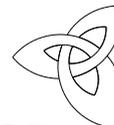


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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Objectives

The principal objectives of this project were:

1. To establish an expert panel able to advise on human-directed dog aggression
2. To conduct a systematic review to identify relevant literature relating to risk factors for human-directed dog aggression.
3. To further investigate risk factors for human-directed dog aggression using meta-analysis*.
4. To identify additional sources of data relating to human-directed dog aggression.
5. To identify specific areas where information is lacking and to provide guidance with regards future research priorities.
6. To disseminate the results of this project via peer-reviewed scientific publications, the lay press, the internet and through CPD events.

* Due to lack of appropriate data, objective 3 could not be undertaken.

Methods

The systematic review process sought to objectively answer research questions whilst minimising bias by;

1. identifying all available relevant evidence through thorough searching of published scientific literature, as well as unpublished and grey literature,
2. critically appraising that evidence to ascertain its methodological quality, and
3. identifying those studies which both answer the research questions and are of a robust standard.

For the narrative systematic review, we identified for inclusion the subset of studies scored as being of at least moderate quality (modified SIGN grade 2+, 2++, 1+, 1++). We took a pragmatic approach in order to identify all moderately high quality research and included those studies where there was a low risk of confounding or bias and at least a moderate probability that relationships identified were causal.

Multiple online literature databases were queried using a high-sensitivity low-specificity strategy. The titles and abstracts of 27,565 records were evaluated; 192 relevant papers underwent detailed appraisal. A database of evaluated studies can be found at www.liv.ac.uk/dog-aggression.

Findings

The majority of studies evaluated provided low quality evidence; a small number (8) were regarded as providing moderate quality evidence regarding risk factors for human-directed dog aggression (HDDA) associated events. It should be noted that researchers may classify events as being HDDA despite there being no assessment of the underlying motivation for the event. For example, some studies rely on medical records of treatment for dog bites, but do not assess the context in which the bite occurred; in

such cases some bites may have occurred during play or the predatory sequence, which from the perspective of the dog may be considered a non-aggressive act (as opposed to aggression used in a fearful situation). However, from the perspective of the human, a bite that punctures the skin or causes a fatality is very likely to be interpreted as an act of HDDA, due to the impact on the target. In this report we simply use the term "bite" to describe a bite outcome and the term "aggression" when the outcome involved non-injurious aggressive behavior such as growling and snapping.

Reasons for study exclusion included: poorly defined or inappropriate outcome measures or measures of exposure; inadequate control of potential confounding; and inappropriate selection process, study design or analysis. Where two studies investigated the same risk factor, findings were generally non-comparable due to variation in outcome definition (e.g. aggression toward known or unknown people) or the way in which the risk factor was measured or categorised (e.g. breed categories differed between studies). Most studies investigated bites as opposed to other forms of aggression.

A key finding of this systematic review was of the need for higher quality research into the factors affecting the risk of HDDA associated events. The eight studies included following the appraisal process provided the following evidence regarding some risk factors for HDDA associated events. It should be noted that the failure to identify a statistically significant effect cannot be assumed to mean that no such effect exists, merely that one was not identified.

1. Dog related factors

- *Size of dog:* There is some evidence that smaller female dogs are at greater risk of biting household members; however there are many confounding factors of size and further study is required to elucidate whether this is a true risk factor.
- *Age of a dog:* No evidence.
- *Sex and neuter status of dog:* There is conflicting evidence for the role of sex as a risk factor for aggression and bite; further study is required. There is conflicting evidence for the role of neuter status as a risk factor; this requires prospective studies to elucidate any true association.
- *Breed of dog:* Despite considerable speculation of a role for breed as a risk factor for human-directed dog aggression, insufficient evidence exists to draw firm conclusions.
- *Genetic determinants:* There is some evidence for heritability of human directed aggression; this however requires further investigation across multiple breeds.
- *Behavioural history of dog:* There is some evidence that aspects of a dog's behaviour are associated with their future propensity to both exhibit aggression and bite; in particular, a history indicating past aggressive acts increases the risk of future aggressive acts. This requires further investigation.
- *Health status of dog:* Whilst there is some evidence for an association between skin conditions and biting, the association of aggression and health requires more extensive study.
- *Diet of dog:* There is some evidence for an affect of dietary protein and tryptophan content on the level of aggression expressed towards either owners or visitors, however this requires further investigation.

2. Dog and owner interaction factors

- *Source of dog acquisition:* There is very limited evidence that source of acquisition may be a risk factor for owner directed aggression, however further work is required in this area with particular attention being paid to the multiple potential confounding factors at play.
- *Early-life environment and experiences of dog:* Very little evidence. This may be a key under-examined area for further research given the ability of both the breeder and the owner to influence early life experience. Due to the complexity of gathering such data, this would likely require studies of longitudinal design where dogs were followed from birth.
- *Extent and type of training:* No evidence.

3. Owner related factors

- *Owner socio-demographic factors:* There is evidence that sharing a home with children or teenagers may be associated with an increased risk of biting both household and non-household members. This is an area requiring further research.
- *Purpose for which dog kept:* No evidence.
- *Husbandry:* There is weak and conflicting evidence of an association between allowing a dog to sleep on the bed and it exhibiting human-directed aggression, and also evidence of an association between chaining a dog whilst in the yard and biting non-household members. These and other areas of the management of a dog require further detailed study.

4. Target of aggression factors

- *Target socio-demographic factors:* No evidence.
- *Relationship between target and dog and owner:* No evidence.
- *Experience and understanding of dog behaviour:* No evidence.

5. Wider environmental factors

- *Geographic location and urbanisation:* We found evidence that for postal workers in Taiwan there is an

apparent association between working in rural areas and increased risk of receiving bite injuries. However it is difficult to extrapolate these findings to the general population and this requires further investigation.

This review has highlighted the absence of high quality evidence relating to risk factors for human-directed dog aggression. Even that evidence identified as having a low risk of confounding and bias, does not provide firm evidence of causal relationships and in a number of cases the results are contradictory. This may be the result of numerous factors, including issues with study design or implementation, differences in study populations or outcome definition, or chance (particularly as many studies utilised small sample populations). As a result of these contradictions, and the moderate level of evidence identified, our findings do not provide robust evidence for any factor affecting the risk of human-directed dog aggression. Our findings can however be utilised in formulating hypotheses for future research.

Other significant events

Two 1-day Seminar events were held in February 2011 to bring together interested parties from diverse backgrounds. Attendees included representatives from; animal welfare and rehoming organisations, dog breeding organisations, risk management, animal behaviour and training, companion animal epidemiology, police officers including Dog Legislation Officers, dog warden associations. The prime aim of these events was dissemination of the findings of our systematic review. In addition the seminar events provided an opportunity for the participants to share opinions and experiences drawn from their varied fields of expertise.

Options for new work

We did not identify research that attempted to list all potential risk factors for human directed dog aggression, or to create a causal web of these. As such, it was often unclear why particular potential risk factors had been selected for study, and others omitted. We believe it would be beneficial for such a causal web to be generated, in order to aid discussion of potential risk factors and also to help guide researchers with regard the design and analysis of their studies.

We recommend an appropriate starting point for future research should be a prioritisation exercise involving a multidisciplinary group of stakeholders with a wide range of interests in the subject, from policy and policing, to treatment of dogs and people affected. However, whilst the results of such an exercise would provide guidance for researchers, it needs to be borne in mind that the results will in part reflect the interests of the experts involved, and hence should not be viewed as an endpoint of discussion, but rather as a starting point for a new dialogue.

Through our investigations and discussions with stakeholders at our seminar events, we have identified a variety of sources of data which may assist in future research. These fall into a number of potential data types and sources that may be utilised in future research into human-directed dog aggression. However, it should be noted that each of these may be subject to a range of biases and as such careful planning would be required prior to their utilisation. Further, many of these datasets are not publically available, and hence appropriate permission would need to be obtained from the data owners. A key recommendation is, therefore, that efforts be made to ensure appropriate data start to be collected to aid future research.

8.

Introduction

Human-directed dog aggression (HDDA) is responsible for considerable worldwide morbidity and a small, but none the less tragic, annual mortality rate. The number of people in the UK injured by dogs annually is difficult to quantify, with many incidents going unreported and multiple potential biases affecting which bites are reported to authorities or presented for medical treatment.

Annual admissions for NHS care in England attributed to being bitten or “struck” by a dog have risen over the past decade. The most recent figures, for the year ending April 2010, indicate that there were 5,252 emergency admissions and a total of 11,503 occupied bed days attributed to these injuries¹. The reason for this trend, or the contribution from injuries received during activities such as play, is not known. During the decade to 2008 there was an average 2.2 deaths registered annually in England and Wales attributed to dog bites or strikes². However, as the Office of National Statistics acknowledge³, even these figures are not entirely accurate, with for example only 1 of those 4 deaths registered in 2008 occurring during that year. Furthermore, human deaths associated with dog attacks are usually extensively reported in the media, particularly when children are involved, and high profile cases have brought the issue of human-directed dog aggression to the fore.

Even where no physical injury has occurred, the psychological impact of dog aggression can be profound and long-lived. In addition to these public health issues, human-directed dog aggression carries implications for the welfare of dogs. For all of these reasons, many parties are keen to reduce the occurrence and consequences of aggressive acts.

Before it is possible to devise potentially effective preventive strategies, it is important to reliably identify which factors alter the risk of an aggressive act occurring. This systematic review seeks to objectively identify all available robust evidence of factors which affect the risk of human-directed dog aggression – termed ‘risk factors’.

Establishment of expert panel (Obj. 1)

A panel of experts with known interest in issues of dog aggression were contacted and invited to assist with our study. Participating persons were consulted as to design of our literature search and systematic review process. At the end of our data collection and analyses we reported our findings at two identical seminar days, attended by interested representatives of UK charities, animal behaviour, veterinary, policing and government organisations, and academic institutions. The implications of our findings were briefly discussed in open sessions and the attendees constitute a source of future expert discussion in this subject area.

Systematic review (Obj. 2)

Systematic review process

Systematic reviews are considered the gold standard for establishing the current evidence base within human health care, forming the foundation for example of the NICE⁴ and SIGN⁵ treatment guidelines. Although it is secondary evidence, the systematic review is considered to be at the peak of the hierarchy of research evidence.

The systematic review process seeks to objectively answer a research question whilst minimising bias by;

- identifying all available relevant evidence through thorough searching of published scientific literature, as well as unpublished and grey literature,
- critically appraising that evidence to ascertain its methodological quality, and
- identifying those studies which both answer the research question and are of a robust standard.

The term systematic review is often used interchangeably with meta-analysis; however “meta-analysis” is also used to describe statistical techniques for combining the findings of equivalent studies. To be reliable this process needs to be preceded by a sound systematic review. In this report we use the term “systematic review” to refer to the process of identifying, appraising and reporting on (sufficiently high quality) studies that address a research question of interest, and “meta-analysis” as the statistical process of pooling the results from sufficiently equivalent studies.

The systematic review process requires objectivity and impartiality. To maintain objectivity, the appraisal process focuses on methodology, with the results of studies only being considered after a decision on inclusion has been reached. In order to further safeguard objectivity it has also been recommended that a systematic review is undertaken by impartial researchers with sufficient distance from the subject matter so as to retain objectivity. This was achieved within our research team by having a medically qualified researcher with only lay knowledge of the subject area managing the project, supported by a research team with epidemiological, veterinary and behavioural expertise.

Identifying research questions

A systematic review requires the identification of specific questions, which the review then seeks to answer. A typical review would usually focus on the effect of a single risk factor on a single outcome in a specific

population. This review of risk factors for HDDA associated events differs from this in that we aimed to review many potential risk factors, acting on different individuals involved in the aggressive act, and a range of relevant outcomes (from aggressive posture to biting to fatality).

An act of HDDA involves at least two parties, possibly more. The interaction between individuals, relationships and their environment, both physical and social, is complex. For example, a dog may bite its owner within their own home, with no other individuals present. The situation becomes more complex when there is a third individual involved in the aggressive act, for instance a visitor to the home of the dog. The social setting, cultural norms and pressures, and the behaviour and education-level of both the owner and target of aggression, may play a part, as may additional dog-related factors such as type and past experiences.

In order to untangle the complex web of interactions and identify potential risk factors we developed the conceptual matrix illustrated in Figure 1. This framework was used to examine the interactions, outcomes and possible risk factors involved in human directed aggressive acts and events that may be associated with aggression. It was clear that focusing on a single potential risk factor would potentially be to the detriment of identifying other equally influential factors. Similarly, in examining outcomes it was feasible that factors affecting the risk of a dog exhibiting non-injurious aggression may be different from those affecting risk of bite injury or life threatening injury. Although there is a progression in severity of outcome, this may not necessarily represent a sequential progression in the degree of aggression exhibited by the dog. It should be noted that researchers may classify events as being HDDA despite there being no assessment of the underlying motivation for the act of aggression. For example, some studies rely on medical records of treatment for dog bites, but do not assess the context in which the bite occurred; in such cases some bites may have occurred during play or the predatory sequence (for example herding behaviour), which from the perspective of the dog may be considered a non-aggressive act (as opposed to defensive aggression used in a fearful situation). However, from the perspective of the human, a bite that punctures the skin or causes a fatality is very likely to be interpreted as an act of HDDA, due to the impact on the target, regardless of the context, and bite prevention is a legitimate aim of prevention of dog aggression. The results for this systematic review incorporate studies that use a variety of outcome definitions of bite and of aggression. The term “bite” commonly means that the outcome measurement included a biting act, regardless of motivation, however, bites in activities such as play or a predatory sequence may have been specifically excluded in some studies. In this report we use the term “bite” to describe a bite outcome and the term “aggression” when the outcome involved non-injurious aggressive behavior such as growling and snapping. Both we classify as HDDA due to the impact on the human.

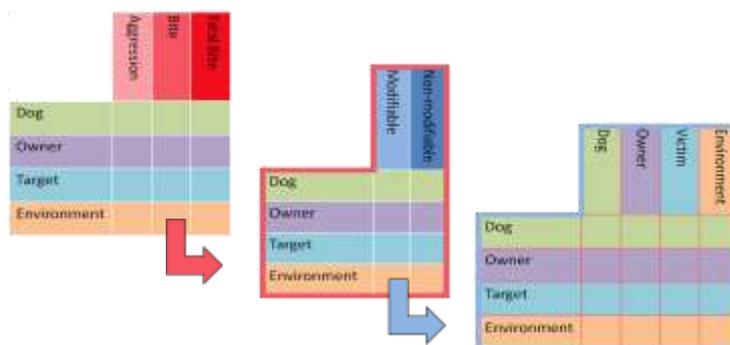


Figure 1: Conceptual framework for examining and categorising potential risk factors and the interactions to which they relate. Risk factors can be stratified by the outcome which they may affect, by our ability to modify, and by interactions between parties or the environment

Standard of evidence

The systematic review process seeks to objectively appraise the quality of studies and thus requires a predetermined threshold level of evidence. Typically the criteria used aim to include only those studies in which there is a low risk that any identified association are due to non-causal mechanisms, thus many systematic reviews only include high quality randomised controlled trials (RCTs). However, when studying “naturally occurring” risk factors, the majority of the research consists of observational studies. We took a pragmatic approach in order to identify all moderately high quality research and included those studies where there was a low risk of confounding or bias and at least a moderate probability that relationships identified were causal. We amended the SIGN levels of evidence, which are widely utilised within the human healthcare field, with the addition of cross sectional studies to level 2, and graded evidence according to this scale (Table 1). It is worth noting that case reports and case series are not considered quality evidence due to lack of a control population for comparison, and likewise, expert opinion is subject to bias, although this can be useful in generating future research questions.

Table 1: Levels of Evidence; Amended from SIGN⁵. Only levels 1++, 1+, 2++ and 2+ met our inclusion criteria

Level	Description of studies meeting this level
1++	High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias
1-	Meta-analyses, systematic reviews, or RCTs with a high risk of bias
2++	High quality systematic reviews of case control, cohort or analytical cross-sectional studies High quality case control, cohort and cross-sectional studies with a very low risk of confounding or bias and a high probability that the relationship is causal
2+	Well-conducted case control, cohort or analytical cross-sectional studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2-	Case control, cohort or analytical cross-sectional studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series, descriptive cross-sectional studies
4	Expert opinion

Search strategy

The search strategy should have few restrictions thereby ensuring an inclusive, unbiased, retrieval of evidence. High recall and sensitivity is the focus of the search, with unavoidable compromise of specificity, i.e. the search will be effective at detecting the evidence sought, but much of what is identified will not be relevant. Having evaluated a range of search terms, with input from experts in the behavioural field (Obj 1), we developed our search equation of:

(dog or dogs or canine or canis) and (bite or bites or bitten or aggress* or attack or death* or fatal*)

As human directed dog aggression and its consequences are of multidisciplinary concern, we sought to identify literature from multidisciplinary journals with no restriction on language, country of origin or publication status. This aimed to minimise the risk of publication and language bias affecting our findings. To this end we utilised our search equation in a range of electronic literature databases including:

- Scopus,
- Pubmed,
- Science Direct,
- ISI Web of Knowledge – limited to the Social Sciences Citation Index and conference proceedings,
- Index medicus for South East Asia,
- Airiti,
- African journals online,
- Educational Research Information Centre,
- Cochrane Library ,
- International theses databases and institutional repositories were also searched.

Publication bias is a well recognised phenomenon; studies with statistically significant positive results are more likely to be submitted and accepted for publication than those with non significant or negative findings⁶, this is particularly problematic when conducting a systematic review where identification of all available literature is key⁷. In order to minimise this risk we took several steps to identify unpublished works. We presented our on-going research and requested information from anyone aware of unpublished work at a behavioural conference of 300 delegates, we published a letter to the same effect in the Veterinary Record⁸ and Vet Times, and we searched conference proceeding and theses databases. Finally, we contacted authors who had published work in the field within the past decade.

Appraisal

All identified literature was imported into a spreadsheet program (Excel 2007, Microsoft Corporation) for data management. Where the title of retrieved studies clearly signified that they related to subjects other than human-directed aggression, these were assigned as “irrelevant,” and studies that could not be excluded at this stage were assigned as “possibly relevant”. Where the title provided insufficient information to determine the subject of an article, the key words and abstract were also evaluated. Assignment was undertaken using only the title, key words and abstract. Other information, such as author names, was not available during this process.

Where studies were published in a language other than English, their title was translated using Google Translate⁹ to enable ascertainment of relevance. Where necessary, further translation (of the abstract and the full paper) was then undertaken using the same software and/or native speakers of the article language.

All retrieved articles on the subject of human-directed dog aggression underwent the first stage of appraisal. At this stage articles were excluded if they were not primary research or related to aspects of human-directed dog aggression other than risk factor analysis; this included those articles concerning the infective consequences of bite injuries, wound management and behaviour management.

Where articles were primary evidence of human-directed dog aggression, they were further evaluated for the presence of a comparator group, this being essential for reliable risk factor analysis. Those articles without a potentially appropriate comparator group were excluded from further appraisal. This was again undertaken with authorship obscured.

Articles that had not been excluded by the above process underwent full appraisal. Appraisal confirmed whether the study was truly appropriate for the systematic review and assessed the methods based on the following criteria using a predesigned form: study design; selection process; measurement of outcome and exposure to risk factors; control of confounding and; analysis. Five reviewers undertook this appraisal process; three of whom were Diplomates of the European College of Veterinary Epidemiology in the sub-discipline Population Medicine. Each study was reviewed independently by at least two reviewers, one being a Diplomat. Where reviewers disagreed, a third independent appraisal was undertaken.

Following this process any study which had not been rejected by both reviewers was examined, on the same criteria, during open discussions involving at least three members of the research team. A consensus was reached on whether each study had a low risk of bias and confounding and a moderate probability that any relationships identified were causal, and thus were of sufficiently robust quality to reach the final review.

Results

Part A: Results of the study identification and appraisal process

The electronic searches retrieved 27,565 publications; 84% of these could be excluded from further appraisal as they concerned an unrelated subject. Of the remaining publications, 28% were removed because they primarily related to rabies, predominantly vaccination development and use, a further 12% because they concerned other infective consequences of dog bite injuries, 10% because they concerned bite injury management and 3% as they concerned management of aggressive behaviour or were opinion based articles (11%). A further 12% were removed for a range of reasons; for example, examinations of biomarkers, forensic investigations and the development of temperament tests. Of the relevant publications that were primary research; this left 24% potentially providing evidence of risk factors for human directed dog aggression.

This subset was further examined with reference to our levels of acceptable evidence. Case reports and series of bite injuries or aggressive dogs were removed as they did not contain a comparator group. Cross sectional studies which only investigated prevalence were also removed, for example of hospital attendances or dogs referred to behaviourists. This left a subset of studies with a potentially appropriate comparator group for risk factor analysis. These studies underwent formal appraisal by at least 2 individuals. In addition, a sample of 28 studies rejected during the sorting process then underwent appraisal in order to confirm correct assignment (appraisers were blind to whether or not a paper had been previously rejected). In all, 192 studies were formally appraised (i.e. 164 that were considered for the systematic review and 28 rejected papers used to check the assignment procedure). Among these, 10 were subsequently found to report only on potential bio-markers for aggression (e.g. measuring catecholamine levels in aggressive dogs), rather than risk factors and were not considered further and 2 were found, following translation, to be reviews. Hence, 152 papers were formally reviewed for the systematic review. In total, these studies attempted to investigate the effect of over 100 potential risk factors. Bibliographic information for these 152 can be found in the searchable database at www.liv.ac.uk/dog-aggression.

In addition, we attempted to contact 87 authors, identified as having published potentially relevant research in the past decade, requesting information regarding unpublished work and potential data sources that they may be aware of. Of these, 13 emails could not be delivered (address failed or spam blocked) and these authors were subsequently contacted by post at their last published address. In all, 12 authors replied but had no additional information and 9 authors replied with information concerning projects or datasets. Of these, 6 described work for which results were not currently available and two provided information on potentially useful datasets. Another provided names of additional researchers who may have further information. We also contacted 29 authors with specific questions to obtain further details about their published studies; 4 responded but had no further useful information. In addition, 4 individuals contacted us with information regarding their work having learned of our research via our publications, presentations or website.

Through the formal appraisal process we identified eight studies which were of a sufficient methodological quality to be considered as providing evidence with low risk of bias and confounding. These studies fell into three broad categories; four were non-specific observational studies, two were studies of heritability and two were studies of the effect of diet on aggression.

Part B: Selected methodological issues identified in the evidence base

As noted above, each study was appraised in terms of; study design, selection process, measurement of outcome and exposure to risk factors, control of confounding, and analysis. Here we outline a number of common

issues identified as problematic within the studies appraised. Many studies had multiple limitations affecting the level of evidence provided. We have not prioritised.

1. Study design

- a. **Case studies and series:** In order to be able to identify a change in risk associated with the presence of particular characteristics, studies needed to include an appropriate comparator group. However, the most commonly identified type of studies that concerned human-directed dog aggression was the case study/series. As a result of the lack of a comparator group, case series and studies do not provide any evidence of the effect of potential risk factors. Despite this, case series were often cited in other papers as evidence of an effect.
- b. **Sample size:** The ability of a study to detect an effect (where it truly exists) is, in part, determined by the size of the population included in the study. An important part of study design is sample size calculations in order to determine the approximate population size required in order to detect the desired effects. However, few studies reported having undertaken sample size calculations in advance. In the absence of these it is difficult to establish the voracity of their findings, especially those reporting lack of an association. In many cases it was likely that the number of individuals included in the study was insufficient to detect anything but a very large effect. A prime example of this is where studies attempt to determine the affect of breed on risk. With only a handful of dogs from each breed within study populations, detecting an effect of breed on risk was problematic. One method utilised to overcome this is grouping of breeds into meaningful groups; hound, working, pastoral etc. This however is in itself problematic due to the diversity of dog characteristics within breed groups, questioning the usefulness of this method.

2. Selection

Study population selection is fundamental to any high quality investigation. Regardless of the quality of subsequent measurement and analysis, if the original selection was potentially biased then all subsequent findings are devalued. However, it should be acknowledged that it is often difficult to access a representative sample of the dog-owning population. Future research should pay close attention to the issue of study sample selection.

- a. **Convenience sampling:** Many studies utilised populations selected by convenience, with a high risk of introducing bias. All types of convenience sampling in observational studies carries the (typically un-measurable) possibility that those who are convenient, or more likely to be sampled, are not representative of the overall population under study, by virtue of the factors increasing their likelihood of being sampled.

A common method of convenience sampling involved the population being recruited via advertisements, with the introduction of volunteer bias. Examples of this included advertisements placed in dog-related magazines where bias is introduced by the select readership of such magazines in addition to those who choose to participate having read the advertisement. Internet based surveys have a similar propensity to introduce volunteer bias in addition to bias resulting for the factors making an owner more likely to access internet based information.

- b. **Selection of controls in case-control studies:** For any risk factor analysis, comparator populations must be derived from the same population as the cases. For example, if dogs that have bitten are cases and dogs that apparently have not are controls, it is important that dogs eligible to be controls should be identified through the case-selection process, if they were (hypothetically) to have bitten. Where this does not occur, like is not being compared to like and any association identified may be as a result of the inherent differences between the case and control populations rather than exposure to the risk factor being investigated. This was a pitfall of a number of studies.
- c. **Registries:** A number of studies utilised registry-based populations as their comparator group in risk factor analysis. The most frequently used registries were of dog registrations and bite incident reports. The use of registries in this manner, whilst on face value an attractive approach, has considerable potential for introducing bias. Multiple factors are likely to influence an individual's decision to report a bite incident to authorities, even where it is compulsory to do so. In the study described by Shuler¹⁰ for example the authors acknowledge that, although multiple parties are required to report dog bites in the county, the reported bite rate was 40% below the national estimated rate of bites attending emergency departments, and that the characteristics of the dogs, owners and recipients involved in unreported bite incidents are not known.

Registries of licensed dogs are most commonly utilised by studies to estimate relative risk of breed or breed groups. The major issue here is that there may be factors inherent to the owners of dogs which make them both more likely to choose to own a given breed and concomitantly less likely to abide by legislation requiring dog registration or licensing. Those owners choosing to license their dog may not be representative of the general dog population or the biting dog population. In Shuler's study 51% of the dogs reported for biting were not licensed. An earlier survey in the same county¹¹ found that only 43% of dogs were licensed. Without knowledge of the population not represented within the comparator dataset it is impossible to gauge relative risk reliably.

- d. **Medically attended bites:** Datasets of those attending for medical treatment of bite injuries are liable to be biased by a range of factors. Whether an injury is considered to require medical treatment will be affected by perception of the severity of injury and risks posed, which may, in turn, be influenced by health beliefs and understanding. Inequalities in health care seeking behaviour and access are well recognised and again will influence who attends for treatment¹². Cognitive biases influencing the perceived risk of a given type of dog causing serious injury may be generated by media reports and breed bias¹³ following severe bite injuries. This may result in bites inflicted by dogs of some breeds or types being more likely to attend for treatment¹⁴.

Bite injuries resulting in hospital attendance are commonly considered an indicator of injury severity; however this does not necessarily follow. Although they did not record injury severity, Beck et al¹⁵ found that for children, the sole factor associated with a bite resulting in attendance for medical care was the ownership category of the dog; with bites inflicted by dogs of unknown ownership more likely to result in attendance followed by those owned by neighbours and in turn dogs belonging to the child's family.

- e. **Randomisation:** Randomisation is fundamental to reducing the risk of introducing selection bias. Within an observational study it is important to consider whether, despite attempts to randomise selection, some members of the population are disproportionately more likely to be selected. In controlled trials, randomisation aims to ensure that those assigned to each group are not, on average, fundamentally different in ways other than their exposure to the exposure being tested.

3. Measurement

Robust research requires reliable and reproducible measurement of both the outcome under study and of exposure to potential risk factors. Inadequate measurement was a shortcoming of many studies.

- a. **Outcome definition:** In order to measure an outcome reliably, and in so doing accurately classify members of the study population, the outcome being studied must be clearly defined. If we are studying owner directed aggression, for example, what do we mean by this? Does it include perceived acts of aggression during play or predatory/chase behaviours? Likewise, if the outcome is a bite, does this include any contact between the dog's teeth and skin or only those breaking the skin? Without a clear definition dogs can readily be misclassified in either direction, generating a fundamentally unreliable study population. Many studies failed to explicitly define their outcome.

One shortcoming particularly relevant to human-directed dog aggression was the introduction of non-objective perceived motivation to the definition. Two dogs with the same behaviour could be classified differently if the owner or target of aggression perceived the behaviour to have been differently motivated. Also, some studies did not differentiate HDDA associated events on the basis of prior behaviour. For example, whilst some studies only included the first biting event for a particular dog, others may have included dogs with a range of biting histories, for which the risk factors may differ.

- b. **Outcome measurement:** In many cases, there was no evidence of validation of the methods used to measure outcomes in the evaluated studies. A number of studies utilised the opinion of veterinarians and other animal care workers in ranking breeds on various behaviours. Opinion of breed behavioural characteristics, even where expressed by an experienced and knowledgeable body, is low level, potentially biased evidence.
- c. **Study factor (exposure) measurement and standardisation:** It is only possible to quantify the effect of potential risk factors when they are reliably measured. For example, a study factor whose measurement was frequently problematic was breed of dog. Breed was assessed in various ways. Some studies only classified purebred dogs by breed, grouping all other dogs in a mixed breed category; others used owner opinion of the predominant breed where a dog was of mixed breeding. Even experienced observers have been found to be unreliable at determining a dog's breed composition¹⁶. Breed determination by the target of aggression, where the breed is not subsequently verified, is further problematic as a result of the effect of cognitive biases, for example those being bitten by an unknown dog may subconsciously misidentify the dog as of a breed that they perceive to be aggressive. Measurement of breed was especially problematic where cases were identified by the target of aggression and controls by the owner.
- d. **Blinding:** Whether a study is observational or interventional, blinding reduces the risk of introducing measurement or observer bias. Bias is potentially introduced by prior knowledge of the outcome by the person measuring exposure to a study factor, or conversely of exposure to a potential risk factor when measuring outcome. If, for example, an interviewer knows that a dog has been reported to have bitten, they may interpret owner's responses or dog behaviours differently to if they know the dog has not bitten, making measurement of exposure to risk factors unreliable.

4. Confounding

Confounding occurs when the true relationship between a potential risk factor and the outcome of interest is distorted by a third factor. Without accounting for confounding, false conclusions may be drawn. Many studies failed to account or control for confounding in either the design of their study or during analysis. A key point when considering control of confounding through the analytical process is

that this can only attempt to control for potential confounders that are (accurately) measured. As a general rule, we believe that studies failed to adequately consider and measure potential confounders, and hence control through analysis may have been inadequate. In part this resulted from the lack of a *a priori* identification of potential confounders. Indeed, a weakness identified with the entire body of research relating to risk factors for human directed dog aggression was the lack of an attempt to consider the “causal web” for human-directed dog aggression. Development of such a web would aid discussion of potential risk factors and highlight those potential confounders that require consideration when considering specific risk factors of interest. Some studies appeared to recognise the presence of confounding, but not its importance to their findings.

5. Analysis

In many cases it was difficult to adequately ascertain the statistical methods employed in the analysis of a study. However, several methodological issues appeared prevalent. These included:

- a. **Inappropriate methods:** Many common statistical tests assume data is normally distributed. Despite this, methods making this assumption were sometimes used for data for which this was unlikely to be the case.
- b. **Univariable vs multivariable regression analysis:** Multivariable analysis is used to determine the effects of individual factors whilst controlling for the effect of other measured factors within an analytical model, allowing the effect of individual variables to be measured when adjusted for the effect of all other variables. It is an important method of controlling for (at least those measured) confounding variables during the analysis stage of a study. However, many studies did not undertake multivariable analysis, reporting only univariable findings.
- c. **Multiple statistical tests:** Typically, statistical significance is assumed when the probability of falsely claiming statistical significance is less than 1 in 20 (i.e. $p < 0.05$). However, where multiple statistical tests are undertaken, the risk that at least one is falsely positive increases. Several methods are available to overcome this problem. Despite this, numerous studies reported the results of multiple statistical tests, but did not consider the potential impact of this when discussing the statistical significance of the results.

A more insidious problem may occur when authors only report (or predominantly report) the significant results of the statistical analyses. This has the effect of hiding from the reader the potential effect of multiple testing and serves to highlight the (potentially erroneous) significant results. This problem is usually undetectable in the absence of detailed information about the study. We identified one paper¹⁷ that reported only a limited number of statistical results compared to those identified in a fuller report of the study¹⁸. However we suspect that the same issue may be present in other studies. In part, this problem results from the limited space available in journals, and increased use of online supplementary material may help overcome this issue. Inclusion of a table describing all variables considered would help.

- d. **Subgroup analyses:** In addition to undertaking analysis of the entire study population, many studies also performed statistical analyses using subsets of the population. This has the effect of reducing sample sizes, and introducing multiple statistical tests into the study, thereby increasing the risk of false statistical results. Methods exist for analysis of subgroups, particularly where such analysis is identified as being of interest *a priori*.
- e. **No hypothesis formation:** As noted above, we did not identify research that attempted to list all potential risk factors for human directed dog aggression, or to create a causal web of these. As such, it was often unclear why particular potential risk factors had been selected for study, and others omitted. We believe it would be beneficial for such a causal web to be generated, in order to aid discussion of potential risk factors and also to help guide researchers with regard the design and analysis of their studies. Authors in other fields have suggested more open and transparent reporting of research (for example see Schriger, 2005¹⁹) and similar approaches may benefit future research into human-directed dog aggression.
- f. **Interpretation of direction of association:** Most studies were cross-sectional in nature, thus could not provide strong evidence of the direction causation, only association, as it is not known what came first, the factor or the outcome. However, some authors interpreted their findings as evidence of causation in a particular direction and in some cases appear to assume that their results are generalizable to other populations.

Part C: Narrative systematic review

Table 2 provides a summary of the studies which met our inclusion criteria for the systematic review. Of note is the propensity of these studies to restrict the population included and risk factors considered. For example, several studies were limited to one or two breeds of dog and most investigated aggression or biting toward a specific target (for example a household member). The use of such inclusion criteria provides a means to control for confounding due to the restricted factor(s). It will also control for effect modification due to this factor, which may arise, for example, where effect of risk factors for aggression toward a stranger may be different to that toward a household member. Hence, this approach has some methodological advantages, but may reduce the external validity (i.e. generalisability) of the results.

Many studies presented both univariable and multivariable analytical results. Where appropriate, we have only used the findings from the multivariable modelling process. Multivariable analysis attempts to control for confounding by creating a model with many predictor variables, thus presenting findings for a variable of interest after adjustment for the effects of other important variables. We also attempted to extract information from papers regarding variables that were tested in the multivariable model but were not included in the final model due to lack of statistical significance or effect on other variables.

It is worth highlighting that the failure to identify a statistically significant effect cannot be assumed to mean that no such effect exists, merely that one was not identified; failure to detect a significant effect may result from so called type II error (where a true effect is not identified) and the probability of this occurring increases as the statistical power decreases. Very few studies stated the expected statistical power, but several had a relatively small sample size and so the power may be expected to be low. In conclusion, failure to report evidence of an effect of a particular risk factor in this report may be because no studies of sufficient quality examined this risk factor, none of the included studies was able to detect an effect, or that the risk factor truly has no effect.

Table 2: Summary of studies included in the systematic review

Study type	Level	Study population	Population characteristics	Comparison group	Outcome measures	Main risk factors studied	Risk factors identified
Chen, S. C., F. C. Tang, et al. (2000). "An epidemiologic study of dog bites among postmen in central Taiwan." <i>Chang Gung Med J</i> 23(5): 277-283. ²⁰							
Cross Sectional	2+	192 postal workers (237 total)	Taiwanese postal workers attending routine medical	Non bitten Taiwanese postal workers (same pop)	Bite during course of work	Socio-demographics Experience Location	Working in rural area
DeNapoli, J. S., N. H. Dodman, et al. (2000). "Effect of dietary protein content and tryptophan supplementation on dominance aggression, territorial aggression, and hyperactivity in dogs." <i>Journal of the American Veterinary Medical Association</i> 217(4): 504-508. ²¹							
Randomised trial	1+	33 dogs (38 commenced trial)	Privately owned dogs	Dogs acted as their own controls	Change in aggression score	Protein and tryptophan content of diet	High protein associated with highest dominance aggression Low protein, tryptophan supplemented, assoc with lowest territorial aggression
Dodman, N. H., I. Reisner, et al. (1996). "Effect of dietary protein content on behavior in dogs." <i>Journal of the American Veterinary Medical Association</i> 208(3): 376-379. ²²							
Randomised Trial	1+	50 dogs	Privately owned dogs divided into subsets according to predominant behavioural problem	Dogs acted as their own controls	Change in aggression score	Protein content of diet	No overall effect Reduced protein content reduced only fear related territorial aggression
Gershman, K. A., J. J. Sacks, et al. (1994). "Which Dogs Bite - a Case-Control Study of Risk-Factors." <i>Pediatrics</i> 93(6): 913-917. ¹⁴							
Case-control	2+	356 dogs in matched pairs	Dogs reported to Denver Animal Control for biting a non household member where it was a first bite	Dogs without history of biting non-household member, matched to cases by neighbourhood	Dog bites to non household members requiring hospital attendance	Signalment Size Acquisition Husbandry Behaviour history Discipline	Male dog Entire Living with ≥1 child Chained in yard
Guy, N. C., U. A. Luescher, et al. (2001). "Risk factors for dog bites to owners in a general veterinary caseload." <i>Applied Animal Behaviour Science</i> 74(1): 29-42. Guy, N. C. (1999). ¹⁷ Canine household aggression in the caseload of general veterinary practitioners in maritime Canada. <i>Department of Anatomy and Physiology, Faculty of Veterinary Medicine, Charlottetown, University of Prince Edward Island. MSc.</i> ¹⁸							
Case control	2+	227 cases 126 controls	Dogs >6/12 old previously recruited from the general veterinary caseload in Canada	Taken from same general vet caseload, identified as non biting dogs by initial questionnaire and subsequent interview	Bite to household member under any circumstances, including during play	Signalment Weight Home environ. Medical history Behaviour history Husbandry	Interaction between weight and sex Teenage children in home History of skin disorder Behaviour history

Reisner, I. R., K. A. Houpt, et al. (2005). "National survey of owner-directed aggression in English Springer Spaniels." <i>Journal of the American Veterinary Medical Association</i> 227(10): 1594-1603. ²³							
Cross sectional	2+	1053 dogs (510 aggressive dogs, 277 had bitten)	Adult AKC registered English Springer Spaniels 44% of questionnaires returned	Same population no owner directed aggression	Owner directed aggression Bite	Signalment Breeding Acquisition Behaviour history	Male dogs Neutered females Specific kennel in pedigree Source of acquisition Aggression towards other targets
Saetre, P., E. Strandberg, et al. (2006). "The genetic contribution to canine personality." <i>Genes Brain and Behavior</i> 5(3): 240-248. ²⁴							
Cross sectional	2+	5964 German shepherds 4589 Rottweilers	Dogs who underwent the Dog Mentality Assessment by the Swedish Working Dog Association between 1989 & 2001	Control within the same population	Finding of aggressive trait during Swedish Dog Mentality Assessment	Heritability of an aggressive behaviour trait	Evidence of heritability
Strandberg, E., J. Jacobsson, et al. (2005). "Direct genetic, maternal and litter effects on behaviour in German shepherd dogs in Sweden." <i>Livestock Production Science</i> 93(1): 33-42. ²⁵							
Cross sectional	2+	5964 German Shepherd dogs (5 excluded as unknown mother)	Dogs who underwent the Dog Mentality Assessment by the Swedish Working Dog Association between 1989 & 2001	Control within the same population	Finding of aggressive trait during Swedish Dog Mentality Assessment	Heritability of an aggressive behaviour trait	Evidence of heritability. Greater environmental effect of the litter.

1. Dog related factors

1.1 Does size of dog affect the risk of it exhibiting human-directed dog aggression?

There is clearly a link between the breed of dog and its size or weight. Thus any study looking at weight or height as a putative risk factor for human directed dog aggression may take into account the potential confounding effect of breed (and also age if growing dogs are included in the study population). Studies which account for breed in the design or analysis stage can ask questions such as; "Are larger dogs within a breed more or less likely to be involved in human-directed aggression?". In contrast, studies that do not account for breed can ask the question; "Are larger dogs (in general) more or less likely to be involved in human-directed aggression?". Hence, in the latter case, some of the effect of any differences between breeds is combined with the effect of size. This is further complicated by the association between the size of a dog and potential to damage as a result of the crude mechanics of greater muscle power and larger jaw, which would potentially result in the bites of larger dogs being more likely to present to Emergency Departments and to be reported in statistics.

In their 2001 case-control study of dog bites received by owners, Guy et al¹⁷ found that the mean weight of biting dogs was lower than that of non biting dogs, 19.5Kg (range 1.8-58.5Kg) as compared to 22.4Kg (3.6-58.5Kg) respectively (p<0.05). This association was especially true of female dogs. However, in their multivariable model, Guy et al found that there was a complex relationship between the weight and sex of a dog, with smaller female dogs being more likely to bite (Figure 2). The multivariable analysis undertaken by Guy et al did not include a variable for "breed", and hence the effect of size may, at least in part, be associated with differences between breeds. It is also worth noting that the definition of biting used in this paper did not take into account motivation for the bite. Indeed, they deliberately included bites occurring under any circumstances, including those which appeared to be accidental events during play.

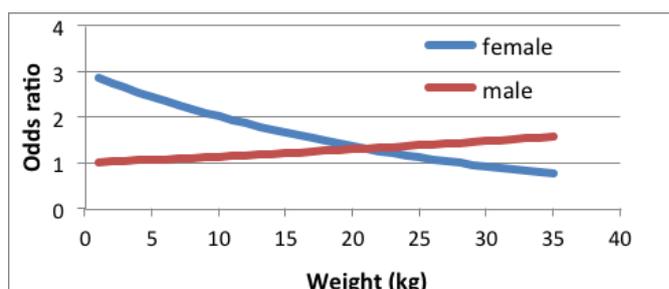


Figure 2: The effect of the interaction between weight and sex found by Guy et al. Note: this graph was created using data presented in Guy et al.

This study and others have found that the size of a dog affects the way in which it is managed and the freedoms which it has within the home, for example, small dogs are more likely to be allowed onto furniture²⁶. As a result it is difficult to interpret the effects of size of the dog without detailed information about the management and general behaviour of the dog, and vice versa.

This study utilised a population previously recruited from the general veterinary caseload in Canada. This had many merits, avoiding the limitations of those studies utilising behaviour referrals or reported bite incidents for example. Despite this, it is recognised that vet-visiting dogs are not representative of the general dog population. The authors themselves suggest that the detected complex relationship with size may reflect owners of larger aggressive dogs being less likely to present to a veterinarian.

Gershman et al¹⁴ examined the relationship between weight and risk of biting and found no evidence of an association with a dog having bitten a non-household member. Again, no underlying motivation for the bite was included in the outcome definition. In this analysis weight was included as a binary variable (>50lb, or not) simultaneously with the variable for breed (German Shepherd, Chow Chow or other). German Shepherd and Chow Chow were the two most numerous breeds in the study and would likely have been within the >50lb category. Hence, any effect of weight may have been accounted for by the variable "breed", as they investigated the effect of weight within a breed category. These authors state that biologically meaningful interaction terms were tested in the model. However, it is not explicitly stated which interactions with weight were examined.

Interpretation of evidence: *There is some limited evidence that smaller female dogs are at greater risk of biting household members; however there are many confounding factors of size and further study is required to elucidate whether this is a true risk factor.*

1.2 Does the age of a dog affect the risk of it exhibiting human-directed dog aggression?

The relationship of a behavioural event with age is somewhat complicated by increasing age providing increasing opportunity for an event to have occurred. For example a three-year old dog has only had three years in which to bite, where as a twelve-year old dog has potentially had four times the opportunity. Increasing age also raises the likelihood of coexistent illness and age-related cognitive changes which may act as confounders in any apparent relationship.

Studies examining the risk of household¹⁷ and non household member¹⁴ directed bites and owner directed aggression²³ found no independent association of risk with age of the dog.

Interpretation of findings: *There is no evidence for an association of age with risk of aggression or biting.*

1.3 Do sex and neuter status of a dog affect risk for human directed dog aggression?

Sex and neuter status are frequently quoted as risk factors for aggression; however the relationship is far from clear-cut, with many animals neutered as a result of undesired behaviour in the hope or belief that it will rectify problems. For example, Reisner et al²³ found that of the 167 neutered males in their study population, 17% had been castrated because of human-directed aggression and 6% because of dog-directed aggression. In comparison, only 1% of the neutered females had been neutered in response to human-directed aggression and none as a result of dog-directed aggression. It is therefore important to establish whether a study is able to distinguish between an association due to "cause" and one due to "effect".

Guy et al¹⁷ identified an interaction between the weight of a dog, its sex, and risk of biting a household member, with females being increasingly likely to bite with decreasing weight. This relationship is illustrated above (Figure 2). The majority of dogs in this study were neutered, 93% of females and 82% of males. Neuter status was not found to be significantly associated with reports of biting, (OR 0.83 (CI 0.37-1.89, p=0.66).

In their 2005 survey of owner-directed aggression by American Kennel Club registered English Springer Spaniels, Reisner et al²³ found that male dogs were significantly more likely than females to exhibit aggression towards a household member, with an odds ratio of 1.68 (CI 1.22-2.33 p=0.002).

Reisner et al²³ found that, overall, neutered dogs were more likely to be reported to be aggressive towards household member with an odds ratio of 1.73 (CI 1.25-2.39 p<0.001). When male and female dogs were analysed independently the association with neutering only persisted in the female dogs, with neutered females having an odds ratio of 1.92 (CI 1.32-2.79 p<0.001) compared to intact females.

Gershman et al¹⁴ found that male dogs were at greater risk of being reported for biting a non-household member with an odds ratio of 6.2 (CI 2.5-15.1). In this study sexually intact dogs were found to be at greater risk of biting with an adjusted odds ratio of 2.6 (CI 1.1-6.3). In their subgroup-analysis of those victims below 12 years of age this relationship was no longer statistically significant; OR 2.3 (0.7-7.3).

Interpretation of evidence: *There is conflicting evidence for the role of sex as a risk factor for aggression and bite; further study is required. There is conflicting evidence for the role of neuter status as a risk factor; this requires prospective studies to elucidate any true association.*

1.4 Does the breed of a dog affect the risk of it exhibiting human-directed dog aggression?

It is often reported that a given breed is more or less likely to be aggressive towards people. However, there is the potential for many factors to confound any relationship between breed and aggression. For example, the size of a dog, inextricably related to its breed, may impact on the damage done if it should bite, and consequently whether the recipient of a bite attends an Emergency Department. The perceived risk of a specific breed of dog biting will also potentially impact on interpretation of both the dog's behaviour and any injury received.

Further adding to the complexity of identifying whether a breed is at increased risk of exhibiting human-directed aggression, recipients of dog bite injuries may not be best placed to identify the breed of dog involved in the incident. Indeed, a recent study of American shelter dogs found that even those trained and experienced in breed identification are unreliable identifiers of breed, with predominant breeds proposed by shelter staff not found to be present in the DNA breed analysis of 87.5% of the dogs studied.¹⁶ This breed misidentification has significant implications, not only for the reliability of any study including breed as a variable, but also the behavioural interpretations and expectations of prospective owners and others who come into contact with a misidentified dog.

Of those studies which examined the effect of breed on risk, a common difficulty was the relatively small study population and large number of breeds represented, resulting in limited ability to identify breed differences.

In their case-control study of risk factors for dog bites to household members, Guy et al¹⁷ found no association between breed and dogs having bitten. However, as the authors acknowledge, there were 62 different breeds represented amongst the 202 purebred dogs in this study, rendering the number of dogs belonging to each breed very small. Thus power to detect differences was likely to have been very low.

The case control study by Gershman et al¹⁴, examining risks of bites to non-household members, had similar difficulty identifying the effect of breed on risk, in addition to a problematic method of breed identification. In this study breed was defined as the predominant breed identified by the owner, as outlined above this may be subject to significant inaccuracies. Gershman et al identified that dogs considered to be predominantly German Shepherd or Chow Chow breeds were at increased risk of biting. However as a result of the issues associated with breed identification, the method of analysis used for breed, and the low numbers of other breeds within the study population, these findings are of low quality evidence.

Interpretation of evidence: *Despite considerable speculation of a role for breed as a risk factor for human-directed dog aggression, insufficient evidence exists to draw firm conclusions.*

1.5 Are there genetic determinants of risk for human-directed dog aggression?

It has long been suggested that the temperament of the sire and dam is a significant predictor of the behaviour of their offspring; the key factor to this claimed relationship being their genetic heritage.

Work presented in the overlapping studies of Strandberg et al²⁵ and Saetre et al²⁴ investigated the heritability of a range of behavioural traits in a cohort of 5964 German shepherd dogs and 4589 Rottweilers which had undergone the Swedish Dog Mentality Assessment, a standardised behaviour test. They determined that only aggression appeared to be inherited independent of other traits, with other behaviours falling along a broad spectrum of canine personality previously denoted as the “shyness-boldness dimension”. These studies estimated that within the study population, in both breeds, 10% of the aggression shown to person who suddenly appeared was controlled by additive genetics and the remainder could be attributed to non-genetic factors ($p \leq 0.01$).

When studying the maternal and litter influences on behaviour amongst the German Shepherd dogs in their study population, the authors found that although there was substantial additive genetic effect, the litter environment had greater influence than either the maternal environment or maternal genetics. In their cross-sectional survey of owner-directed aggression in the English Springer Spaniel, Reisner et al²³ found that amongst their study population of 1053 adult English Springer Spaniels, dogs reported to have a history of aggression were significantly more likely to have one particular breeding kennel within their four generation pedigree (OR 1.6, CI 1.13-2.27, $p=0.009$). This kennel was specifically studied because of a noted frequent presence in the pedigrees of dogs being referred for aggression. The kennel was present in 34% of the pedigrees in the study. The authors acknowledge that this finding may reflect non-genetic factors associated with the kennel under study.

Reisner et al also consider the effect of the genetically determined characteristic, coat colour. They reported no association between coat colour and the risk aggression in English Springer Spaniels.

Interpretation of evidence: *There is some evidence for heritability of human directed aggression; this however requires further investigation across multiple breeds.*

1.6 Does the behavioural history of the dog affect risk of human-directed aggression?

It is perhaps intuitive that a dog that has bitten once may go on to bite again; however is there any evidence for this? Are there factors in the behavioural history which may provide forewarning that a dog is at high risk of exhibiting aggression in the future? If such factors could be identified and well described this could provide mechanisms for detection of dogs at greatest risk of human-directed dog aggression.

In their study of risk factors for bites of a household member, Guy et al¹⁷ found that dogs who were reported to have exhibited aggression over food in the first two months of ownership had an odds ratio of 3.08 (CI 1.05-9.01, $p=0.040$) of later biting a household member, compared to those that had not exhibited that behaviour. Those who had scored highly for excitability during the same period had an odds ratio of 1.14 (CI 1.02-1.26, $p=0.018$) compared to those that had not. These aspects of behavioural history were only examined in those dogs acquired prior to six months of age. More recent behavioural history was recorded but not included in multivariable models due to difficulty in establishing the causal direction of any relationship identified.

Reisner et al²³ reported that dogs exhibiting owner-directed aggression were more likely to have a history of aggression towards familiar non-household members; with an odds ratio of 18.27 (CI 2.41-138.81 $p=0.005$) and OR 4.02 (CI 1.47-10.95 $p=0.007$) for those with a history of aggression towards a familiar child and adult respectively. There was also an association between a dog having a history of aggression towards unfamiliar

children within the dog's own territory and exhibiting aggression towards a household member; OR 2.55 (CI 1.06-6.14 p=0.037).

Reisner et al²³ also found an association with having exhibited aggression towards other dogs and risk of aggression towards household members; OR 1.85, CI 1.26-2.7 p=0.002.

Gershman et al¹⁴ did not identify any association between factors in the behavioural history, including previous bites to household members, and biting a non-household member.

Interpretation of the available evidence: *There is some evidence that various aspects of a dog's behaviour are associated with their future propensity to both exhibit aggression and bite; in particular, a history indicating past aggressive acts increases the risk of future aggressive acts. This requires further high quality investigation.*

1.7 Is the health status of a dog a risk factor for human-directed dog aggression?

It is well recognised that ill health influences behaviour. Indeed, illness in an animal is often first recognised by deviation from their usual behaviour pattern. This association may also be influenced by factors involved in the management of illness, such as separation from owner, removal from usual environment, the impact of medication and pain, and change of normal routines and rules. It is also likely that the effects of health, for example reactions to pain, will vary depending on the personality and inclination of individual dogs.

In their case-control study of dogs that had bitten a household member, Guy et al¹⁷ found that dogs with a history of having a malodorous or pruritic skin condition which had been treated by a veterinarian had an odds ratio of 1.87 (CI 1.03-3.38, p=0.039) for biting, compared to those that did not have such conditions. There was no association identified with having had a serious illness requiring overnight admission to a veterinary clinic and risk of biting. Within their interview Guy et al¹⁸ also asked whether a dog had suffered a serious illness requiring overnight admission for veterinary care, they found no association between admission and risk of a dog biting.

Reisner et al²³ found no association between a history of seizures and aggression towards a household member in their population of English Springer Spaniels.

Interpretation of evidence: *Whilst there is some evidence for an association between skin conditions and biting, the association of aggression and health requires more extensive study, ideally across the general dog population and not restricted to vet visiting dogs.*

1.8 Does the diet of a dog alter risk of human-directed dog aggression?

It has been suggested that altering the protein content of the diet may modify the behaviour of aggressive dogs.

Dodman et al²² investigated the effect of altering the protein content of the diet using a controlled trial with a cross-over design. Owners were blinded to their dog's dietary protein content during the two weeks that each diet was fed and were asked to report behaviour using defined criteria. This study found that dietary protein content made no significant difference to the primary problem behaviour of dogs exhibiting owner-directed aggression (p=0.5) or hyperactivity (p =0.13), nor the control dogs. However, in the group whose main reported behavioural issue was aggression towards visitors to their home, low or medium dietary protein content was associated with a reduction in the reported intensity of the aggression (p=0.035) as compared to high dietary protein content. On further evaluating this group, Dodman et al found that the effect was present in those dogs that scored highly for fearfulness (p <0.0001) but not in the remainder of the group (p=0.054).

DeNapoli et al²¹ undertook a similar randomised trial with internal cross over design, examining the effect of dietary protein and tryptophan content on the level of aggression in a population of 33 privately owned dogs. This study found that overall the group with lowest "territorial" (visitor-directed) aggression scores were those fed a low protein tryptophan supplemented diet and that the high protein unsupplemented diet was associated with the highest "dominance" (owner-directed) aggression scores.

These two studies, whilst similar in design and undertaken in part by the same research group, analysed their data differently. Dodman only found an effect within certain sub-groups and DeNapoli only when the study population was analysed as a whole. This, in addition to the very small population size raises questions as to the validity of the findings.

Interpretation of evidence: *There is some limited evidence for an affect of dietary protein and tryptophan content on the level of aggression expressed towards either owners or visitors, however this requires further investigation with a larger population and longer duration of study.*

2. Factors which primarily relate to the interaction between dog and owner

2.1 Does the source of acquisition of a dog affect risk for human-directed dog aggression?

Dogs are acquired from a range of sources, the distribution varying with location and culture. Any risk associated with source of acquisition may be multifactorial and affected by a range of factors including early life experience, genetic factors and age at acquisition. Breed and pure breed status is also likely to confound a relationship with the source of acquisition.

In their cross-sectional survey of owner-directed aggression in English Springer Spaniels, Reisner et al²³ found that dogs that were acquired through newspaper advertisements had an OR of 1.53 (CI 1.12-2.09 p=0.007) for all dogs, and 2.33 (CI 1.62-3.34 p<0.001) for female dogs, of being reported to be aggressive towards a member of their own household, compared to dogs acquired via all other sources. The authors did not find this association when male dogs were analysed alone. Of note, the multivariable analyses did not adjust for age of

dog at acquisition, which may be related to the source of dog being through newspaper advertisements if it was for rehoming.

This study exclusively included purebred dogs of a single breed registered with the American Kennel Club, and thus may have limited external validity. One notable absence from their findings is of dogs obtained from rehoming organisations; only 0.9% of the dogs were classified as coming from a miscellaneous source and so presumably that is the maximum proportion of dogs in the study that were acquired from a rescue organisation. This is a notable absence in terms of determining risk factors in the general dog population.

Neither Gershman¹⁴ nor Guy et al¹⁸ found an association between a dog's source of origin and the risk that it would subsequently bite.

Interpretation of evidence: *There is very limited evidence that source of acquisition may be a risk factor for owner directed aggression, however further work is required in this area with particular attention being paid to the multiple potential confounding factors at play.*

2.2 Does environment and experiences in the early life of a dog affect subsequent risk of human-directed dog aggression?

It is believed that there are periods in a dog's early life experience which are developmentally sensitive and help to shape their future behavioural attributes. Experiences gained during these periods are strongly attributed to the breeding environment and the first few weeks at the new home. They will also likely be interlinked with the age and source of acquisition, the dog owning experience of both the owner and the breeder and their behavioural understanding and beliefs, which in turn will be influenced by their socio-demographic and cultural environment.

Guy et al¹⁸ examined early experiences to a limited extent, including training and correction used during first months of ownership for those dogs acquired prior to six months of age, and urbanisation. They found no association with any of these factors.

Strandberg et al²⁵ examined the magnitude of the effect of litter and maternal environment via their pedigree analysis in German Shepherd dogs and found that the effect of the litter environment was greater than that of maternal environment. However the nature of this study did not permit further investigation of which factors of the litter environment this related to.

Interpretation of evidence: *We found very little evidence regarding early life experience/environment. This is a key under-examined area for further research given the ability of both the breeder and the owner to influence early life experience. Due to the complexity of gathering such data, this would likely require studies of longitudinal design where dogs were followed from birth.*

2.2 Does extent and type of training undertaken affect the risk of human directed dog aggression?

How and when to train a dog is a topic associated with some controversy amongst the public, dog trainers and behaviourists (for example, see www.dogwelfarecampaign.org). Some are advocates of 'positive' reward-based training used to increase the relative frequency of desired behaviour, whilst others prefer aversive methods to reduce undesirable behaviour (relying heavily on the use of negative reinforcement and positive punishment to create avoidance).

Reisner et al²³ found no evidence of an association between training and risk of aggression. However, they did not appear to distinguish between reward based or aversive training methods, and it is not clear whether they differentiated between attendance at formal training classes and training at home. Further, amongst their variables, as potential precipitants of aggression, were several actions which could be described as aversive training methods but do not appear to have been analysed as such.

Gershman et al¹⁴ found no independent association between training and use of discipline and a dog's risk of being reported for biting a non-household member.

Interpretation of evidence: *To date we have no robust evidence of an association between training and risk of aggression.*

3. Owner related factors

3.1 Do socio-demographic factors of the owner effect risk for human directed dog aggression?

Socio-demographics may have wide ranging influence on an individual's experiences and available choices, actions and responsibilities. There is potential for many of these factors to influence various aspects of dog ownership; from the breed of dog that is owned, through its early life experiences to its on-going husbandry and training.

The gender and age range of the dog's primary human attachment was examined amongst the variables analysed by Reisner et al for an association with owner-directed aggression amongst their population of pure bred English Springer Spaniels. No independent association was identified.

In their study of bites requiring medical attention, Gershman et al¹⁴ found an association between one or more children below 10 years of age sharing the home with the dog and risk of biting non-household members, with an odds ratio of 3.5 (CI 1.6-7.5). Where the recipient of the bite was below the age of 12 years the odds ratio increased to 6.9 (CI 1.8-26.1).

Guy et al^{17,18} found no association between children living within the dog's household and risk of biting a household member. However this study did find an association between the risk of a dog biting and the number of

teenagers in the dog's home. With each additional teenager the risk of biting increased; OR 2.09 (CI 1.30-3.35 p=0.002)

Interpretation of evidence: *There is evidence that sharing a home with children or teenagers may be associated with an increased risk of biting both household and non-household members. This is an area requiring further research.*

3.2 Does the purpose for which a dog is kept effect risk for human-directed dog aggression?

The reasons for acquiring and keeping a dog are multiple; from companionship through assistance to hunting and protection. The purpose for keeping a dog may influence its source of acquisition, genetic heritage, husbandry, early life experience and training amongst other factors. These all have the potential to affect any relationship between purpose and exhibited aggression.

Reisner et al²³, Guy et al¹⁸ and Gershman et al¹⁴ all looked for an association between the purpose for which a dog is kept and risk of aggression or bite. None of these studies identified an independent association with the risk of human-directed dog aggression.

Interpretation of evidence: *We have found no robust evidence of an association between the purpose for which a dog is kept and its risk of exhibiting human-directed dog aggression.*

3.4 Does husbandry affect risk of a dog exhibiting human-directed dog aggression?

Factors affecting the manner in which a dog is managed in its home environment are complex and potentially related to socio-demographic factors, experience and beliefs of the owner, size and breed of the dog, in addition to the purpose for which it is kept. The evidence in this area is particularly difficult to interpret due to the problem of distinguishing cause from effect; dogs thought to have aggressive tendencies may be managed differently to other dogs.

Guy et al^{17,18} examined many factors related to the manner in which a dog is kept. In their univariable analysis they found several associations between current management and biting, however the authors concluded that these associations could readily be the consequence rather than cause of aggression and so they were not further evaluated within their multivariable model. Guy et al did include factors relating to husbandry during the first two months of ownership in those dogs acquired prior to six months of age, as they concluded that these were less likely to be consequences of aggressive behaviour. This study found that allowing a dog to sleep on the bed during the first two months of ownership was independently associated with risk of the dog having bitten a household member (OR 1.93; CI 1.06-3.53, p=0.032), after adjustment for weight. As described previously, this study found a complex relationship between the size of a dog, its sex and risk of biting. The authors acknowledge the potential association between a dog's size and how it is managed.

Reisner et al²³ found no independent association between a range of factors relating to the husbandry of the dogs within their study population and their risk of owner-directed aggression. This included no evidence of an association between the risk of aggression and either allowing the dog to sleep on the owner's bed or the duration of active exercise each day.

Gershman et al¹⁴ found evidence of an association between dogs being chained whilst in the yard and having bitten a non-household member OR 2.8 (CI 1.0-8.1). However, it is worth noting that the lower bound of the confidence interval for this relationship was 1, and that the relationship was not found in the sub-group analysis of dogs that had bitten a child younger than 12 years of age. The authors of this study acknowledge that the relationship may not be causal.

Interpretation of evidence: *There is weak and conflicting evidence of an association between allowing a dog to sleep on the bed and it biting, possibly related to the relationship with the target of aggression, and also evidence of an association between chaining a dog whilst in the yard and biting non household members. These and other areas of the management of a dog require further detailed study.*

4 Factors related to the target of aggression

4.1 Do socio-demographic factors related to the target of human-directed dog aggression influence the risk of aggression occurring?

Determining who is at greatest risk of being bitten, in terms of their age, sex and gender is complex. Issues such as risk taking behaviour, occupation, pet ownership and what leads to an individual seeking medical attention and how an individual perceives risk and health are determined by a combination of past experience, education and culture amongst other factors.

In their study of bite injuries received by postal workers in Taiwan, Chen et al²⁰ found no evidence of an association with the gender, age, experience, nor hours worked, and risk of receiving a dog bite injury.

Interpretation of the evidence: *We have found no evidence that the risk of a dog exhibiting human-directed dog-aggression is associated with socio-demographic factors of the target of aggression.*

4.2 Is the relationship between the target of aggression and the dog and owner a risk factor for human – directed dog aggression?

Each of the general observational studies which have been appraised as being of an adequate standard examined the risk to a specific target of aggression in relation to the dog; Guy et al¹⁷ and Reisner et al²³ investigated aggression towards, or bites to, the dog's owner or a household member. Gershman et al¹⁴

examined risk of bites to a non-household member, and Chen et al bites to a postal worker. That these studies were targeted in this way enabled them to more readily control for some potential confounding variables relating to different motivations behind a dog's aggression towards humans. However, we did not identify any adequately robust studies which compared the risk across different groups.

Interpretation of the evidence: *We have found no evidence of an association between the risk of a dog exhibiting HDDA and the relationships between the target and the dog and owner.*

4.3 Is the degree of experience and understanding of dog behaviour a risk factor for human-directed dog aggression?

Understanding of canine behaviour varies in the community and indeed there is disagreement even between behavioural experts over what motivation a given behaviour represents. Intuitively we may infer that greater experience and understanding of dog behaviour would be associated with less risk of injury as a result of an aggressive act, however without evidence we cannot form this conclusion.

Guy et al¹⁸ examined the effect of members of the household having read about or watched information on dog training or attended obedience or puppy classes with a previous dog and found no association with biting household members.

Interpretation of the evidence: *We found no evidence of an association between the experience and understanding of dog behaviour and risk of being the target of human-directed dog aggression.*

5. Factors which interact with the environment

5.1: Does geographic location or degree of urbanisation affect risk of human directed dog aggression?

In their study of dog bites to 237 postal workers across 9 post offices in Taiwan, Chen et al²⁰ found that those working in rural areas were significantly more likely to be bitten, with an incidence of 0.96 dog bites for each person-working year in rural areas compared to an incidence of 0.45 bites per person for each working year in urban districts. This gave an odds ratio for bites to postal workers in rural areas of 2.70 (CI 1.39-5.25) following adjustment via logistic regression as compared to urban postal workers. The authors examined the demographics of those postal workers in rural and urban areas and found no other significant differences.

Guy et al¹⁸ looked for an association between degree of urbanisation and the risk of a dog biting a household member; they found no association.

Interpretation of evidence: *We found evidence that for postal workers in Taiwan there is an apparent association between working in rural areas and increased risk of receiving bite injuries. This evidence of association is restricted to a specific group who by virtue of their work may enter the territory of an unknown dog on a regular basis. It is therefore difficult to extrapolate these findings to the general population.*

Further, this finding may be due to uncontrolled confounding, for example the number of dogs in an urban compared to rural environment and their access to different parts of the home environment, such as gardens and post-boxes. However, this study does highlight that there may be an association which requires further investigation.

Meta-analyses (Obj. 3)

The studies included in the systematic review vary in terms of the risk factors investigated and the outcomes assessed. Even where a risk factor is tested in two studies, it is often measured differently (e.g. age may be categorised into different sub-groups, e.g. >3, or <5 years, or treated as an integer). Hence, due to the lack of sets of equivalent studies, we were not able to under-take meta-analyses (i.e. quantitative pooling of data from multiple equivalent studies; Objective 3).

Summary of findings and recommendations for future research (Obj 5)

This review has highlighted the absence of high quality evidence relating to risk factors for human-directed dog aggression. Even that evidence identified as having a low risk of confounding and bias, discussed above and summarised in Table 3 below, does not provide firm evidence of causal relationships and in a number of cases is contradictory.

As a result of these contradictions, and the moderate level of evidence identified, our findings do not provide sufficient robust and strong evidence for specific factors affecting the risk of human-directed dog aggression. One likely reason for this is that an aggressive outcome, such as a bite, may be performed for a multitude of different reasons and motivations in a wide range of circumstances, and thus simply studying all bites together as comparable may be misleading and result in contradiction. Our findings can however be utilised in formulating hypotheses for future research and clearly illustrate the need for research in this area to improve in terms of the methods used. Our conceptual matrix may be helpful to identify and categorise those factors which are modifiable and relate to a given interaction; this may assist in identifying those most amenable to change. There is also a need for research activity to focus on the needs of policy makers and others involved in reducing HDDA.

In brief, we recommend:

1. Prioritisation of research aims and potential risk factors requiring investigation, to fit with the needs of policy makers and others charged with reduction of HDDA. A prioritisation exercise should be conducted in a transparent manner, and involve a wide range of stakeholders and include multidisciplinary expertise.
2. Development of a consensus statement detailing appropriate outcome definitions for the range of HDDA behaviours (e.g. based on aggressive behavioural postures and expressions, those based on biting, etc). Further investigation of the relationship and overlap between these outcomes are warranted. For example, investigation of the contexts and behaviours associated with bites that are likely to have different motivators, such as fear, play, frustration and predation, and estimation of the proportion of bite events that are due to these different motivators.
3. There is a need for clear guidance and training for HDDA researchers' regarding epidemiological (i.e. population-based) research methods. The "Guide to good practice for quantitative veterinary epidemiology" (<http://www.qve-goodpracticeguide.org.uk/>) provides a starting point, but more detailed guidelines are still required. Training courses for researchers would also be beneficial.
4. Guidelines for high quality data collection methods should also be developed. These should include recommendations for collection of new datasets, but could also work with holders of existing and on going datasets (see Table 4) to ensure best practice, with modification in current practice where necessary (and possible).
5. HDDA researchers and funders should aim for study designs likely to provide high quality evidence. In particular, the use of randomised trials to test plausible interventions should be considered, including those based on education or incentives. Large, carefully designed and well-executed cohort studies (possibly multi-centre) should also be considered. Although relatively expensive, these have the ability to consider multiple potential risk factors and outcomes. Consideration could be given to funding "bolt-on" components to other (perhaps on-going) life-cohort studies, but inclusion of dogs (and collection of data) from near birth would likely be important.
6. Organisations and bodies that fund HDDA research should ensure that research methodology is carefully considered at the application stage. It may also be warranted to have an interim assessment of proposed methods (by an expert in epidemiological methods) following funding, but prior to data collection commencing. Research plans should provide details of all plans, including those describing study design, selection, measurement and statistical analysis.
7. Researchers may want to consider the data sources outlined in Table 4 as potential sources of data for future studies. However, in all cases the sources of data should be selected on the basis of the needs of the research, rather than availability.

Table 3: Summary of results and identification of hypotheses for future research

	No association found	Association identified	Some associations found, others not found	Not analysed as risk factor	Gershman	Guy	Reisner	Chen	Saetre	Strandberg	Dodman	DeNapoli
Sex (male)		↑	↓	↑								
Heritability/pedigree												
Dietary protein												
Teen in home												
Child in home												
Size (large)												
Neutering												
Behaviour History												
Physical illness												
Source of acquisition												
Early experience												
Husbandry												
Urbanisation												
Age of dog												
Breed												
Coat colour												
Purpose												
Training												
Owner gender												
Owner experience & knowledge												
Target gender												
Target age												
Bite experience												
Target Experience & knowledge												
Owner Age												
Target relationship to owner												

Additional sources of data (Obj 4)

Through our investigations and discussions with stakeholders at our seminar events, we have identified a variety of sources of data which may assist in future research. These fall into a number of potential data types and sources that may be utilised in future research into human-directed dog aggression (Table 4). However, it should be noted that each of these may be subject to a range of biases and as such careful planning would be required prior to their utilisation. Further, many of these datasets are not publically available, and hence appropriate permission would need to be obtained from the data owners. A point for further consideration is the limited information known about the general pet dog populations, which makes examining risk factors for aggression within these populations difficult.

Table 4: Datasets which may be of use in future research into one or more aspects of human-directed dog aggression

Type	Example	URL for further information	Limitations of type of data
Standardised behaviour assessments	Canine Behavioural Assessment and Research Questionnaire (CBARQ) Dog mentality assessment	http://vetapps.vet.upenn.edu/cbarq see Strandberg et al (2005)	Primarily collected via convenience sampling
Ongoing human study cohorts	Avon Longitudinal Study of Parents and Children (ALSPAC) National Child Development Study (NCDS)	http://www.bristol.ac.uk/alspac/ http://www.cls.ioe.ac.uk/text.asp?section=000100020003	Not designed with the intention of collecting information regarding exposure to human-directed dog aggression and so information limited
Ongoing canine study cohorts	The Dogslife Project	http://www.roslin.ed.ac.uk/dylan-clements/the-dogslife-project/	Limited anticipated duration and not specifically designed to evaluate risk factors for aggression
Veterinary surveillance datasets	Small Animal Veterinary Surveillance Network (SAVSNET) Venom	http://www.liv.ac.uk/savsnet/ http://www.venomcoding.org/	Not currently designed to provide information on risk factors for human directed dog aggression. Potential for bias by owner reporting and restriction to vet visiting dog population
Human injury surveillance	Injury surveillance on-line	http://dsol-smed.phac-aspc.gc.ca/dsol-smed/is-sb/index-eng.php	Seldom contains sufficient information for risk factor analysis, may however assist in quantifying the issue and identifying cases
Canine genetic	Canine Behavioral Genetics	http://www.k9behavioralgeneti	Robust control selection is frequently

information banks	Project	cs.com/	problematic in genetics studies, however appropriately collected samples and data may prove useful.
Dogs reported to authorities for aggressive or antisocial behaviour	Dogs reported for offences under the Control of Dogs (Scotland) act	http://www.legislation.gov.uk/asp/2010/9/contents	May be subject to biases, however may be useful in identifying cases for future case control studies
Census population	UK Census	http://www.census.gov.uk/	UK census does not currently ascertain information regarding dog ownership. The addition of this to future census may be beneficial to future research regarding the dog population.
Data relating to hospital attendance as a result of bite injuries	Hospital Episodes Statistics	http://www.hesonline.nhs.uk/	Seldom contains sufficient information for risk factor analysis, may however assist in quantifying the issue and identifying cases
Micro-chip registration records	Petlog database	http://www.petlog.org.uk/	Micro-chipping is not universal and likely to be affected by bias,
Dog licensing records	Northern Ireland local council records of dog licenses issued	http://www.newtownabbey.gov.uk/dogs/doglicence.asp	Even where compulsory not all dogs may be licensed and bias is likely to be introduced by the inherent differences between those who chose to comply with licensing and those who don't
Breed and kennel club registries	UK Kennel Club	http://www.thekennelclub.org.uk/	Not suitable for establishing population demographics, however could be utilised to identify a random sample of owners of registered dogs of specific breeds
Dog rescue and welfare records of relinquished dogs and behaviour assessments	Relinquishments to multibreed rescue organisations such as the RSPCA and Dogs Trust		Will not be without bias introduced for example by factors which make an aggressive dog less acceptable to the current owner, size for example, and owner related factors.
Databases of dogs receiving rabies vaccination in endemic countries			Likely to be subject to some biases, however may provide data for identifying participants in future studies.
Health and safety reports of work place incidents			Subject to biases introduced by those who report incidents. Where this can be minimised may provide access to cases for studies within the populations at risk by virtue of their occupational exposure.
Records of dogs attending training classes	Association of Pet Dog Trainers	http://www.apdt.co.uk/	Bias introduced by those who choose to attend training classes with their dogs, however may provide access to dog owners for future studies
Records of dog seen by behaviourists	Association of Pet Behaviour Counsellors (APBC)	http://www.apbc.org.uk/	Bias introduced by virtue of an owner recognising that their dog has a behaviour problem and seeking or being referred for behaviour counselling. May provide access to cases for future study
Pet insurance records			Potential biased dataset in the UK as a result of the inherent differences between those who choose to insure and those who don't
Human health insurance records			In the UK emergency care is seldom provided in the private sector and so this is unlikely to be useful. In countries where health care is funded primarily in the private sector these records may be of more use however still potentially biased.
Destruction of dogs following bites and as a result of aggressive behaviour – not available & what is the control			Not currently available. Would be subject to similar biases as those records of dogs relinquished for similar reasons.

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References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Knowledge exchange (Obj 6)

1. Publications

- a. Letter to the Veterinary Record⁸ & Vet Times requesting information concerning unpublished studies, 27th March 2010
- b. Project website at www.liv.ac.uk/dog-aggression hosting a description of our work, our findings and a searchable database of reviewed studies.
- c. Results of systematic review currently being prepared for submission in a peer-reviewed scientific journal.

2. Presentations

- a. Presentation of research and call for information on unpublished work at the Association of Pet Behaviour Counsellors (APBC) annual conference, 6th March 2010, attended by 300 delegates with an interest in animal behaviour and aggression.
- b. Poster presentation at the Society for Veterinary Epidemiology and Preventative Medicine (SVEPM) conference 24th - 26th March, Nantes, France
- c. Two 1-day Seminar events held in February 2011. These events brought together interested parties from diverse backgrounds, attendees included representatives from; animal welfare and rehoming organisations, dog breeding organisations, risk management, animal behaviour and training, companion animal epidemiology, police officers including Dog Legislation Officers, dog warden associations.
The prime aim of these events was dissemination of the findings of our systematic review. In addition the seminar events provided an opportunity for the participants to share opinions and experiences drawn from their varied fields of expertise.
The seminar days consisted of a series of short presentations setting the scene of the theory behind and consequences of human-directed dog aggression, whilst highlighting the large degree of uncertainty that exists, especially when trying to quantify the size of the problem. This was followed by an outline of types of evidence and the hierarchical nature of evidence and presentation of the systematic review methods and findings.
We encouraged open discussion during the events and provided a breakout session in the afternoon where smaller groups were encouraged to discuss our research findings, the implications to their field, and future research needs.
- d. Presentation at the Companion Animal Behaviour Therapy Study Group (CABTSG) Study Day 2011, 30th March 2011. Presenting an overview of our research and findings.
- e. Accepted oral presentation at the International Society for Anthrozoology (ISAZ) conference, August 4-6 2011, Indianapolis, Indiana.