✓ | ✓ | | | | | Y | Low |
| Pines and Phillips | 2013 | Peer-reviewed article | ✓ | | | ✓ | | | | Y | Low |
| Schipp | 2013 | Peer-reviewed article | ✓ | ✓ | | | | ✓ | | N | High |
| Caulfield et al. | 2014 | Peer-reviewed article | ✓ | ✓ | | | | ✓ | | N | Moderate |
| Chauhan et al. | 2014a | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Chauhan et al. | 2014b | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Foster and Overall | 2014 | Peer-reviewed article | ✓ | ✓ | | | | ✓ | | N | Moderate |
| Moore et al. | 2014 | Peer-reviewed article | | ✓ | | | ✓ | | | Y | Low |
| Alhidary et al. | 2015 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Chauhan et al. | 2015 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| DiGiacomo et al. | 2016 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Phillips | 2016 | Peer-reviewed article | ✓ | | | | | ✓ | | N | Moderate |
| Zhang et al. | 2017 | Peer-reviewed article | ✓ | | | | ✓ | | | Y | Low |
| Jackson and Adamson | 2018 | Peer-reviewed article | ✓ | | | | | ✓ | | N | Moderate |

7 **Table S2 continued.**

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| Study | Year | Publication type | Livestock species | | Study type | | | | | Original data (Y/N) | Risk of bias |
|---------------------------------------------------|------|-----------------------|-------------------|--------|------------|-----------------------------|--------|-----------|---------------------|---------------------|--------------|
| | | | Sheep | Cattle | Experiment | Monitoring and epidemiology | Review | Modelling | Procedural document | | |
| Santurtun and Phillips | 2018 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Sinclair et al. | 2018 | Peer-reviewed article | ✓ | ✓ | | ✓ | | | | Y | Low |
| Zhang et al. | 2018 | Peer-reviewed article | ✓ | | ✓ | | | | | Y | Low |
| Commonwealth of Australia | 2011 | Procedural document | ✓ | ✓ | | | | | ✓ | N | High |
| Department of Agriculture, Fisheries and Forestry | 2013 | Procedural document | ✓ | ✓ | | | | | ✓ | N | High |
| Department of Agriculture and Water Resources | 2018 | Procedural document | ✓ | ✓ | | | | | ✓ | N | High |
| MAMIC Pty Ltd | 2000 | Report | ✓ | ✓ | | ✓ | | | | Y | Moderate |
| Sparke et al. | 2001 | Report | | ✓ | | | ✓ | | | N | High |
| MAMIC Pty Ltd | 2002 | Report | ✓ | ✓ | | ✓ | | | | Y | Moderate |
| Gaughan et al. | 2003 | Report | | ✓ | | ✓ | | | | Y | Moderate |
| Keniry | 2003 | Report | ✓ | ✓ | | | ✓ | | | N | Hgh |
| Maunsell Australia | 2003 | Report | ✓ | ✓ | | | | ✓ | | N | High |
| Tudor et al. | 2003 | Report | | ✓ | ✓ | | | | | Y | Moderate |
| Barnes et al. | 2004 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Maunsell Australia | 2004 | Report | ✓ | | | ✓ | | | | Y | Moderate |
| McCarthy | 2005 | Report | ✓ | ✓ | | ✓ | | | | Y | Moderate |
| Byrne et al. | 2006 | Report | ✓ | ✓ | | ✓ | | | | Y | Moderate |

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11 **Table S2 continued.**

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| Study | Year | Publication type | Livestock species | | Study type | | | | | Original data (Y/N) | Risk of bias |
|-----------------------------------|------|------------------|-------------------|--------|------------|-----------------------------|--------|-----------|---------------------|---------------------|--------------|
| | | | Sheep | Cattle | Experiment | Monitoring and epidemiology | Review | Modelling | Procedural document | | |
| Barnes et al. | 2008 | Report | ✓ | ✓ | ✓ | | | | | Y | Moderate |
| Ferguson et al. | 2008 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Kennedy | 2008 | Report | | ✓ | ✓ | | | | | Y | Moderate |
| Banney et al. | 2009 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Farmer | 2011 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Ferguson and Lea | 2013 | Report | ✓ | | ✓ | | | | | Y | Moderate |
| Shiell et al. | 2013 | Report | ✓ | | | | ✓ | | | N | High |
| Gobbett et al. | 2014 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Perkins et al. | 2015 | Report | | ✓ | | ✓ | | | | Y | Moderate |
| McCarthy and Banhazi | 2016 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| McCarthy and Fitzmaurice | 2016 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Norman | 2016 | Report | ✓ | ✓ | | ✓ | | | | Y | Moderate |
| Norman | 2017 | Report | ✓ | ✓ | | ✓ | | | | Y | Moderate |
| Wickham et al. | 2017 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Wiebe et al. | 2017 | Report | ✓ | ✓ | | | | ✓ | | N | High |
| Animals Australia | 2018 | Report | ✓ | ✓ | | | ✓ | | | N | High |
| Australian Veterinary Association | 2018 | Report | ✓ | | | | ✓ | | | N | High |
| McCarthy | 2018 | Report | ✓ | | | | ✓ | | | N | High |
| Beatty | 2005 | Thesis | | ✓ | ✓ | | | | | Y | Moderate |
| Outschoorn | 2005 | Thesis | | | | ✓ | | | | Y | Moderate |
| Stockman | 2006 | Thesis | ✓ | | ✓ | | | | | Y | Moderate |

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14 **Table S2 continued.**

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| Study | Year | Publication type | Livestock species | | Study type | | | | | Original data (Y/N) | Risk of bias |
|----------------|------|------------------|-------------------|--------|------------|-----------------------------|--------|-----------|---------------------|---------------------|--------------|
| | | | Sheep | Cattle | Experiment | Monitoring and epidemiology | Review | Modelling | Procedural document | | |
| Aguilar Gainza | 2015 | Thesis | ✓ | | ✓ | | | | | Y | Moderate |
| Tait | 2015 | Thesis | | ✓ | ✓ | | | | | Y | Moderate |

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